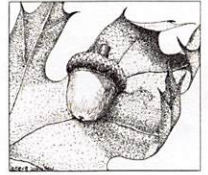


dcr



Forest Management Plan

Submitted to the Massachusetts Department of Conservation and Recreation for enrollment in CH61/61A/61B and/or Forest Stewardship Program



CHECK-OFFS

CH61	CH61A	CH61B	STEWARDSHIP	Cost Share
cert <input type="checkbox"/>	cert <input type="checkbox"/>	cert <input type="checkbox"/>	new <input type="checkbox"/>	EEA <input type="checkbox"/>
recert <input type="checkbox"/>	recert <input type="checkbox"/>	recert <input type="checkbox"/>	renew <input checked="" type="checkbox"/>	Other <input type="checkbox"/>
amend <input type="checkbox"/>	amend <input type="checkbox"/>	amend <input type="checkbox"/>	Climate <input type="checkbox"/>	Birds <input type="checkbox"/>
Plan Change <input type="checkbox"/> to _____			Conservation Rest. <input type="checkbox"/>	CR Holder _____

Administrative Box

Case No. (Wh) 337-9497 (W) 340-9498 (H) 127-10697	Orig. Case No. (H) 127-9496
Owner ID 503169	Add. Case No. _____
Date Rec'd 4/2/24	
Plan Period 2025-34	
Rare Spp. Hab. <u>Yes</u>	

OWNER, PROPERTY, and PREPARER INFORMATION

MTN**

Property Owner(s) The City of Northampton, Department of Public Works (DPW) *
 Mailing Address 125 Locust Street, Northampton, MA, 01060 Phone 413-587-1570 x1376
 Email Address jstacy@northamptonma.gov *Attention Johanna Stacy, Senior Environmental Planner
 Property Location Town(s) *Whately, Williamsburg, Hatfield Road(s) See***

Plan Preparer Michael Mauri Mass Forester License # 161
 Mailing Address 20 West Street, South Deerfield, MA 01373 Phone (413) 665-6829

RECORDS

Assessor's Map No.	Lot/Parcel No.	Deed Book	Deed Page	Total Acres	Ch61/61A 61B Excluded Acres	Ch61/61A 61B Certified Acres	Stewshp Excluded Acres	Stewshp Acres
SEE		Next		Page				
				TOTALS	744.6	N/A	See next page	650.9 (=87% of "Total Acres")

Excluded Area Description(s) (if additional space is needed, continue on separate paper)

Reservoirs, dams and associated grassy and brushy areas.

HISTORY Year acquired 1901 Year Management began unknown

Are boundaries marked: Yes blazed/painted/flagged/signs posted (circle all that apply) No Partially

What treatments have been prescribed, but not carried out (last 10 years if plan is a recert.)?

stand no. _____ treatment _____ reason _____

(If additional space is needed, continue on separate page)

Previous Management Practices (last 10 years)

Stand #	Cutting Plan #	Treatment	Yield	Acres	Date
See discussion of recent management in plan					

Remarks: (if additional space is needed, continue on separate page)

**Mountain Street Reservoir Forest.

***Mountain Street and Reservoir Rd in Williamsburg; Haydenville Rd, Laurel Mountain Rd and Chestnut Mountain Rd in Hatfield Page 1 of 189

Adds 94.5 acres. This submission combines Hatfield ac. (case #127-9496 (expired 2022) with parcels under (case #127-10967) (2017-2026) and replaces those.

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Tables (A), (B) & (C): Property Records: Parcels, Exclusions, Acreages to Use

(A) Ryan and West-Whately watershed										
TOWN	Watershed	Assessors' Parcel MAP_PAR_ID (Assessor Identifier)	Assessors' Parcel Acres (a)	DPW GIS ACRES for entire ownership* (b)	STWDSHP excluded acres (c)	Excluded feature	APPROX FOREST STEWARD-SHIP ACRES based on DPW GIS (d) [= b - c]	Acquired since previous Plan in 2012?	Parcel	Actual Forest Stand Acres to Use in Plan **** (e)
Conway	R-WW	068/416.0-0017-0000.0	6.7	7.3	0.0		7.3			
Conway	R-WW	068/417.0-0012-0012.0	78.1	76.4	0.0		76.4			
Conway	R-WW	068/419.0-0002-0000.0	30.4	31.2	0.0		31.2			
Conway	R-WW	068/419.0-0002-0001.0	26.5	26.9	0.0		26.9	26.9	Bardwell	
Conway	R-WW	068/419.0-0003-0000.0	93.0	87.8	0.0		87.8			
Conway	R-WW	068/419.0-0006-0000.0	199.0	199.4	0.0		199.4			
Conway	R-WW	068/419.0-0008-0000.0	105.7	110.6	0.0		110.6			
Whately	R-WW	16 0 01	13.5	14.0	0.0		14.0			
Whately	R-WW	16 0 02	224.0	206.5	0.0		206.5			
Whately	R-WW	16 0 03	106.0	89.8	0.0		89.8			
Whately	R-WW	16 0 05	298.0	309.3	102.6	***	206.7			
Whately	R-WW	16 0 06	1.5	1.8	1.8	Misc	0.0			
Whately	R-WW	16 0 06-2	3.7	3.4	0.0		3.4	3.4	Golonka	
Whately	R-WW	22 0 06	108.0	109.3	0.0		109.3	109.3	Boone	
Whately	R-WW	28 0 01	113.0	109.8	0.0		109.8			
Williamsburg	R-WW	340/002.B-0000-0019.0	388.9	403.6	0.0		403.6			
Williamsburg	R-WW	340/002.B-0000-0023.0	94.1	106.3	0.0		106.3			
Williamsburg	R-WW	340/002.B-0000-0024.0	14.9	5.6	0.0		5.6			
Williamsburg	R-WW	340/002.B-0000-0025.0	82.0	114.1	0.0		114.1			
Williamsburg	R-WW	340/002.B-0000-0025.1	50.0	38.0	0.0		38.0	38.0	Krawczyk	
Williamsburg	R-WW	340/002.B-0000-0026.0	243.0	384.7	0.0		384.7			
Williamsburg	R-WW	340/002.B-0000-0027.0	14.9	14.3	0.0		14.3			
Williamsburg	R-WW	340/002.B-0000-0028.0	78.0	78.9	0.0		78.9			
Williamsburg	R-WW	340/002.B-0000-0035.0	57.0	47.5	0.0		47.5			
Williamsburg	R-WW	340/002.B-0000-0036.0	32.0	43.5	0.0		43.5			
Williamsburg	R-WW	340/002.B-0000-0037.0	20.0	14.8	0.0		14.8	14.8	Przasnyski	
Williamsburg	R-WW	340/002.B-0000-0040.0	10.5	4.8	0.0		4.8	4.8	Boone	
Total	R-WW		2,492.3	2,639.9	104.4		2,535.5	197.3		2,523.5

(B) Mountain Street watershed										
TOWN	Watershed	Assessors' Parcel MAP_PAR_ID (Assessor Identifier)	Assessors' Parcel Acres (a)	DPW GIS ACRES for entire ownership* (b)	STWDSHP excluded acres (c)	Excluded feature	APPROX FOREST STEWARD-SHIP ACRES based on DPW GIS (d) [= b - c]	Acquired since previous Plan in 2012?	Parcel	Actual Forest Stand Acres to Use in Plan **** (e)
Hatfield	MTN	208-1	22.0	49.9	27.8	Reservoir	22.1			
Hatfield	MTN	208-2	9.1	9.5	0.0		9.5	9.5	Martin	
Hatfield	MTN	208-4	9.1	9.1	0.0		9.1	9.1	Marchand	
Hatfield	MTN	208-7	31.0	31.2	0.0		31.2			
Hatfield	MTN	209-10	8.8	8.8	0.0		8.8			
Hatfield	MTN	209-11	7.6	7.9	0.0		7.9	7.9	Martin	
Hatfield	MTN	209-12	7.2	7.3	0.0		7.3	7.3	Benney	
Hatfield	MTN	209-4	52.0	52.5	0.0		52.5	52.5	Steidler	
Whately	MTN	03 0 04	86.0	99.3	0.0		99.3			
Whately	MTN	03 0 05	41.2	39.7	0.0		39.7			
Whately	MTN	03 0 06	50.0	51.6	0.0		51.6			
Whately	MTN	03 0 07	138.6	139.2	1.8	Reservoir	137.4			
Whately	MTN	03 0 08	2.1	2.1	0.0		2.1			
Whately	MTN	03 0 09-2	4.1	4.1	0.0		4.1	4.1	Delano	
Whately	MTN	03 0 09-3	4.1	4.1	0.0		4.1	4.1	Martiniano	
Whately	MTN	03 0 14	21.0	21.3	0.0		21.3			
Williamsburg	MTN	340/005.E-0000-0011.0	29.8	68.5	39.3	Reservoir	29.2			
Williamsburg	MTN	340/005.E-0000-0012.0	7.1	4.5	1.4	Below dam	3.1			
Williamsburg	MTN	340/005.E-0000-0013.0	150.0	134.1	12.0	WTP**	122.1			
Total	MTN		680.8	744.6	82.3		662.3	94.5		650.9

(C) Combined watersheds										
TOWN	Watershed	Assessors' Parcel MAP_PAR_ID (Assessor Identifier)	Assessors' Parcel Acres (a)	DPW GIS ACRES for entire ownership* (b)	STWDSHP excluded acres (c)	Excluded feature	APPROX FOREST STEWARD-SHIP ACRES based on DPW GIS (d) [= b - c]	Acquired since previous Plan in 2012?	Parcel	Actual Forest Stand Acres to Use in Plan **** (e)
(a) + (b) Grand Total both watersheds			3,173.1	3,384.6	186.8		3,197.8	291.8		3,174.4

*Source for DPW GIS Acres: shapefiles "nton_lots_20221025" emailed from knelson@northamptonma.gov, 2-15-2023; ** WTP = Water Treatment Plant and associated grounds; ***Excluded acreage for 2 reservoirs, dams, and associated non-forest grass, etc.; ****Total acreage of STANDS as redrawn and adjusted for boundaries, etc. This is the acreage used in the Forest Stands. Note: lacking a comprehensive survey for the entire ownership, the exact ownership acreage cannot be exactly known.

Landowner Goals

(1) Please **check** the column that best reflects the importance of the following goals:

(goals may change over time and this table may be updated to reflect any changes)

Goal	Importance to Me			
	HIGH	MED	LOW	N/A, Don't Know
Improve access for walking/skiing/recreation			X	
Improve hunting or fishing			X	
Maintain or enhance privacy			X	
Preserve or improve scenic beauty		X		
Protect special features, including those of historical or person significance		X		
Enhance the quality and/or quantity of forest products*		X		
Practice agroforestry				X
Produce income from timber products, or other products and services		X		
Produce firewood for personal use			X	
Enhance habitat for birds		X		
Enhance aquatic habitat in streams, ponds, and other wetlands		X		
Enhance habitat for wildlife		X		
Promote diversity of plant species and habitat types	X			
Increase forest resiliency	X			
Minimize damage from forest pests and pathogens	X			
Protect water quality	X			
Sequester and/or store carbon to mitigate climate change		X		
Suppress or eradicate invasive plants	X			
Lower property taxes			X	
Protect land from development	X			

* This goal must be checked "HIGH" if you are interested in classifying your land under Chapter 61/61A.

Owner(s) (print) City of Northampton DPW

(This page will be included with the completed plan.)

Page ____ of ____

(2)

In your own words please describe your goals for the property:

Promote complex forest structure featuring tall forest cover, vigorous tree growth, broad species and habitat diversity, and effective regenerative capacity so that essential water quality protection functions are maintained even in the face of a changing climate.

In support of the above, maintain necessary forest roads and associated infrastructure and immediate roadside environments so that these support watershed operations without detracting from water quality (even at times of peak flow).

Provide outreach as needed to give the public the opportunity to understand the condition and management of the watershed forest.

Stewardship Purpose

By enrolling in the Forest Stewardship Program and following a Stewardship Plan, I understand that I will be joining with many other landowners across the state in a program that promotes ecologically responsible resource management through the following actions and values:

1. Managing for long-term forest health, productivity, diversity, and quality.
2. Conserving or enhancing water quality, wetlands, soil productivity, biodiversity, cultural, historical and aesthetic resources.
3. Following a strategy guided by well-founded silvicultural principles to improve timber quality and quantity when wood products are a goal.
4. Setting high standards for foresters, loggers and other operators as practices are implemented; and minimizing negative impacts.
5. Learning how woodlands benefit and affect surrounding communities, and cooperation with neighboring owners to accomplish mutual goals when practical.

(3)

Signature(s): _____

Date: _____

Owner(s) (print) City of Northampton DPW

(This page will be included with the completed plan.)

Page ____ of ____

Purpose of this Forest Stewardship Plan

In pursuing its mission to provide an adequate supply of clean drinking water, the City of Northampton owns and maintains over 3,000 acres of watershed forest in the towns of Conway, Whately, Williamsburg and Hatfield – see **Locus Maps 1, 2 and 3a&b**. These watershed forests surround the Ryan, West-Whately and Mountain Street Reservoirs, from which the City of Northampton obtains the vast majority of its tap water. Through the capture, filtering, storage and slow release of clean water into the tributaries and groundwater feeding the reservoirs, these watershed forests contribute significantly toward ensuring that this water is of high-quality. The purpose of this Forest Stewardship Plan is to present information, concepts and recommendations that will help DPW ensure that the watershed forests owned by the City of Northampton DPW will continue to be able to provide these critical water quality functions. Specifically, this Forest Stewardship Plan takes stock of the forest in its current condition, assesses the condition of the forest relative to its ability to provide essential water quality functions in the present and future, re-evaluates and re-states the landowner objectives for the coming 10 years, and provides a set of recommended management steps that will help sustain the forest in a suitable condition that meets those objectives.

The current, marvelous watershed forest is the result of a long and continuous history of natural development tendencies, processes and events combined with periodic influences caused by a variable legacy of human activity both pre-dating the arrival of Europeans and ever since. In earlier times, the human influence tended to be devoted to obtaining food and materials necessary for survival; in more recent times, the focus has been on maintaining the forest in a condition suitable for water supply purposes. By and large, it has taken roughly a century to develop the current trees of this forest – the oldest patch of trees that could be confirmed is about 135 years old – see **Figure 1: Natural Aging and Disturbance in an Old Hemlock Grove (Dating to ca. 1875)**. Though there are a small number of plantations (planted forests), most of the current forest has grown naturally, without being planted, and any remaining plantations are well along in a long-term process of naturalizing. The City of Northampton took ownership of the watershed forests with the intention of protecting water quality and ensuring a reliable supply of clean water over time. Under its ownership, the City of Northampton has managed the forests in various ways over time in an attempt to support this mission. As the understanding of the forest and opportunities for management have changed over time, so has the forest management. Going forward, management will need to *continue* to change and adapt as the prevailing conditions and factors that have a major impact on forests continue to intensify or change. These include mortality, poor health and outright loss of established trees and potentially whole tree *species* as a result of pests, pathogens and diseases, combined with factors that significantly impede the growth of the young trees that would replace them, including high levels of herbivory (especially feeding by deer at current population levels), the ever-expanding spread of non-native invasive plants (especially the overwhelming growth of bittersweet vines) and aggressive competition from certain native vegetation that is avoided by deer (especially hayscented fern, which forms monocultural thickets). All of these factors are discussed in this plan, and all of these factors will make any efforts to adapt to the projected changes in the climate all the more difficult.

Water quality functions of the forest

Through their unique structure and composition, forests have the potential to provide the essential water quality functions of continuous capture, infiltration, filtration, cooling, storage and attenuated release of rainfall and other precipitation upon which a public surface water supply relies. The essential water quality functions of the forest (in this case, of the watershed forest) derive from the unique ability of forests to protect and structure the soil and facilitate beneficial soil processes. In turn, the soil supports the forest. Together, the forest and soil are seamlessly integrated forest-soil *ecosystem*. This seamlessly-integrated forest-soil ecosystem – i.e., the watershed forest – is able to capture water from precipitation and overland runoff and transfer it by a process of infiltration into the soil. Once within the soil framework, the water’s movement is slowed, and it is temporarily stored. Once underground within the soil, the water undergoes physical, chemical and biological filtering, before, ultimately, a portion of it is gradually released through groundwater, springs and streams as a source of fresh, clean water that feeds the reservoirs.

The water quality functions of the forest are *enabled* by the various features and ecological processes of the forest and therefore are directly facilitated by the *condition* of the forest. Watershed forest management is concerned with the condition of the forest. To assess the condition of the forest, we refer to a number of tree-based attributes, sometimes grouped into “layers”, stretching from the roots in the soil to the tips of the tall trees at the top of the canopy. Together, these layers constitute the structure of the forest.

The key elements of forest structure relevant to water-quality protection are:

- the forest overstory and associated root structure,
- the midstory, and
- the forest floor environment.

For purposes of this discussion, large woody roots and associated finer roots and mycorrhizal fungal networks are associated primarily with the forest overstory (large trees), but also with the midstory layer. Low vegetation on the forest floor provides additional root structure near the surface and, together with deadwood, supports associated fungal networks and other biological activity.

Not surprisingly, forests can and will differ considerably in many aspects of their condition, ranging from healthy to degraded. There can be a great variety of reasons for this. Forests are remarkable in that they are able to provide good levels of water quality functions over a broad range of conditions. But, as forests differ in their condition, that is, as forests differ in their relative degree of tree-based structural complexity, tree-based species diversity, and soil protection, they will ultimately differ in the level of water quality functions they provide as well.

Therefore, in relying on this seamlessly integrated *forest-soil ecosystem* to provide essential water quality functions, a watershed forestry program will have two key

objectives. The first objective is to ensure that the forest develops into or is maintained – over time – in a condition that is as complex in its structure and as diverse in its species composition as can be reasonably expected for the types of forest that can naturally grow at that given site under prevailing conditions. The second objective is to ensure that the soil is protected from any potentially compromising impacts that may undermine its ability to provide its share of the essential water quality functions discussed above.

Ownership acreage & scope

This Forest Stewardship Plan is intended to cover the vast majority of the known forest and associated natural area acreage belonging to the City of Northampton at the Ryan and West-Whately and Mountain Street watersheds. In the absence of a complete survey of the watershed properties, the exact acreage of the watershed properties cannot be not known. However, in order to research and prepare this Forest Stewardship Plan, it was not truly crucial to know the *exact* acreage or the exact location of all boundaries.

The primary and controlling source of land ownership data used for this plan was provided in a shapefile provided by Northampton DPW.¹ This parcel-shapes, locations, and assessor data were used to develop **Locus Maps 1, 2 and 3a&b** and **Tables A B C: Property Records: Parcels, Exclusions, Acreages to Use**. The total forest area is estimated to be over 3,000 acres.

Additional sources of information and knowledge of the boundary include:

1. Fieldwork and mapping done for the Forest Stewardship Plan in 2012 and for subsequent Forest Stewardship Plans (GIS acreage) (see column (d) in Table 1).
2. Existing surveys referencing on-the-ground boundary evidence (e.g., iron pins, etc.) for some of the parcels (including for parcels acquired since 2012).
3. The locations of stone walls which can be seen using Lidar imagery and which in some cases may delineate a boundary.

Note, however, that though there is broad and general agreement among the various data sources but there are also discrepancies. These first two sources are largely in agreement but do not entirely overlap or arrive at the same acreage total. The two sources differ by only about 23 acres – See **Tables A B C: Property Records: Parcels, Exclusions, Acreages to Use**. A main area of discrepancy is in the southwest portion of the Ryan and West-Whately tract. Here, it seems the current assessors’ records have shifted a bit to the north, occupying some of the Town of Williamsburg parcel. The third source (surveys) pertains to certain individual parcels within the larger ownership but not to the ownership as a whole.

This Forest Stewardship Plan cannot definitively resolve any boundary or acreage questions, and so a best estimate must be used. From a practical perspective, the GIS acreage (Column (e) in **Tables A B C: Property Records: Parcels, Exclusions, Acreages to Use**) seems to most closely represent the location and acreage of the actual watershed forest. For calculations in this plan, a total estimated acreage of 3,174.4 total

¹ The shapefile “nton_lots_20221025” was provided by email on 2-15-2023.

acres of forest will be used. This is the acreage covered in all of the forest stands. Much of the forest data is gathered and reported on a per-acre basis and is therefore not dependent on an exact acreage figure. Any acreage-dependent totals can be adjusted as needed if the acreage estimate changes or if more accurate estimates become available.

Forest data

In order to develop a representative picture of the forest as it is at this time, data was gathered in a number of ways. The primary data was gathered *systematically* at a set of 318 non-biased, evenly-distributed sample plots. At each of these plots, a subset of trees was measured and assessed in detail, and broader conditions at the plot were documented. Secondary data was freely gathered on an *as-encountered* basis at points, that is, whenever something of interest was happened upon, a note was made and recorded in GPS at that point. This secondary data was gathered both while traveling to and from systematic plots and while otherwise investigating conditions on the ground. From the outset, overstory species diversity and the presence of non-native invasive plants were a special focus in gathering the as-encountered data. In the course of the field work, a third special focus was added: situations of regeneration failure in canopy gaps, referred to in this Forest Stewardship Plan as *gap process failure*. For locations of all data gathering, see **Methods Map 1: Systematic Forest Inventory Plots and As-Encountered Data Points**. The data gathering methods are described in greater detail in the Appendix: Methods used to gather data for the Forest Stewardship Plan.

Key findings and recommendations related to landowner objectives

The data gathered for this Forest Stewardship Plan show that the watershed forests are remarkably well-suited – both in terms of structural complexity and species diversity – to *currently* provide the water quality functions essential to the maintenance and operation of a public surface water supply. The watershed forests are tall, closed-canopy, species-diverse forests with complex (vertical) structure that is well suited to providing the various water quality functions that the City of Northampton relies on to provide sufficient amounts of usable raw water to its reservoirs. The forest contains a diverse mix of common trees as well as a notable presence of less-common species. The diversity constituted by these less-common species may become increasingly important going forward; this may be especially true as pests and pathogens affect these common species and as it becomes more necessary to adapt to anticipated climate change, in part by promoting the spread, establishment and growth of trees that may be better adapted to future climate conditions. Notably, this species diversity is not evenly distributed, but is concentrated in the Mountain Street watershed forest. In this sense, the Mountain Street watershed forest can be thought of as a special reserve of species diversity for future use in the larger Ryan and West-Whately watershed forest.

At the same time, based on data gathered, it is very evident that the forest as a whole is at risk of significant *deterioration* over the coming decades. Deterioration may be driven both by a loss of species diversity and by a simplification or loss of vertical structure including, most strikingly, the loss of a tall forest canopy and, more subtly, the simplification of the forest floor environment. Factors driving the process of deterioration include the ravages of pests, pathogens and diseases (which are already affecting existing

trees) and factors that interfere with and prevent the successful establishment of young trees (e.g., excessive deer feeding on desirable young trees and unchecked competition from both non-native invasive plants and native interfering vegetation). The process of deterioration caused by these interfering factors will not happen quickly, but is likely to accelerate and compound over time, in some cases by leaps and bounds, becoming ever harder to reverse or even to slow. And it is already happening now. Already now, we experience the substantial effort – through ongoing mowing of forest areas – needed to try to prevent further deterioration of just a mere subset of the total forest (in ca. 50 acres of forest around the Water Treatment Plant). All of these aspects of the forest are summarized and discussed in the present Forest Stewardship Plan, along with a set of management recommendations. The focus of forest management in the coming 10 years will be twofold. On the one hand, efforts will be made to slow and where possible reverse the progressive deterioration of current forest conditions. On the other hand, efforts will be made to protect the biodiversity that is already present now and which will be needed in the future to adapt not only to the continued harmful impacts of introduced pests, pathogens and diseases, but also to climate change.

Forestwide overview of watershed forest components

For purposes of this Forest Stewardship Plan, the current condition of the watershed forest was assessed as it relates to the key water quality functions. Important aspects of the forest condition are its vertical structure, species composition, any known or anticipated threats, and any expected trends. The assessment of the forest was carried out at three levels. The present section looks at the entire forest as a whole, through a forestwide lens spanning the forests of both the Mountain Street watershed and the Ryan and West-Whately watershed. The next section looks at the two watershed forests separately and contrastively with each other. The forest is assessed at a still finer scale in the Stand Descriptions section of this plan.

Components of vertical structure

The term vertical structure as used in this Forest Stewardship Plan refers to the combination of the forest overstory, the midstory, and the forest floor environment.

Forest Overstory

Key data about the forest overstory such as species, abundance, numbers and sizes of trees, amount of wood, etc. is presented in **Forestwide Overstory Tables 1-3**. These tables will be referred to in the course of the discussion below, but may warrant a separate examination for orientation purposes. The tables are as follows:

- Forestwide Overstory Table 1 – Basic forest parameters
- Forestwide Overstory Table 2 – Species presence and abundance
- Forestwide Overstory Table 3 – Wood volumes

Hardwood-softwood mix

The overstory canopy is typically comprised of a mix of hardwoods (broadleaved trees such as oaks, maples, birches) and softwoods (needle-bearing evergreens, mainly

hemlock and white pine). A hardwood-softwood mix was present at 84% of plots. The remainder of plots (16%) are pure hardwoods. Though there can be small groves of pure softwood, there were no plots that were purely softwood. The diversity of species is discussed in detail in the Species Composition section below.

Canopy structure

At this time, the watersheds are principally covered by an overstory of large, tall trees that generally forms either a completely closed-canopy or a closed-canopy with small openings. This was the case at about 97% of plots (see Table: Forest canopy at plots), or over 3,000 acres. A little more than 2/3 of the mature forest is a tall, closed-canopy forest with layers (at 68.9% of all plots). Other configurations include tall, closed-canopy forest with no layers (11.0% – usually due to dense hemlock shade), mature forest with small openings (openings ≤ 1/3 acre) (12.9%), and mature forest with larger openings (openings >1/3 acre) (4.1%). Canopy openings were mainly associated with natural disturbance (blowdown) or logging since 2014.

Table: Forest canopy at plots		
Status	Acres	% of plots
Mature Forest	3074.2	96.9%
Mature-closed canopy no layers or minimal layers	349.3	11.0%
Mature-closed canopy w/ under- or mid layers	2185.9	68.9%
Mature irregular canopy small openings	409.2	12.9%
Mature irregular canopy large openings (>1/3 ac)	129.8	4.1%
Tall closed-canopy REGEN (>30')	0.0	0.0%
Uniform or patchy early-successional trees (<30') or shrubs	0.0	0.0%
Shrubby wetland, marsh, etc.	10.0	0.3%
Red pine deteriorating	20.0	0.6%
Mowed open forbs or mowed woodland	69.9	2.2%
	3174.0	100%

Canopy height

The overstory canopy is typically 50 to 100 feet tall (80% of plots) or taller (18% of plots had trees > 100' tall, always due to white pines). Very few plots (< 2%) had canopies less than 50' tall. See Table: Canopy height at plots.

Table: Canopy height at plots (feet)

Status	% of plots
>100'	18.2%
50-100'	80.2%
20-50'	1.3%
<20'	0.3%
	100%

Number and size of trees

A key attribute of the watershed forest is that there are a lot of trees. In all, there are about 297 trees per acre. This equates to roughly 900,000 trees on about 3,000 acres. The diameter of trees measured at the plots ranged from 2” to 58” – see Table: Size of trees. As is typical of forests in the region, most of the trees are comparatively small and relatively few are quite large. About half of the trees (51%) are ≤ 6 ” in diameter (see “running total” column). About 91% of all trees are ≤ 16 ” in diameter. Only about 1% of all trees were 25” in diameter or larger. The forestwide average diameter was 9.8 inches – see Table: Canopy status of trees at plots, further below.²

²quadratic mean average

Table: Size of trees

Diameter (inches)	Trees per acre	% of total trees per acre	running total % of trees per acre
2	34.6	11.6%	11.6%
3	33.3	11.2%	22.9%
4	25.9	8.7%	31.6%
5	24.9	8.4%	40.0%
6	32.7	11.0%	51.0%
7	17.9	6.0%	57.0%
8	17.3	5.8%	62.8%
9	14.8	5.0%	67.8%
10	13.4	4.5%	72.3%
11	14.1	4.7%	77.0%
12	11.7	3.9%	81.0%
13	11.1	3.7%	84.7%
14	8.2	2.8%	87.5%
15	6.6	2.2%	89.7%
16	4.9	1.6%	91.3%
17	4.2	1.4%	92.7%
18	5.3	1.8%	94.5%
19	2.7	0.9%	95.4%
20	2.6	0.9%	96.3%
21	2.6	0.9%	97.1%
22	1.6	0.5%	97.7%
23	1.3	0.4%	98.1%
24	1.1	0.4%	98.5%
25	1.3	0.4%	98.9%
26	0.6	0.2%	99.1%
27	0.6	0.2%	99.4%
28	0.4	0.1%	99.5%
29	0.3	0.1%	99.6%
30	0.4	0.1%	99.7%
31	0.2	0.1%	99.8%
32	0.2	0.1%	99.8%
33	0.2	0.1%	99.9%
34	0.08	0.0%	99.9%
35	0.08	0.025%	99.937%
36	0.04	0.012%	99.949%
38	0.02	0.005%	99.955%
39	0.03	0.010%	99.965%
40	0.07	0.024%	99.989%
43	0.02	0.008%	99.998%
58	0.01	0.002%	100.000%
Stand Total	297.2	100.0%	

Canopy status and size of trees

In the systematic sampling process, a total of 1,239 trees were measured at a total of 318 plots. Each tree measured at a plot was assigned a canopy status as follows: dominant, co-dominant, suppressed, viable regeneration or snag (i.e. standing dead). Of the 297 trees per acre, about 37 trees per acre are dead, leaving about 260 live trees per acre – see Table: Canopy status of trees at plots, a & b. To put this in perspective, this equates to roughly 800,000 live trees and more than 100,000 dead trees on about 3,000 acres. The ratio of live to dead trees is similar to that for other forests in the region, with about 13% of all trees being snags. Over time, snags will naturally tend to fall and join the forest floor environment as coarse woody debris (see discussion of coarse woody debris below).

The forest canopy contains about 110 dominant and co-dominant trees per acre.³ Only 15 of these trees are dominant, while the remaining 95 are co-dominant (i.e. trees growing tightly with other trees, sometimes shaded on all sides and only free to grow above). Not surprisingly, the dominant and codominant trees tend to be larger than the forest-wide average, with the dominant trees being the largest. The dominant trees averaged 17.2” in diameter compared to 12.7” for codominant trees, 5.9” for suppressed trees, and 2.7” for viable regeneration. Snags were similar in size to the forestwide average, suggesting that mortality is proportionally distributed across size classes (i.e., mortality is not disproportionately concentrated in small trees, live trees, etc.). About half of all live trees are suppressed, and about half of these – or, about ¼ of all live trees – are (shade-tolerant) suppressed hemlock and beech. It is normal for a lot of trees to be suppressed as, over time, competition between trees leads toward a forest of fewer, larger trees. This is especially true when, as is the case here, there are an appreciable number of hemlock or beech trees, which can form part of a long-lived midstory of trees beneath the shade of a tall canopy.

³ As used here, a dominant tree is free to grow on ≥ 2 sides, a co-dominant tree may only be free to grow on one side but, in any case, is not overtopped. A suppressed tree is completely overtopped. Viable regeneration refers to regeneration that is not overtopped or is sufficiently shade tolerant to survive indefinitely under prevailing conditions. A snag is any standing dead or very-nearly dead tree. By definition, a co-dominant tree is crowded as judged in the field.

Table: Canopy status of trees at plots

(a) Tree Status including snags	Basal area (ft ² /ac)	% of total Basal Area	Trees per acre	% of total trees per acre	Size (average diameter - quadratic mean) (in.)
Dominant	25	16%	15	5%	17.2
Co-dominant	84	54%	95	32%	12.7
Suppressed	27	17%	139	47%	5.9
Viable regeneration	0	0%	10	3%	2.7
SNAG	19	12%	37	13%	9.7
Total	156	100%	297	100%	9.8
(b) Tree Status - Live trees only	Basal area (ft ² /ac)	% of total Basal Area	Trees per acre	% of total trees per acre	Size (average diameter - quadratic mean) (in.)
Dominant	25	18%	15	6%	17.2
Co-dominant	84	62%	95	37%	12.7
Suppressed	27	20%	139	54%	5.9
Viable regeneration	0	0%	10	4%	2.7
Total	137	100%	260	100%	9.8

Wood volume

The forest canopy contains an appreciable amount of wood volume in the stems – see Table: wood volume at plots. Seen in terms of traditional roundwood products, the forest contains over 10,000 board feet of timber *per acre*, on average, with, additionally, over 16 cords of hardwood firewood, softwood pulp, and rough cavity tree sections per acre. These numbers do not include additional wood volume in tree tops and branches, crooks and other unmerchantable sections of lower stems, and both coarse and fine roots. Snag volume was also not computed. The substantial amount of wood growing and accumulating above and below the ground is one of the distinctive attributes of a forest that helps enable its water quality functions.

Table: Wood volume of live trees at plots

Tree status	Basal area (ft ² /ac)	Trees per acre	Size (average diameter - quadratic mean) (in.)	Board feet per acre (bf)	Stemwood cords per acre
Dominant	25	15	17.2	3,829	2.5
Co-dominant	84	95	12.7	6,212	11.6
Suppressed	27	139	5.9	85	2.4
Total	136	250	10.0	10,126	16.6

Forest Midstory

The term midstory as used here refers to relatively long-lived or persistent woody plants that are able to thrive or at least survive in the shade of the taller overstory. The midstory provides many of the same water quality functions as the overstory, though at a smaller scale, and potentially provides important and immediate redundancy in the case of disruptions to the taller canopy. Throughout much of the forest there is a scattered midstory layer of native trees or tall shrubs beneath the overstory.

Very shade-tolerant trees in the midstory: hemlock and beech

Hemlock and beech play the most prominent role in the midstory. Midstory hemlock is present at 78% of plots and abundant at 52% of all plots – see Table: Abundance of Midstory Hemlock and Beech. Midstory beech is present at 75% of plots and abundant at 47% of all plots. Midstory beech and hemlock often *co-occur* (58% of all plots), and in most cases there is at least some presence of either midstory beech or hemlock (94% of plots). Note: the role played by hemlock and beech could be reduced in the future due to pests and pathogens – see the section on “Threats” below. Very rarely, there was a midstory presence of red spruce or balsam fir (each < 1% of plots).

Table: Abundance of Midstory Hemlock and Beech

Abundance Level	% of Plots			
	Hemlock	Beech	Hemlock and Beech	Hemlock and/or Beech
PRESENT (>0)	78%	75%	58%	94%
ABSENT (=0)	22%	25%	42%	6%
RANK/LEVEL1	25%	28%		
RANK/LEVEL2	52%	47%		
RANK/LEVEL3	0%	0%		

Other trees in the midstory

Altogether, there are about 139 suppressed trees per acre. About half of these are beech and hemlock, which, though suppressed, can persist indefinitely in the shade. Additionally, a number of other tree species can be found in the midstory. Half of these non-beech and non-hemlock midstory trees are black birch and red maple which, in many cases, are in a state of decline due to being suppressed and are on track to become snags.

But some of the midstory trees appear to have some level of ability to persist in the shade, if perhaps not as reliably as beech and hemlock. These include yellow birch, red and sugar maple, hophornbeam and white pine, with trace levels of shagbark and bitternut hickory.

Regeneration

In many cases there is a small amount of *potentially* viable tall regeneration (tall seedlings or saplings) (43% of plots) that is currently serving functionally in a midstory capacity – see Table: Regeneration abundance. Most of this regeneration occurs either as a single sapling/seedling (21% of plots) or along with a few other saplings/seedlings in small gaps in the canopy (19% of plots). At a small number of plots (3%), regeneration forms an overstory in large gaps within a two-aged structure in the midst of scattered taller residual overstory trees. These areas are associated with logging since 2014. The species diversity of regeneration is further discussed in a section below. Note that given the largely closed-canopy of the watershed forest, it is not unexpected to find low levels of established regeneration. Of particular interest is how the forest responds to disturbance. This is discussed in the *Future forest trends* section (see gap process failure).

Table: Regeneration abundance (% of plots)

Status	Description	Regeneration abundance	Red oak seedlings
PRESENT (>0)	Present	43%	31%
ABSENT (=0)	0 = None	57%	69%
RANK/LEVEL1	1 = one or a few individuals is free to grow in a single-tree gap	21%	31%
RANK/LEVEL2	2 = regeneration is abundant in a several-tree gap or small group	19%	NA
RANK/LEVEL3	3 = regeneration forms an overstory in large gaps in 2-age structure with scattered taller residuals	3%	NA
RANK/LEVEL4	4 = regeneration forms the entire overstory or nearly so (with very few or no residuals)	0%	NA

Native shrubs (non-interfering)

Desirable native shrub and small tree species were present at 50% of all plots – see Table: Native shrub structure. Though many of these shrubs were small (or even very small) in stature due to age, shaded conditions, browsing impacts, or some combination thereof, any presence of a desirable native shrub was counted. This reflects the potential positive contribution that these shrubs may make going forward. Some shrub and small tree species seem able to grow taller under the current circumstances of shade, browse, etc, including ironwood, musclewood, winterberry and spicebush. One or more of these potentially taller shrubs was present at about half of all plots with shrubs (25% of all plots). The diversity of shrub species is further discussed in a section below.

Abundance level	Description	Non-interfering native shrubs	Mountain laurel	Striped maple	Witch hazel	Mtn and/or striped and/or witch
PRESENT (>0)	Present	50%	39%	41%	22%	74%
ABSENT (=0)	Absent	50%	61%	59%	78%	26%
RANK/LEVEL1	Minor presence		18%	28%	13%	
RANK/LEVEL2	Moderate to abundant		20%	11%	8%	
RANK/LEVEL3	Significant, overwhelming		1%	1%	1%	

Native shrubs (often interfering)

There is a second group of native shrubs and small trees that is also able to grow to a large size but which is listed separately here. These species (mountain laurel, striped maple and witch hazel) play a dual-role in that they both provide structure that contributes to the water quality functions of the forest in the shorter term but interfere with the perpetuation of tall tree establishment and species diversity in the longer run. Though native, these shrubs are therefore referred to as “interfering” in the section on threats below. Indeed, these shrubs are more abundant than the native, non-interfering shrubs. One or more of these species was present at 74% of all plots, with striped maple present at 41%, mountain laurel present at 39% and witch hazel present at 22% of all plots.

When taken altogether, between midstory hemlock and beech, other tree species, tall regeneration, native shrubs and native interfering shrubs, there is a woody midstory presence of some kind or other at about 99% of all plots (calculation not shown).

Forest Floor Environment

Key elements of the forest floor environment include low vegetation, scattered pieces of coarse woody debris, and a covering of leaf litter.

Low vegetation

Low vegetation (excluding seedlings of shrubs, hayscented fern, and non-native invasive plants, which are discussed elsewhere) was present at most of the plots (79%), though only abundant at about 26% of all plots. The overall modest abundance of low vegetation is presumably a result of both ongoing deer browse and over- and midstory shade and is not an inherent feature of the soil or site.

Leaf litter

Leaf litter protects the soil from extremes of temperature change and drying, as well as from the direct impact of raindrops. It is likely that thick leaf litter reduces the quantity of seeds that germinate, including seeds of non-native invasive plants. There was generally a thick layer of leaf litter covering the soil (at 88% of all plots), but at 12% of the plots the leaf litter was thinner, with some of the soil exposed. The cases of thin leaf litter were typically associated with richer soil conditions that promote faster leaf litter breakdown.

Coarse woody debris

Coarse woody debris refers to large, fallen sections of a tree that lie on or near the forest floor (as opposed to snags, which are upright dead trees). Coarse woody debris contributes to water quality functions in a number of ways, including potentially slowing overland flows of water and thereby increasing infiltration. Over time, coarse woody debris contributes to increased infiltration capacity through decomposition. Coarse woody debris in streams plays a unique role in holding back organic matter and forming pools. It goes without saying that coarse woody debris is only created at a site when there are large trees present. Coarse woody debris (in excess of 6" thickness) was common, with an average of 7-8 pieces of separate origin seen at or near any plot, but with a highly variable range of 0 – 25 pieces.

Species composition and diversity

The complex vertical structure of the forest described above, and the water quality functions it provides, are enabled through the ongoing and differential establishment, growth, survival and perpetuation of a variety of tree, shrub and other plant species. If the structure is the construction design, the species are the building materials.

Overstory composition

The overstory consists of 31-33 tree species – see **Forestwide Overstory Tables 1 & 2**. Of these, 11 species are currently common – see Table: Overstory species diversity. An additional 17-19 species are present but are, to varying degrees, are currently uncommon.⁴ An additional three species occur only in softwood plantations. A total of four shade-tolerant species were tracked both as overstory trees and, separately, as midstory trees (and are not counted twice in the total number of species). White pine

⁴ Balsam fir was only observed as a midstory tree, and tulip poplar was only observed as a stout, tall sapling, and so the observed number of confirmed uncommon species in the *overstory* is technically only 17.

occurs both naturally in the forest and in plantations but is not listed separately here as a plantation species.

Mini-Table: Overstory Species Diversity
(# of species)

Diversity group	No. of species
Common	11
Uncommon	18
Plantation	3
Total	32
Common midst.	2
Uncommon midst.	2
Total	4

Note: Species labeled "midst." (midstory) also occur in the overstory and are not counted twice toward the total number of species.

Across the forest as a whole, there are, on average, about 6 species present in any given location (i.e., the average number of species seen at or within sight of any plot was 6.16, with a range of 1-11 species seen in any one place) – see Table: Number of species present at plots. Not surprisingly, the species at each plot tend to be the common species (average count = 5.75 “species” per plot). At least one common species was present at every plot – see **Map - Diversity of Common Overstory Species**. Also not surprisingly, uncommon species were absent as a whole from most plots (absent from 73% of plots). Plantation species contributed in only a minor way across the forest as a whole, being detectable at only 3% of plots.

Mini-Table: Number of species present at plots

	All Overstory species	Common overstory species	Uncommon overstory species	Plantation species
Average Count of Species	6.16	5.75	0.37	0.03
% of plots present	100%	100%	27%	3%
% of plots absent	0%	0%	73%	97%
Max	11	10	4	2

Common overstory species

The eleven overstory species which, based on data gathered and presented here, are considered common, are as follows: white pine, black birch, hemlock, red maple, red oak, sugar maple, paper birch, yellow birch, white ash, beech, and black cherry.

The common overstory species (together with their two midstory variants, midstory hemlock and midstory beech) account for 96% of the total basal area, 95% of the live trees per acre, and 96% of the total wood volume (as measured in cord-equivalents) – see columns a & b in **Forestwide Overstory Table 1** and see column a in **Forestwide Overstory Table 3**.

Among the common overstory species, five species (white pine, black birch, hemlock, red maple, red oak), together with midstory hemlock, account for 75% of basal area, 66% of trees and 80% of wood volume. Individual parameters for each species can be seen in **Forestwide Overstory Tables 1 & 2**.

Black birch and red maple are the most *widely occurring* overstory species, being *present* at about 80% of all plots – see column a in **Forestwide Overstory Table 2** – while red oak, white pine and hemlock were somewhat less likely to be present (seen at 69%, 61% and 49% of all plots, respectively).

Black birch stands out as the species most likely to be *abundant* in the overstory at any given plot (it was *abundant* – with ≥ 6 individuals seen – at 47%, or about half, of all plots – see column b in **Forestwide Overstory Table 2**. Black birch was followed in abundance by white pine (abundant at 35% of plots) and then by red maple, red oak and hemlock (26%, 25% and 21%, respectively).

The other common species – sugar maple, paper birch, yellow birch, white ash, beech, and black cherry – were each *present* at 31% to 45% of all plots, but were *abundant* at only 5% - 10% of all plots.

Based on the variety of findings presented above, it is reasonable to conclude that, currently, these eleven common overstory species drive the lion's share of the tree-related water quality functions provided by the watershed forests.

Uncommon species in the forest overstory

In addition to the common species, there is a remarkable diversity of uncommon tree species in the watershed forest, including four additional species of oak, three species of hickory, pitch pine, red spruce, bigtooth poplar, basswood and other species. By definition, these species are currently less prevalent than the common species – see Overstory composition Tables 1 & 2 for a complete list. Uncommon species are found across the forest in an irregular distribution that ranges from areas lacking uncommon species altogether to larger, extended runs of uncommon species – see **Map - Presence and Abundance of Uncommon Overstory Species**.

Living up to their designation as *uncommon*, all of these species taken together account for only about 3% of total basal area, 5% of total live trees, and 2.8% of total wood volume – see columns a & b in **Forestwide Overstory Table 1** and see column a in **Forestwide Overstory Table 3**.

Bitternut and shagbark hickory are the most *widely occurring* of the uncommon species, with a *presence* at about 8% and 6% of all plots, respectively – see column a in **Forestwide Overstory Table 2**. Chestnut oak, bigtooth poplar, scarlet oak, white oak, pignut hickory and basswood were also sometimes observed at plots, being present at 2% - 4% of plots. Other species such as pitch pine, red spruce, and elm were half again as uncommon, being present at less than 1% of plots in most cases.

The plot-level data described above provides a systematic, non-biased sample of the rates of occurrence of uncommon species. In order to not lose sight of these infrequent species, it seemed worthwhile to accord them special attention whenever they were encountered outside of the systematic sample plots. In such cases, and with perhaps a few exceptions, GPS points and notes were taken. A partial summarizing of this data is presented in column (d) in **Forestwide Overstory Table 2**. On this as-encountered bases, bitternut hickory was the most frequently seen, and was observed (either as a single tree or as a group of trees) 130 times. Shagbark hickory was observed 66 times, both chestnut oak and pignut hickory were observed 59 times and ironwood was observed 56 times. Pitch pine was observed 37 times and white oak was observed 34 times. By contrast, red spruce (in the overstory) was observed only 9 times, and cottonwood was observed 3 times, and black ash and sassafras were observed only once in the overstory. Tulip poplar is listed as having one occurrence in the overstory, but it is more correct to note that this was actually a tall, stout sapling growing on the edge of Grass Hill Road.

Despite their current low rate of occurrence and the low abundance, the uncommon species are a real presence in the forest. Importantly, the uncommon species add valuable diversity to the current forest and hold significant promise for future resilience and adaptation. This potential may be especially important as pests and pathogens attack species that are currently common (e.g., hemlock, white pine, ash, beech, etc.) and as the changing climate becomes potentially less suitable to some of the common species (while potentially becoming more suitable to some of the uncommon species).

Plantation species

Though the remaining plantations of red pine, Norway spruce and Scots pine are impressive in the amount and size of large trees they contain, the plantations are limited in extent and currently play a limited role in the overall water quality functions of the forest. Indeed, due to their tendency to become overrun with non-native invasive plants, the plantations are at risk of becoming non-native invasive plant hotspots and thus constitute an elevated liability. Altogether, the plantations currently comprise about 0.9% of the total basal area, 0.37% of the live trees, and 1.2% of the wood volume – see columns a & b in **Forestwide Overstory Table 1** and see column a in **Forestwide Overstory Table 3**. It should be noted that, in response to an anticipated wave of red pine mortality, the extent of the plantations has been significantly reduced through salvage logging and conversion to mowed savanna and field since the previous Forest Stewardship Plan – see **Figure 4: Watershed forest areas maintained by mowing as a partial response to non-native invasive plants**.

Regeneration diversity

At more than half of all plots (56.5%), no viable regeneration was observed. At the 43.5% of plots where potentially viable regeneration was observed, a total of 17 species were found – see Table: Regeneration presence and abundance by species. Typically, there was either one, two or sometimes three species present (24% of all plots had one species, 10% of all plots had two species, 6% of all plots had 3 species). On rare occasions there were four or as many as five different species of regeneration at a given plot.

Black birch is the most common regeneration species: it occurred at 24% of all plots and accounted for 33% of all occurrences of regeneration. Surprisingly, sugar maple was the second-most common regeneration species, occurring at 11% of all plots, and accounting for 15% of all occurrences of regeneration. Beech, red maple, hemlock, white pine and yellow birch followed in decreasing order, ranging from a 9% down to a 3% occurrence rate (i.e. occurring at as little as 3% of plots). Together, the aforementioned species (black birch through yellow birch) account for 92% of all regeneration occurrences.

Ten species make up the remaining 8% of all regeneration occurrences, a list that includes three hickories, two oaks (red and chestnut), as well as white ash, paper birch and black cherry. While the hickories and chestnut oak belong to the group of less-common overstory species, red oak, white ash, black cherry and paper birch belong to the common overstory species. In particular, red oak is present in the overstory at 69% of all plots, and so it is interesting to note that viable red oak saplings or large seedlings are only established at a mere 0.9% of all plots. Curiously, and in stark contrast to this, short red oak *seedlings* are one of the most common species of low vegetation (present at 31% of all plots). For reasons discussed in this Forest Stewardship Plan, these seedlings rarely go on to become tall, established plants (see discussion or *browse* in the section on *threats*).

Table: Regeneration presence and abundance by species

Category	PRESENT	ABSENT	LEVEL1	LEVEL2	LEVEL3
Regeneration presence and abundance*	43.5%	56.5%	21%	19%	3%
Regeneration presence and abundance*	42.8%	57.2%			
Regeneration not including beech or hemlock	39.6%	60.4%			
Black Birch	24.2%	75.8%			
Sugar Maple	11.0%	89.0%			
Beech	8.8%	91.2%			
Red Maple	7.2%	92.8%			
Hemlock	7.2%	92.8%			
White Pine	4.1%	95.9%			
Yellow Birch	2.8%	97.2%			
Hickory Bitternut	2.2%	97.8%			
Hickory Pignut	1.3%	98.7%			
Ash	1.3%	98.7%			
Oak_Red	0.9%	99.1%			
Cherry	0.9%	99.1%			
Paper Birch	0.3%	99.7%			
Oak Chestnut	0.3%	99.7%			
Red Pine	0.3%	99.7%			
Hickory Shagbark	0.3%	99.7%			
Chestnut	0.3%	99.7%			

* Regeneration presence was tracked by two methods; the two results are close but not identical.

Shrub diversity

A total of 22 species (or species groups) of desirable native shrub and small tree species were observed at the systematic plots. At least one of these species was present at about half of all plots – see Table: Presence of desirable native shrubs by species. In some cases, as many as five species of desirable native shrub were visible at a single plot. No individual shrub species was particularly abundant; no single species was observed at more than 18% of the plots. Ironwood and maple-leaved viburnum were the most abundant, followed by spicebush and lowbush blueberry, shadbush, winterberry and blackberry/raspberry. Many of the shrubs were quite uncommon, of the 22 species, 14 species occurred at less than 2% of all plots.

Table: Presence of desirable native shrubs by species

Species	% of Plots at which PRESENT	% of Plots at which ABSENT
At least one species	49.7%	
Ironwood	17.6%	82.4%
Maple-leaved viburnum	17.3%	82.7%
Spicebush	10.4%	89.6%
Lowbush blueberry	9.1%	90.9%
Shadbush spp.	7.9%	92.1%
Winterberry	6.0%	94.0%
Blackberry/raspberry	5.7%	94.3%
Musclewood	3.5%	96.5%
Red elderberry	1.6%	98.4%
Highbush blueberry	1.6%	98.4%
Spirea spp.	1.6%	98.4%
Beaked hazel	1.6%	98.4%
Mountain maple	0.9%	99.1%
Chestnut sprouts	0.9%	99.1%
Hobble bush	0.9%	99.1%
Alternate-leaved dogwood	0.9%	99.1%
Northern arrowwood	0.6%	99.4%
Speckled alder	0.6%	99.4%
Wild raisin	0.6%	99.4%
Canada honeysuckle	0.6%	99.4%
Red currant	0.6%	99.4%
Hawthorn spp.	0.6%	99.4%

Total = 22 species

Diversity of low-growing vegetation

The term low-growing vegetation, as used here, refers to plants growing close to the ground. There was a broad variety of species in this category. Christmas fern and evergreen woodfern were quite abundant (present at 74 and 75 plots, respectively). Partridgeberry (37 plots), Canada mayflower (32 plots), various sedges but not including broad-leaved sedge (30 plots), clubmosses (26 plots), poison ivy (18 plots) and wintergreen (11 plots). Broad-leaved sedge – an indicator of rich mesic conditions – was present at 4 plots.

Interestingly, short red oak seedlings (generally about 6” tall or less) were observed at more plots than any other desirable understory plant, being present at 99 plots (31% of all plots). As noted previously, this stands in stark contrast to the distribution of tall red oak seedlings or saplings, which were present at just 0.9% of all plots.

Summary of forest structure and composition

In summary, in its current condition the watershed forests is remarkably well-suited – both in terms of structural complexity and species diversity – to provide the water quality functions essential to the maintenance and operation of a public surface water supply. If this forest or a comparable forest could be maintained going forward, DPW’s water-supply interests would be very well served.

Threats: factors that interfere with the perpetuation of desirable forest conditions

As was the case in the 2012 Forest Stewardship Plan, a number of factors have been identified that are already having a negative impact on the forest or are likely to do so in the future. The ongoing and in some cases compounding impact of these factors will continue to have a negative effect both on the current forest and will undermine the ability of the forest to respond to and adapt to these changes. These negative impacts are listed below, in no particular order:

- The harmful effects of insect pests (such as hemlock wooly adelgid) and diseases (such as white pine needle disease) on existing and future trees
- The harmful effects of excessive browse impacts on young trees, shrubs and other low vegetation
- Aggressive competition from certain native vegetation (interfering native vegetation such as hayscented fern)
- Aggressive competition from non-native invasive plants (such as oriental bittersweet)
- The potential arrival of other types of non-native organisms (aggressive earthworms)

The combined upshot of these factors will be to undermine the ability of the forest to maintain the type of complex structure and diverse mix of species described in the sections above. Some of these factors may be made worse by expected changes in the climate. Indeed, as the forest is faced with a range of harmful impacts from climate change, the factors described above will limit and curtail the forest’s ability to remain resilient and adaptive.

Major introduced pests, pathogens and diseases by host species

An increasing number of introduced pests, pathogens and diseases are affecting the trees of the watershed, compromising their health or causing outright mortality. Many of these introduced pests, pathogens and diseases tend to act primarily on a single species. Tree species that are currently being impacted in a significant way by introduced pests, pathogens and diseases – or could soon be impacted – comprise about more than half of all live basal area and a little less than half of all live trees – see **Table: Basal area and trees-per-acre of tree species affected by significant introduced pests, pathogens and diseases.**

Table: Basal area and trees-per-acre of tree species affected by significant introduced pests, pathogens and diseases

Species	LIVE Basal Area (BA) Per Acre (sq ft)	% of total LIVE BA	Live trees per acre	% of Live trees per acre
Ash white	3.3	2.4%	4.3	1.6%
Beech	3.0	2.2%	8.1	3.1%
Beech (midstory.)	1.6	1.2%	17.7	6.8%
Hemlock	10.1	7.4%	6.9	2.7%
Hemlock (midstory.)	13.5	9.9%	47.7	18.4%
Oak chestnut	0.6	0.5%	0.7	0.3%
Oak RED	16.4	12.0%	9.2	3.6%
Oak white	0.1	0.1%	0.1	0.03%
<i>Pine red</i>	0.9	0.6%	0.7	0.3%
Pine WHITE	26.5	19.4%	13.6	5.2%
Total	76.0	55.6%	109.1	42.0%

The discussion of introduced pests, pathogens and diseases that follows is organized by the sole or primary species of host trees that are impacted.

White ash (currently 2.4% of all live basal area, 1.6% of all live trees)

Ash (primarily white ash) is already being impacted by emerald ash borer, which continues to spread across Massachusetts and is expected to cause near-total mortality in all species of ash for all ash trees larger than seedling size. Emerald ash borer was first detected in the active watershed in January, 2022 (Poplar Hill in Conway). An example of dead ash trees is shown in **Figure 6: Gap Process Failure Example 2: Loss of overstory shade (due to a pest, emerald ash borer) with unchecked rampant growth of oriental bittersweet**. The emerald ash borer has already devastated ash as it has emanated toward Massachusetts from its continental epicenter in Michigan. Though white ash is not one of the most prominent tree species in the DPW watershed forests, it is especially prevalent in moister or wetter areas such as riparian corridors and wetlands and on richer slopes and thus plays an elevated role in water quality protection. There is no expectation that any area of ash will be spared, though it is possible that a very small percentage of ash trees may possess resistance to emerald ash borer.

Beech (currently 3.4% of all live basal area, 9.9% of all live trees)

Beech has long been subject to an ongoing and apparently permanent infestation by beech bark disease, a canker-forming disease complex that results when beech scale insects feed on the bark and create small cracks that are then infested by one or more species of nectria fungus, causing mild to extreme cankering and in some cases death. Very few beech trees are unaffected. The upshot has been that very few beech trees will

grow to a large size and be healthy. Some, however, will do so. This will be apparent if their bark is “clean” rather than riddled with cankers. Often, infested trees do not die outright, but instead send up a lot of shoots from their root systems, creating thickets of trees that will, in turn, become diseased. Despite the beech bark disease, beech has been able to survive as a midstory tree, which, with its canopy layering, substantial root system, and abundant leaf litter, allows it to make an appreciable contribution to the overall water quality functions of the forest. However, a new health problem is now affecting beech, especially midstory beech: beech leaf disease. Beech leaf disease is caused, apparently, by a nematode feeding inside the dormant leaf bud, causing the leaves to emerge with varying degrees of deformity or even to fail to emerge. The nematode is apparently spread by birds. It has been spreading very rapidly through Massachusetts, and was first observed in the DPW watershed forest in October, 2022, in Williamsburg (RWW Stand 4, near the Henhawk Trail). Though it is still early in the process, the prognosis for beech right now is not good: beech leaf disease is already causing outright mortality in midstory beech trees. At the time of data gathering for this Forest Stewardship Plan, no severe beech leaf disease was observed, though it there were early indicators of an incipient infestation.

Hemlock (currently 17.2% of all live basal area, 21.1% of all live trees)

Hemlock appears likely to continue to undergo, a general and ultimately precipitous decline due to the introduced insects hemlock woolly adelgid and hemlock elongate scale. The insect damage is most evident in the thin crowns of hemlock to which we have become accustomed. In recent years, hemlock has had ups and downs, with crowns becoming thinner then thicker again over a course of years. Insect-caused mortality in hemlock had been expected to be much greater by now than it actually is – and it is still possible that many hemlocks will survive, albeit with a lower degree of growth and vigor. It is possible that cold snaps in winters have prevented hemlock woolly adelgid – which is cold sensitive – from causing greater decline and mortality to date. However, by the same token, it is possible that a warming climate will result in less winter-kill of hemlock woolly adelgid, leading to an intensification of adelgid impact. We simply do not know how this will play out.

Oaks (currently 12.5% of all live basal area, about 3.9% of all live trees)

There is always a risk of a recurrence of an insect traditionally known as the gypsy moth and currently known as the spongy moth. This defoliating insect impacts a variety of trees species but **all species of oak** in particular. These outbreaks can cause multiple, successive years of complete defoliation, which is detrimental to tree health. A nearby outbreak occurred most recently in the 2016-2018 timeframe around the nearby Quabbin Reservoir and in towns further east, causing mortality in up to 1/3 of the oaks over large areas (with considerable variability within smaller areas). As successively defoliated trees enter a dramatic phase of mortality, this is accelerated by secondary pathogens such as shoestring root rot, two-lined chestnut borer, and red oak borer. Ultimately, we rely on fungal and disease factors of the insect itself to cause outbreaks of gypsy moth to crash. Spongy moth last had a major outbreak in the DPW watersheds around 1980. So far, the DPW watersheds have been spared from the current resurgence in spongy moth, and oaks are among the healthier trees at the moment in the watershed – see below the **Table**:

Apparent health of large trees based on mortality rates – though there is no reason to assume that this will remain the case. And there may be fungal pathogens of oaks on the horizon, such as oak wilt (*Ceratocystis fagacearum*), an aggressive pathogen that is spreading in the Midwest.

Red pine (currently 0.6% of all live basal area, 0.3% of all live trees)

Red pine does not tend to occur naturally in the watershed forests and is found almost exclusively in plantations that were established long ago for water quality protection. Red pine was once quite important within the DPW watershed forests, but, by now, red pine has largely been eliminated, either by outright mortality due to the introduced red pine scale, an introduced insect, or by pre-emptive salvage logging in response to red pine scale. Remaining areas of red pine (which are minor in extent) are likely to continue to decline. The loss of the red pine overstory has unleashed a severe infestation of non-native invasive plants in many red pine stands, especially bittersweet, most notably in a 50-acre area around the Water Treatment Plant.

White pine (currently 19.4% of all live basal area, 5.2% of all live trees)

White pine has been, over the past 8 or so years, in the early stages of what may be a protracted decline due to a set of fungi referred to collectively as “white pine needle disease” that causes yellowing, breakage and dropping of needles. In addition, white pine is also being impacted by a fungal canker of the stem (Caliciopsis canker) that causes deformity in the wood and extreme bleeding of sap, especially in the finer branches and upper stem areas with thinner bark. This set of problems is still in the early stages of being understood. The effect, so far, is that, overall, white pines tend to have thinner crowns (i.e., fewer needles, and/or shorter or broken needles) than one would expect, and thus, with less foliage, their growth and vigor is likely to be considerably reduced, and their long-term survival is much less certain that it once was presumed to be. But, as with hemlock wooly adelgid affecting hemlock, there have been ups and downs in recent years. Large seedlings and saplings of white pine can be heavily infested with Caliciopsis canker, which may cause outright mortality and may greatly reduce the ability of young white pines to become established.

Currently OK – Maples and birches

Maples and birches are not currently plagued within the DPW watershed forests by major introduced pests, pathogens and diseases, but could someday be threatened by the ongoing infestation of Asian longhorned beetle. Considered a very serious pest, the Asian longhorned beetle is currently found only in a 6-town area around and north of Worcester, where it was first detected in 2008. A small population in Boston was successfully eradicated in 2014. A gigantic effort has been expended to contain the spread of the ALB around Worcester, and we can all be thankful that it has not spread even further. There is no indication that this insect has been spreading toward DPW lands, but this could change in the future.

How healthy are the current trees?

How healthy are existing trees at the moment? The data gathered for this plan afford a look at the current health of the large (mostly overstory) trees. In looking at mortality in well-established trees (for example, trees $\geq 12''$ in diameter), it seems that some species are experiencing higher rates of mortality at this time – see Table: Apparent health of large trees based on mortality rates. For example, while 8.1% of all trees $\geq 12''$ are midstory hemlock (in this case, large suppressed trees), 14.8% of snags $\geq 12''$ are midstory hemlock. Similarly disproportional mortality rates can be seen for paper birch, red pine, white ash, black cherry and beech. There are undoubtedly a number of reasons for this, including competition (midstory beech), species-level maturity (paper birch), and insect infestation (red pine). White ash has been in a state of decline for some time and now faces the additional impact of emerald ash borer. Beech has been battling with beech bark disease for some time, and black cherry seems to become outcompeted in some cases.

On the other hand, two species seem especially healthy – red oak and sugar maple, as evidenced by their very low rates of mortality at this time. Other species (white pine, hemlock, red maple, black birch, yellow birch) did not have a pronounced trend of being either healthy or unhealthy – at least based on their current rate of snag formation.

Table: Apparent health of large trees based on mortality rates

Species	% of All trees live & dead per acre ≥12" (a)	Snags per acre ≥12"		
		Snags per acre ≥12"	% of snags ≥12" (b)	dbh of snags (in.)
Hemlock midstory	8.1%	1.2	14.8%	13.4
Pine WHITE	17.1%	1.1	14.0%	18.4
Hemlock	10.0%	1	13.0%	18.4
Birch paper	3.9%	0.8	9.9%	13.3
Maple red	10.6%	0.8	9.9%	14.5
Birch black	16.1%	0.7	9.3%	15.9
Pine red	2.1%	0.7	8.5%	14.4
Ash white	3.4%	0.5	6.2%	16.9
Cherry black	1.9%	0.3	4.1%	12
Beech	2.0%	0.3	4.0%	17.2
Oak RED	11.2%	0.1	1.8%	22.4
Oak chestnut	0.7%	0.1	1.7%	13
Maple sugar	8.3%	0.1	1.7%	13
Birch yellow	1.7%	0.1	1.2%	16
Other species	2.9%			
Stand Total	100%	7.8	100%	15.8

Trees highlighted in orange seem to be disproportionately unhealthy (e.g., 3.9% of all trees ≥ 12" are paper birch but 10% of all dead trees ≥ 12" are paper birch). There can be a variety of reasons for this. Trees highlighted in green seem to be very healthy.

As with the rate of snag formation in large trees, there is considerable variation between species in the apparent rate of health of live trees, as classified in the field – see Table: Apparent health of live, large trees based on crowns or stems. Designations of healthy/unhealthy were based on crown thickness (amount of foliage) or in some cases by the degree of rot in the stem. A designation of “unhealthy” (see Methods in the Appendix for the options of tree-level designation of “Apparent health”).⁵ Not surprisingly, most live red pine appeared to be unhealthy (see column a). White ash was also unhealthy (40% of large ash trees were classified as unhealthy). Not surprisingly – yet, nonetheless it is alarming to see – about half of all large hemlock (54%) and about 1/3 of white pine (30%) were classified as currently unhealthy.

⁵ “Apparent health” cannot be determined in an absolute way but was used as a relative measure compared to other trees of the same species. Thus, for example, given the known pests and pathogens that are found in the forest, no hemlock or white pine may be truly “healthy” at this time, but some appear decidedly less healthy than others – such trees were classified as unhealthy.

Red maple was somewhat intermediate, with 9% of its large trees classified as unhealthy. On the other hand, sugar maple, yellow birch, black birch and red oak appear to be quite healthy, with only 1% to 5% of the large trees being classified as unhealthy.

Table: Apparent health of live, large overstory trees based on crowns or stems

Species	Live trees per acre ≥ 12"	Live trees per acre ≥ 12" dbh classified as "in poor health"	% of Live trees ≥ 12" dbh by species in poor health (a)	dbh of trees in poor health (in.)
Pine red	0.7	0.5	74%	13.4
Hemlock	5.5	3	54%	16.9
Ash white	1.8	0.7	40%	13.9
Pine WHITE	9.9	3	30%	21.1
Maple red	6.1	0.5	9%	14.5
Maple sugar	5.2	0.3	5%	16.3
Birch yellow	1	0	4%	24
Birch black	10	0.2	2%	12
Oak RED	7.4	0.1	1%	18
Total	47.6	8.3	17%	

Excessive browse impacts due to deer and moose

The term browse refers to the consumption of young or low vegetation, including wildflowers, native shrubs and young trees, by deer or moose. Though browsing is a perfectly natural activity, when there is an exceedingly large population of browsers relative to the available vegetation, there is an automatic tendency for overbrowsing to occur.

Deer and moose browse preferentially, selecting certain species on which to feed while avoiding other species. When *overbrowsing* occurs, there is often a co-occurring *decrease* in desirable vegetation – including a decrease in the abundance and diversity of young trees and a concurrent *increase* in *undesirable* vegetation (such as hayscented fern or non-native invasive plants – see discussion of these undesirable plants below). The result is a marked shift away from forest conditions that are conducive to water quality functions. In this sense this plan refers to “excessive browse impacts.”

Driven by concerns about excessive browse impacts, the nearby Quabbin Reservoir reversed a long-standing no-hunting policy and instituted a controlled deer hunt over 30

years ago – see the Mass.gov website for information about the role of hunting in managing the Quabbin forest.⁶

With pervasive evidence of heavy browsing activity ubiquitous throughout the watershed, there was no systematic effort to quantify deer or moose browse impacts for the Forest Stewardship Plan. Indeed, it was rare to see any understory plant of a preferred browse species that had *not* been browsed, and it was not even uncommon to see *non-preferred* species that were also browsed, including beech, mountain laurel and oriental bittersweet.

The impact of deer on the development of young trees is demonstrated most clearly by the deer- and moose exclosure experiments in Whately and Williamsburg installed by Harvard Forest staff in 2017. The initial results of these 30'X30' experimental exclosure fences show that protection from browse greatly increases the likelihood that red oak – a preferred browse species of deer and moose – can become established, thrive and grow into the future overstory. With sufficient protection from browse impacts, young red oak trees are more abundant, more vigorous, taller, and appear to be healthier – see **Figures 2s – 2d**.

Native interfering vegetation

This term as used here refers to woody native plants that can aggressively compete with, and often outcompete, other native vegetation (such as tall, native trees) that is decidedly more desirable for and conducive to providing forest-based water quality functions. Native vegetation that is classified here as *interfering* is generally a poor substitute for other native trees and shrubs that can much better form a tall, layered, closed-canopy structure that is so conducive to water quality functions, and it can have a profound impact on the regeneration process but can also limit the maintenance of biodiversity in the understory. In some cases, native interfering vegetation is not preferred by deer or moose, giving it an extra edge in competition against nearby native vegetation. This is most true for hayscented fern, which appears to be avoided altogether, and is also true for witch hazel and mountain laurel, and comes at the expense of oaks, maples, ash, etc. Moose prefer striped maple but deer tend to avoid it; thus, if moose are absent, striped maple can be very competitive in the understory and midstory. The vines of wild grape species can also have a strongly interfering effect, smothering and pulling down young trees (sometimes in conjunction with bittersweet vines). For the purposes of this Forest Stewardship Plan, based on their observed potential to interfere with the establishment and growth of desired tree seedlings, especially in conjunction with high levels of deer and moose browse and the encroachment of non-native invasive plants, a total of five species of native vegetation were classified as native interfering vegetation see column (a) in the Table: Occurrence of Native Interfering Vegetation by Species.

Native interfering vegetation is present across the watershed, with at least one of the five species occurring at 84% of all plots. Only a small percentage of plots (16%) did not have any native interfering vegetation at all – see column (a) in the Table: Occurrence of Native Interfering Vegetation by Species.

⁶<https://www.mass.gov/info-details/quabbin-reservation-deer-hunt>

Individual species of non-native invasive plants tended to be present at 22% to 41% of plots, with witch hazel being the least common, and striped maple being the most common. Generally speaking, about half of the time an occurrence of a native interfering species was noted, it was a minor presence (Rank = 1) and was not having an appreciable impact at that plot. The other half of the time, the native interfering species was found to be having an appreciable impact at the plot (Rank = 2). Infrequently – at about 1% to 3% of all plots – the native interfering species was having an overwhelming impact at the site.

Of the five species listed here as native interfering vegetation, the most troubling, perhaps, are hayscented fern and wild grapes.

Table: Occurrence of Native Interfering Vegetation by Species (% of Plots)

Rank	Mountain Laurel	Striped Maple	Witch Hazel	Hay-scented Fern	Grape Vines	At least one species of native interfering vegetation (a)
PRESENT (>0)	39%	41%	22%	36%	36%	84%
ABSENT (=0)	61%	59%	78%	64%	64%	16%
RANK=1, minor presence	18%	28%	13%	17%	19%	
Rank = 2, having an appreciable impact	20%	11%	8%	16%	15%	
RANK=3, overwhelming impact at plot	1%	1%	1%	3%	2%	

Non-native invasive plants (woody species of vine, shrub and tree)

Non-native invasive plants are widespread in the watershed forest. Data gathering for this plan focused on woody species only. Though non-woody species of non-native invasive plants are present as well (e.g., garlic mustard and Japanese stiltgrass), these tend to occur along roadsides and other highly disturbed areas and have not yet been found within the forest. A total of ten species of non-native invasive woody plant species was observed at systematic plots – see Table: Occurrence of Non-Native Invasive Plants. Oriental bittersweet was by far the most common non-native invasive plant, occurring more than twice as frequently as Japanese barberry and four times as frequently as multiflora rose, and accounting for about half of all occurrences noted, followed by Japanese barberry and multiflora rose. The remaining species ranged from 1 to 9 occurrences each.

Table: Occurrence of Non-Native Invasive Plants (Data Gathered at Systematic Plots)

Species	# of systematic plots (out of 318 plots total) where species occurred	% of all occurrences
Oriental bittersweet	89	50.9%
Japanese barberry	34	19.4%
Multi-flora rose	22	12.6%
Glossy buckthorn	9	5.1%
Honeysuckle	9	5.1%
Winged euonymous	6	3.4%
Autumn olive	2	1.1%
Privet	2	1.1%
Cork tree	1	0.6%
Norway maple	1	0.6%
Total	175	100%

Other species detected on an *as-encountered* basis (but not at any of the systematic plots) include black locust, Japanese knotweed, phragmites, European buckthorn, and garlic mustard.

If there is any good news to be had from this systematic data, it is that most systematic plots did NOT have a presence of non-native invasive plants. Nonetheless, non-native invasive plants were found at 36% of all plots, or in about 1/3 of the forest – see Table: Presence and Severity Rank for Non-Native Invasive Vegetation. This is much higher than a level of zero, which would be the most favorable level for water quality purposes. Furthermore, this rate of occurrence (36% of all plots) is much higher than at two other regional forests for which data on non-native invasive plants was gathered in a similar manner within recent past.⁷

⁷ At the 1,427.9-acre Blair Pond Tract in Blandford, MA, non-native invasive plants were observed at just 5.4% of all 242 systematic plots. See page 70, mini-table: “Severity Rank for Non-Native Invasive Vegetation Blair Pond”, in the Blair Pond Tract Forest Stewardship Plan (owner: the Springfield Water and Sewer Commission) which is on file with DCR.

At the 1,110.8-acre Tom Swamp Tract in Petersham, MA, non-native invasive plants were observed at about 7% of all 123 systematic plots. See page 34, mini-table: “Table N: Severity rank of non-native invasive plants at systematic plots”, in the Tom Swamp Tract Forest Stewardship Plan (owner: Harvard Forest), which is on file with DCR.

At each plot, the *severity* of the non-native plant presence was ranked for the plot as a whole based on the combined abundance of any non-native invasive plant species found there - see Table: Presence and Severity Rank for Non-Native Invasive Vegetation. Non-native invasive plants were considered *extremely minor* at 14% of all plots (see Severity Rank 1). In other words, it is estimated that non-native invasive plants had only a minor presence in 14% of the watershed forest. Meanwhile, non-native invasive plants were considered *minor and readily treatable* (Rank = 2) at 9% of all plots.

At a small number of plots (0.3% of all plots), the presence of non-native invasive plants was so extreme that it in effect constituted the overstory for at least a portion of the plot area. This severity level (Rank = 5) can be thought of as a worst-case scenario because tall trees are lacking from the site and there is little chance that any will grow in the foreseeable future. About 4% of plots were given a severity rank = 4, in which cases there is still a tall overstory of trees but the understory is so dominated by non-native invasive plants that a prospect of desirable native regeneration seems unlikely. Finally, 8% of the plots were assigned a rank = 3 which refers to a situation in which non-native invasive plants are so well established in the understory that there is little prospect of readily controlling them, even though they have not (yet) taken over the understory entirely.

Forestwide, the average *severity rank* across all systematic plots is 0.74 – see **Table: Presence and severity Rank for Non-Native Invasive Vegetation**. One may reasonably ask: of what use is this averaged and somewhat unfamiliar and abstract number? One may further ask, if the scale is 0-5, then isn't a value of 0.74 a good number? There are at least three aspects to an answer to this question.

- First, this averaged severity rank number indicates that the process of infestation by non-native invasive plants is still in a comparatively early phase, which means that the situation could still become (and, indeed, is likely to become) much worse. The watershed-wide average severity rank provides a means to track and quantify change in any direction (improving or worsening) over time.
- Secondly, this averaged number can help put the relative threat of non-native invasive plants in the two separated watersheds (the Mountain Street watershed and the Ryan and West-Whately watershed) into a relative perspective. For example, at this time, the average *severity rank* across all systematic plots for non-native invasive plants at the Mountain Street watershed was 1.71, which is a little *more than three times the average rank of 0.49 for the Ryan and West-Whately watershed* – see **Table: Comparative SEVERITY RANK of non-native invasive plants across the watersheds** in the subsequent section: Comparison of Mountain Street and Ryan and West-Whately watershed forests. Based on these numbers, it is reasonable to conclude that the non-native invasive plant situation is *much worse* at the Mountain Street watershed than at the Ryan and West-Whately watershed.
- Thirdly, this averaged and somewhat abstract severity rank could be used to compare the Northampton watershed forests covered in this plan with other regional forests for which the same severity ranking methods were used. This would provide a better context for assessing the current level of infestation of

non-native invasive plants in Northampton’s watershed forests. For example, in 2023, non-native invasive plants were assessed using the same methodology in two other large tracts in the region. The Forest Stewardship Plans prepared for these forests report a forestwide severity rank of 0.10 and 0.16, respectively, which is substantially lower than the 0.74 forestwide value reported for the Northampton watershed forests.⁸ Here again, based on these numbers, it is reasonable to conclude that the non-native invasive plant situation at the Northampton watershed forests is *much worse* than at these other forests.

Forestwide, the average *severity rank* across all systematic plots for bittersweet is 0.58.⁹ Indeed, of all of the non-native invasive plants currently impacting the watershed forest, oriental bittersweet – with its shade tolerance, viny and tangling growth, shallow and far-reaching root systems, abundant seed production, ability to rapidly resprout both above and below ground, the fact that deer tend to avoid browsing it and the fact that it almost never seems to die – seems likely to have the most deleterious effect on the forest – see **Figure 3: Oriental Bittersweet -- a Non-Native Invasive Plant**. Alarming, bittersweet is present at 28% of all plots, or a little less than 1/3 of the forest. Even worse, bittersweet is already at a difficult if not impossible level to control at roughly 10% of the forest (Ranks 3-5). This confirmation of the widespread extent and severity of bittersweet is certainly one of the most alarming findings of the entire forest inventory. The arrival and extremely rapid and prolific spread of the invasive cork tree (Mountain Street Reservoir, Stand 4) was perhaps the most unexpected finding and also does not bode well.

⁸ For the 1,427.9-acre Blair Pond Tract in Blandford, MA, the average severity rank across all 242 systematic plots was **0.10**. See page 70, mini-table: “Severity Rank for Non-Native Invasive Vegetation Blair Pond”, in the Blair Pond Tract Forest Stewardship Plan (owner: the Springfield Water and Sewer Commission) which is on file with DCR.

For the 1,110.8-acre Tom Swamp Tract in Petersham, MA, the average severity rank across all 123 systematic plots was **0.16**. See page 34, mini-table: “Severity of Non-Native Invasive Vegetation at Systematic Plots”, in the Tom Swamp Tract Forest Stewardship Plan (owner: Harvard Forest), which is on file with DCR.

⁹ Interpreting the significance of the forestwide severity ranking of bittersweet (or any other non-native invasive plant) is parallel to interpreting this number for non-native invasive plants in the aggregate – see preceding discussion of the 0.74 forestwide severity ranking for all non-native invasive plants.

Table: Presence and severity Rank for Non-Native Invasive Vegetation

Severity Rank at Systematic Plots	Interpretation of Rank	% of all plots having a presence of any woody non-native invasive	% of all plots having a presence of bittersweet
	Present	36%	28%
0	ABSENT / NONE DETECTED	64%	72%
1	EXTREMELY MINOR (< 1% cover)	14%	14%
2	MINOR AND READILY TREATABLE (1% - 5%)	9%	4%
3	MODERATE TO SEVERE – CANNOT READILY BE CONTROLLED (6%-90% cover in understory)	8%	7%
4	SEVERE (>90% invasives cover in understory, tall overstory intact)	4%	3%
5	NO LONGER A FOREST – IS IN NEED OF COMPLETE RESTORATION (mostly invasives cover, no tall overstory)	0.30%	0.30%
Forestwide average rank		0.74	0.58

The plot-level data described above provides a *systematic*, non-biased sample of the rates of occurrence of non-native invasive plants. As with uncommon tree species (see discussion of overstory species diversity above), in order to not lose sight of these impactful species outside of sample plots, a note was made whenever non-native invasive plants were encountered outside of the systematic sample plots. With perhaps a few exceptions, each occurrence of a non-native invasive plant or small group or localized population of non-native invasive plants that I happened across outside of the sample plots was noted with a GPS point – see Table: As-encountered occurrences of invasives. A total of 16 species of non-native invasive plants with a total of 974 occurrences was noted in this way.¹⁰

As with the data gathered at systematic plots, bittersweet accounted for about half of all occurrences of non-native invasive plant species, followed again by barberry and rose. Other species were less – or much less – common. But, though currently at a low level, some of these non-native invasive plant species have the potential to become much more prolific and severe in forest settings in the future, including glossy buckthorn and, apparently, cork tree.

Table - As-encountered occurrences of non-native invasive plants (not at plots)				
Species	# of as-encountered occurrences – both w-sheds	% of all as-encountered occurrences – both w-sheds	% of as-encountered occurrences at Ryan and West-Whately w-shed only	% of as-encountered occurrences at Mountain Street w-shed only
Oriental bittersweet	509	52.5%	64%	42%
Japanese barberry	206	21.3%	15%	27%
Multi-flora rose	108	11.1%	9%	13%
Honeysuckle	46	4.7%	5%	4%
Glossy buckthorn	31	3.2%	0.0%	6.1%
Autumn olive	21	2.2%	3.1%	1.4%
Winged euonymous	9	0.9%	0.2%	1.6%
Cork tree	9	0.9%	0.0%	1.8%
Phragmites	8	0.8%	0.7%	1.0%
Privet	6	0.6%	0.7%	0.6%
Knotweed	6	0.6%	0.0%	1.2%
European buckthorn	3	0.3%	0.7%	0.0%
Black locust	3	0.3%	0.7%	0.0%
Norway maple	2	0.2%	0.2%	0.2%
Catalpa	1	0.1%	0.2%	0.0%
Garlic mustard	1	0.1%	0.2%	0.0%
Total	969	100%	100%	100%

In recording the presence of non-native invasive plants on an as-encountered basis, an effort was made to rank the severity of the most common ones – bittersweet and barberry. In some cases, a rank could be inferred later upon reviewing the data in the office. The

¹⁰ Note: Occurrences as noted here are at the species level; if two species of non-native invasive plants were found at a single location, this was noted as an occurrence of each species, or a total of two occurrences at that location.

estimated severity ranking of bittersweet and barberry are shown in the Table: Presence and severity Rank for As-Encountered Bittersweet & Barberry.

Across the watershed forest, on an as-encountered basis, bittersweet was observed at all severity levels. Less than half of the time, at 217 locations, bittersweet had a low severity ranking (1 or 2) at this time. In the case of bittersweet, this is not really *good* news. For bittersweet, these low severity levels can be interpreted as evidence of its continued and progressive spread, and it is understood that the severity of bittersweet at any given location will only tend to *increase* over time. At over half of all locations (291 locations), and viewed in terms of a long-term process of perpetual increase, bittersweet already has a severity rank of 3, 4 or 5, indicating that the forest in these locations is already greatly compromised – it is in the process of being overrun with bittersweet, or already is overrun by it (see discussion above of severity rankings).

Barberry was also common across the watershed forest, but much less so than bittersweet. When barberry was observed, it tended to have a severity rank of 1 or 2. Barberry was also found at higher severity levels, but mostly with a rank = 3. There were 6 instances where barberry dominated the understory (rank = 4) and no cases where barberry had become the overstory.

Table: Presence and severity Rank for As-Encountered Bittersweet & Barberry

Severity Rank in As-Encountered Locations	Interpretation of Rank	# of ranked occurrences of bittersweet	# of ranked occurrences of barberry
1	EXTREMELY MINOR (< 1% cover)	120	119
2	MINOR AND READILY TREATABLE (1% - 5%)	97	54
3	MODERATE TO SEVERE – CANNOT READILY BE CONTROLLED (6%-90% cover in understory)	180	27
4	SEVERE (>90% invasives cover in understory, tall overstory intact)	51	6
5	NO LONGER A FOREST – IS IN NEED OF COMPLETE RESTORATION (100% invasives cover, no tall overstory)	60	0
Total # of ranked occurrences on an as-encountered basis		508	206
Average rank at as-encountered locations		2.7	1.6

Non-native invasive plants are abundant and widespread, though not uniformly – see **Non-Native Invasive Plant Map 1: Occurrence of Non-Native Invasive Plants at Systematic Forest Inventory Plots & As-Encountered Data Points**. The map illustrates the complexity of the distribution and severity of non-native invasive plants. Some areas are much less infested than others, and some areas appear to be essentially free of invasives at this time. And though non-native invasive plants can occur on a thinly scattered basis, they often occur in larger extents or runs, often in association with plantations (existing or former), logging or blowdowns. Areas around systematic plots shown with a rank of 3-5 and concentrations of as-encountered observations are in a state of severe infestation.

The situation appears even more dire if one uses the severity rankings both for plot-level data and as-encountered data and focuses solely on bittersweet, the most abundant invasive and the one that seems (for reasons discussed above) likely to do the most harm to the watershed forest in the foreseeable future – see **Non-Native Invasive Plant Map 2: Occurrence of BITTERSWEET at Systematic Forest Inventory Plots & As-Encountered Data Points**. In looking at this map, it is evident that while some areas are

relatively free of bittersweet, other areas are very severely – even catastrophically – infested with bittersweet. This is most true for parts of the Mountain Street watershed forest, but also true some areas near the Ryan and West-Whately Reservoirs. And it is also true for some “deep forest” areas that are remote from any of the reservoirs, including areas along roads or log landings.

There is no pathway evident at this time by which non-native invasive plants are likely to become less common in the future. On the contrary, one must assume that these plants will continue to increase over time, sometimes rapidly, and sometimes in a compounding manner. There is ample evidence that this process is already occurring (see discussion of *gap process failure* further below).

Co-occurrence of native interfering vegetation and non-native invasive plants

Few areas of the forest are free of interference from undesirable vegetation. Indeed, either native interfering plants OR non-native invasive plants, or both, were present at 87% of all plots– see Table: Presence of native interfering and non-native invasive plants. At about 1/3 of all plots, native- and non-native invasive interfering plants co-occurred. Perhaps the most alarming example of co-occurrence is that of bittersweet and grapes – both of which are impactful vines that can pull down large trees and overwhelm small trees. Bittersweet and grapes were found together at 16% of all plots!

Table: Presence of native interfering and non-native invasive plants

Status	Either interfering or invasives are present	Both interfering AND invasives are present	BOTH Bittersweet AND Grapes are present
Present	87%	32%	16%
Absent	13%	68%	84%

Non-native invasive earthworms

One may take the current thick covering of leaf litter for granted at this time (see discussion of leaf litter as part of the forest floor environment above), but it is worth noting that there are areas in Eastern North America, including in New England, that are experiencing a severe loss of leaf litter due to a newer wave of non-native invasive *earthworms*. Impacts of the loss of leaf litter due to invasive earthworms may include increased run off and soil erosion, increased cycling of nutrients, and elevated risk of the spread of non-native invasive plants.

Locally, invasive earthworms have been found in the rich riparian zones along the Mill River in Deerfield, about 6 miles to the northeast of Poplar Hill. An initial check in the Northampton watershed found no evidence of invasive earthworms. To be sure, at each plot, the leaf litter was observed for potential signs of earthworms and was sometimes

scratched away as a double-check. No evidence of non-native invasive earthworms was found at any plot or at any other location. This is good news at this stage. However, it is possible that an incipient presence of non-native invasive earthworms may already exist in areas not closely scrutinized by the forest inventory process (e.g. reservoir shorelines), or that these worms were present in the forest but overlooked. In summary, though not currently found in the Northampton watershed forest, non-native invasive earthworms should be considered a potential future threat to watch out for.

Comparison of Mountain Street and Ryan and West-Whately watershed forests

The preceding discussions treat the forests of Ryan and West-Whately watershed forest and Mountain Street watershed forest as part of a combined, overarching forest which, on one level, they are. This section looks at key differences (and notable similarities) between the administratively separated Mountain Street and Ryan and West-Whately watershed forests. A comparative overview is presented in **Forest Overstory by Watershed Tables 1, 2A & 2B**. These are as follows:

- Forest Overstory by Watershed Table 1 - Core forest parameters
- Watershed Table 2A - Species composition and diversity
- Forest Overstory by Watershed Table 2B - Detailed species composition and diversity

Canopy structure

Both watersheds are predominantly covered by mature, well stocked forests with lots of trees including large trees (i.e., trees of timber size). Total live basal area is similar for the two forests, though slightly greater for Ryan and West-Whately watershed – approx. 140 sq-ft/ac for Ryan and West-Whately approx. 121 sq-ft/ac for Mountain Street – see **Forest Overstory by Watershed Table 1 (b)**. The total number of live trees in both forests is also similar – about 264 trees per acre for Ryan and West-Whately compared to about 244 trees per acre for Mountain Street. While the difference in basal area is *statistically* significant (though there is not much practical difference between the two basal areas), the differences in trees per acre is not *statistically* significant – see **Forest Overstory by Watershed Table 1 (a)**. As can be seen (using for example, the parameter *coefficient of variation*), the number of trees is the most variable of the core parameters. Basal area is the least variable (which should be born in mind when comparing species).

One factor contributing to the difference in basal area is the fact that, at the Mountain Street watershed, an appreciable area of former red pine plantations (and adjacent old orchard) located around the water treatment plant has been converted to a set of meadows and “partial woodlands” (i.e., areas marked by variable tree densities with frequent openings in the canopy) that need to be maintained by periodic mowing of understory grass and brush – see **Figure 4: Watershed forest areas maintained by mowing as a partial response to non-native invasive plants**. This area encompasses about 50 acres, or about 8% of the Mountain Street watershed, and was established in former red pine plantations (and an adjacent orchard) in response to (i.e., as a non-chemical response to) the threat of bittersweet and other non-native invasive plants.

There is more *timber* per acre at Mountain Street (13.1 Mbf/ac at Mountain Street compared to 9.4 Mbf/ac at Ryan and West-Whately); on the other hand, there is more *cordwood and pulpwood* (i.e., roundwood products other than timber) at Ryan and West-Whately (17.7 cords per acre at Ryan and West-Whately compared to 11.9 cords per acre at Mountain Street). When timber volumes are converted to cord equivalents so that a *total volume of wood* (in cords) can be compared, then two watersheds are very similar in

terms of total wood volume (31.8 cords per acre at Ryan and West-Whately compared to 31.5 cords per acre at Mountain Street) – see **Forest Overstory by Watershed Table 1 - wood volumes (c)**.

The average size of all live trees is very similar for the two forests – 9.8” for Ryan and West-Whately and 9.6” for Mountain Street – see **Forest Overstory by Watershed Table 1 - site occupancy by trees and size (b)**.

Composition and diversity: common species based on basal area sampling

The two forests are similar in terms of composition and diversity, but there are many potentially relevant differences as well. In both cases, the top five species (four species plus hemlock overstory and midstory) in terms of basal area are white pine, black birch, red maple and red oak, though these species differ in their abundance between the watersheds – see **Forest Overstory by Watershed Table 1 (b)**. Hemlock is discussed separately below.

At both watersheds, white pine and black birch are the two most abundant species. But while their total basal area is similar at Ryan and West-Whately (about 15%-16% of total basal area each), white pine is quite dominant at Mountain Street (white pine makes up about 40% of total basal area at Mountain Street, compared to just under 16% for black birch). White pine also stands out in terms of having the greatest wood volume at both watersheds, which is most pronounced at the Mountain Street watershed: while white pine has almost twice the volume of wood as the next species (red oak and black birch) at Ryan and West-Whately, it has about *six times as much* wood as runner-up black birch at Mountain Street. Though both watersheds would be impacted significantly by a decline or loss of white pine (due for example to white pine needle diseases), the big difference in white pine abundance suggests that Mountain Street might be more affected in such a case.

Though white pine has a greater total volume of wood than black birch, there are more black birch trees than white pine trees. Black birch had the greatest number of overstory trees at both watersheds, with about 56 trees per acre at Ryan and West-Whately and about 76 trees per acre at Mountain Street – see **Forest Overstory by Watershed Table 1 (b)**.

By contrast, red oak and red maple are similar in their basal area, both to each other and across the two watersheds, comprising about 9% of total basal area each at Mountain Street and 11.5% - 12.6% at Ryan and West-Whately. Together, these four species comprise about 55% of total basal area at Ryan and West-Whately and 74% at Mountain Street. But in terms of the *number of trees*, there are more red maples than red oaks, a difference which is more pronounced at Mountain Street, with three times more red maples than red oaks at Ryan and West-Whately, and eight times more than red oaks at Mountain Street.

A surprise is the relative prevalence of sugar maple at both watersheds, with about 8.6% of total basal area at Ryan and West-Whately and 5.8% at Mountain Street. A presence of

sugar maple may to some degree suggest a presence and scattered inclusion of soils of elevated fertility (and also an elevated risk of non-native invasive plants).

Other common species (yellow birch, paper birch, white ash, and black cherry) have a much smaller presence, ranging from about 0.5% to 3% of total basal area each at each watershed. White ash was much more common at Ryan and West-Whately (2.8% of total basal area) than at Mountain Street (0.5%), suggesting that the impacts of emerald ash borer may be greater at the Ryan and West-Whately watershed. Yellow birch is more abundant at Ryan and West-Whately, suggesting a potentially enhanced capacity of the forest to replace ash with yellow birch's similar hardwood functionality in riparian areas, where both white ash and yellow birch thrive.

Hemlock is a case unto itself. Because of its shade tolerant growth form, hemlock can be viewed functionally as both a dominant or co-dominant overstory tree (in some cases) and as a suppressed but shade-tolerant midstory tree (in other cases). As a species, including both overstory and midstory, hemlock has a significant presence – see bottom row of **Forest Overstory by Watershed Table 1 (b)**, with about 19% of the live basal area at Ryan and West-Whately and 7% at Mountain Street. With 19% of total live basal area at Ryan and West-Whately, hemlock is actually the dominant species by this measure, exceeding even white pine and black birch. Meanwhile, at Mountain Street, hemlock is less abundant than white pine, black birch, red maple and red oak. While at Ryan and West-Whately there are on average about 8 overstory hemlocks per acre, at Mountain Street there are less than 2 trees per acre. Likewise, at Ryan and West-Whately there are on average about 55 midstory hemlocks per acre, at Mountain Street there are only about 17 midstory hemlocks per acre. On the whole, these differences in hemlock suggest that Ryan and West-Whately will be more heavily impacted by a loss of hemlock (due for example to hemlock woolly adelgid) than would Mountain Street.

Beech, like hemlock, is also a case unto itself, with both an overstory and a shade-tolerant midstory component. Though beech is more abundant at Ryan and West-Whately than at Mountain Street, it is not particularly abundant at either watershed. At 63 sample plots at the Mountain Street watershed there was no overstory beech; meanwhile, at the Ryan and West-Whately watershed, overstory beech comprises just 2.7% of total basal area. Both watersheds have a relatively small presence of midstory beech – as measured using trees large enough and close enough to be included at plots – with about 13 trees per acre at Ryan and West-Whately and 36 trees at Mountain Street. These numbers of trees should be regarded with a grain of salt as there can be a lot of distortion when measuring a small number of small trees, and midstory beech seemed to be a bit more abundant than plot-level basal area measurements would indicate – see entries for midstory beech in **Forest Overstory by Watershed Table 2A**.

Composition and diversity: common species based on as-seen sampling from plot centers

In order to further characterize composition and diversity, the species composition at each *plot* was evaluated two ways: both by prism sampling and by as-seen sampling.¹¹ Prism plots are essential for gathering certain types of forest data, including information about basal area, tree size, number of trees, and wood volume. Prism plots are generally used for composition sampling as well. In order to provide more context, other ways of sampling composition – for example, with *as-seen* observations at systematic plots – provide a valuable, additional reference point. Unlike species information based on prism plots, *abundance* as used in this here is based on sightings of a species at any distance from plot centers (see methods) and is independent of diameter, and is a way of capturing composition data for trees that one sees from the plot but which are not captured by the prism sampling.

In terms of overstory trees sampled by the plot-level as-seen method, four species are the most dominant at both watersheds – black birch, white pine, red maple and red oak – see **Forest Overstory by Watershed Table 2A**. Black birch is the most widespread at both watersheds, and, as the only species with an average abundance level ≥ 2.0 at both watersheds, was seen at 83% - 84% of all plots across both watersheds. This corresponds with the previously-discussed finding that black birch has the highest number of trees per acre at both watersheds – see **Forest Overstory by Watershed Table 1 (b)**. Not only is black birch the most common, it is also the most likely to be abundant at any given location, with at least 6 black birch trees being seen at about half of all plots at both watersheds – 46% at Ryan and West-Whately and 54% at Mountain Street – see **Forest Overstory by Watershed Table 2B**. Seen in this way, by its widespread presence and abundance, black birch may be more important than its wood volume or size derived from prism plots alone might suggest.

Red maple is also quite widespread at both watersheds (present at 77% of plots at Ryan and West-Whately and 84% of plots at Mountain Street), though it less likely to be very abundant (red maple was abundant at 26% of plots at Ryan and West-Whately and 29% of plots at Mountain Street). Sugar maple is also similar in abundance at both watersheds; with an average abundance of 0.86 - 0.89, though it was *abundant* (≥ 6 trees seen) at only 8% - 11% of plots.

While there are notable similarities in black birch, red maple, and sugar maple across both watersheds, with other species there are notable differences:

- Red oak is more abundant at Ryan and West-Whately, where it is present at 74% of all plots (compared to 52% at Mountain Street)
- White pine is more abundant at Mountain Street, where it had the highest abundance level of any species (with ≥ 6 white pine trees seen at 56% of all Mountain Street plots, compared to 30% at Ryan and West-Whately)

¹¹ This is discussed in the Methods section – see Appendix. A third method of capturing diversity – as-encountered sampling – was used for uncommon species and is discussed further below.

- In the overstory, hemlock is about three times as abundant at Ryan and West-Whately when compared to Mountain Street. Midstory hemlock is also more abundant at Ryan and West-Whately, though not by as much. Hemlock is much more likely to occur in concentrations of ≥ 6 trees at Ryan and West-Whately (25% of plots) than at Mountain Street (6% of plots).
- Beech is also more common at Ryan and West-Whately, occurring in the overstory at more than twice its rate at Mountain Street, and occurring in the midstory at over three times the rate.

Using these data sets, one can continue with these types of assessments and comparisons depending on what one needs to know. For example, though white ash is at the low end of the average abundance among common species, it sometimes tends to occur in concentrations, especially at the Ryan and West-Whately watershed, where at 6% of the plots there were ≥ 6 ash trees.

Composition and diversity: uncommon species

By definition, uncommon species are less likely to be encountered and thus are less likely to be captured in systematically-gathered data. For this reason, for this Forest Stewardship Plan, uncommon species are sampled in three ways, two of which are systematic, and one of which relies on chance (see **Appendix: Methods used to gather data**) for further discussion). From these combined data sources, it is clear that there are very strong differences in the populations of uncommon species across the watersheds. For an overview of the distribution of selected uncommon species, see **Map: Diversity of Common Overstory Species, Annotated**. Please continue to refer to **Forest Overstory by Watershed Tables 1, 2A & 2B** for the following discussion of species diversity at each watershed.

Species Diversity at the Ryan and West-Whately watershed

Bitternut hickory was the most frequently observed of the uncommon species at Ryan and West-Whately, having a presence at 9% of the plots (compared to 2% at Mountain Street). Shagbark hickory was the second-most frequent of the uncommon species, having a presence at 6% of the plots (and was also at 6% of the plots at Mountain Street). Basswood was also seen at Ryan and West-Whately (3% of plots, compared to 0% at Mountain Street). Separately, there were 115 as-encountered sightings of bitternut hickory (the most for any of the uncommon species), 87 sightings of shagbark hickory, and 36 sightings of basswood. Note that each of the sightings can represent more than one tree.

Pitch pine occurred almost exclusively – albeit very rarely – at Ryan and West-Whately. Though found at only 2% of all plots, there were 36 distinct sightings of pitch pine, mostly on Poplar Hill in Conway. Many of these sightings were of multiple trees, with many of the trees in the 12” – 17” diameter range. About 130 live pitch pine trees were seen, along with many dead trees. No pitch pine seedlings were seen.

Likewise, entirely unique to Ryan and West-Whately, there was a faint presence of red spruce in the overstory. Though red spruce was not seen at any of the plots, there were 7

distinct sightings of red spruce, mostly near and around the top of Walnut Hill in Williamsburg. About 45 live red spruce trees were seen, with diameters in the 13”-18” range. There were also smaller red spruce trees in the 3” – 6” range, and a few seedlings, suggesting that this species could regenerate here.

Separately from the red spruce, on the west side of the former Williamsburg Reservoir, there was a very faint hint of balsam fir as a tall midstory tree, both at 2 plots (representing 0.8% of all plots at Ryan and West-Whately) and at one as-encountered point.

In summary, while the bitternut hickory, basswood and red spruce suggest perhaps legacies of earlier forests that reflected northern hardwood and spruce-fir mixes, perhaps one with a more robust mixture of diverse species. This mixture suggests perhaps a colder climate zone and more mesic site conditions. Diverging entirely from this, the concentrated presence of pitch pine suggests a localized history of fire. The shagbark hickory is intermediate between suggesting fire and suggesting mesic conditions.

Species Diversity at the Mountain Street watershed

The uncommon contingent of species at Mountain Street is strikingly different from the uncommon species at Ryan and West-Whately. Though there is some overlap between the two watersheds (especially in shagbark hickory and bigtooth poplar – see below), the Mountain Street watershed has a pronounced oak-hickory mix that resembles oak-hickory forests that tend to be found further to the south. Chestnut oak was present at 21% of all plots at Mountain Street, scarlet oak was present at 17% and white oak was present at 16% of all plots (compared to 0% for all three species at Ryan and West-Whately), with as-encountered sightings of these species, respectively, of 59, 43 and 34 sightings each) – for sightings of uncommon tree species at the watershed level, see **Forest Overstory by Watershed Table 2A, column (d) - Species composition and diversity**. There may also be black oak – though at times this can be difficult to distinguish from scarlet oak. At about 3% of plots there appeared, in the field, to be black oak.

Pignut hickory – also a component of oak-hickory forests that tend to lie further to the south – was also widespread, being present at 11% of all plots at Mountain Street (compared to 0% at Ryan and West-Whately). Separately, there were 56 as-encountered sightings of pignut hickory at Mountain Street, compared with just 3 at Ryan and West-Whately. Main concentrations of these species were found around the top of Laurel Mountain, Chestnut Mountain, and in some spots to the east of Borowski Brook, with significant additional chestnut oak on Horse Mountain.

Black ash was found in a single location across the two watershed forests, this location being a swamp to the north of Rocks Road. Black ash is a diminutive tree that thrives in certain swamps (in this case with yellow birch, red maple and hemlock) that are too wet for most other trees. Black ash vulnerable to emerald ash borer and so, like white ash, is at risk of effectively vanishing altogether.

In summary, the oak species listed above along with pignut hickory are associated with climates further to the south (reflecting a warmer climate zone and, additionally, potentially associated with past fires) and therefore are part of a subset of native species that are currently uncommon but hold particular promise in the face of anticipated climate change, which may result in a local climate that resembles climates now found further to the south (tulip poplar, shagbark hickory, and pitch pine may be counted in this group as well).

Miscellaneous diversity

Bigtooth poplar has a presence at 4% of Ryan and West-Whately plots and 8% of Mountain Street plots. The presence of bigtooth poplar may have less to do with site suitability than with chance. Bigtooth poplar is a sort of ecological wild card, depending as it does on preceding heavy disturbance, such as wildfire or logging, within the previous 80-100 years.

Ironwood (*Ostrya virginiana*) is a medium-sized, somewhat shade-tolerant tree that was tracked among the shrubs at plots and was sometimes noted on an as-encountered basis. Ironwood was noted 44 times at Ryan and West-Whately and 12 times at Mountain Street, which suggests a similar rate of occurrence across the watersheds (given the Ryan and West-Whately forest is about four times larger than Mountain Street forest).

There was only a single occurrence of tulip poplar at Ryan and West-Whately (and none at Mountain Street). If there are others, they were not detected. Though the watersheds seem to be located at the northern fringe of the range of tulip poplar, and though there are large and impressive naturally-established, forest-grown tulip poplars in the Mineral Hills of the Leeds section of Northampton, and though this species does grow natively further to the north (near Whately center), tulip poplar was simply missing. There is no ready explanation for why this is the case other than the straightforward explanation that tulip poplar must have been lacking as a seed source at the time earlier generations did the rounds of major cutting that established the current forest in the early 1900s.

Surprisingly, no black gum was observed at either watershed. Nor was swamp white oak or tamarack. That said, any or all of these species could be present at low levels and could simply have been overlooked.

Comparison of native interfering vegetation

There is remarkable similarity between the two watersheds in the distribution of hayscented fern native interfering vegetation species. At both watersheds, hayscented fern is present at about 1/3 of all plots – see **Table: Comparative presence and severity of NATIVE INTERFERING VEGETATION**. In half of all cases, the hayscented fern is present at a low level – but present nonetheless. In about half of the cases, hayscented fern is present at an appreciable level, and in a small percentage of cases, hayscented fern has overwhelmed the understory (see Rank = 3).

Table: Comparative presence and severity of NATIVE INTERFERING VEGETATION						
Rank	Hay-scented Fern – Both watersheds (% of all plots)	Grape Vines – Both watersheds (% of all plots)	Hay-scented fern – Ryan and West-Whately watershed (% of all plots)	Hay-scented fern – Mountain Street watershed (% of all plots)	Grape Vines – Ryan and West-Whately watershed (% of all plots)	Grape Vines – Mountain Street watershed (% of all plots)
PRESENT (>0)	36.0%	36.0%	35.7%	36.1%	32.3%	50.8%
ABSENT (=0)	64.0%	64.0%	64.3%	63.9%	67.7%	49.2%
RANK=1, minor presence	17.0%	19.0%	16.9%	16.4%	16.3%	29.5%
Rank = 2, having an appreciable impact	16.0%	15.0%	16.1%	14.8%	13.9%	18.0%
RANK=3, overwhelming impact at plot	3.0%	2.0%	2.7%	4.9%	2.0%	3.3%

Wild grapes are present at both watersheds but are much more widespread at Mountain Street, being found at about half of all plots (compared to about 1/3 of all plots at Ryan and West-Whately). As with hayscented fern, when grapes do occur, it tends to be at a low level roughly half of the time (or, slightly more than half of the time at Mountain Street). Again, in about half of the cases, hayscented fern is present at an *appreciable* level, and in a small percentage of cases, hayscented fern has overwhelmed the mid- or upper layers of the forest.

When one compares the highest severity (Rank = 3) of native interfering vegetation between the watersheds, it does appear that the situation is more severe at Mountain

Street, which has about twice the level of *severe* (Rank = 3) hayscented fern and 1.5 times the level of severe (Rank = 3) grapes.

Non-native invasive plants

As discussed in the forestwide overview section, non-native invasive plants are widespread in the watershed forest. A total of 10 species of woody, perennial non-native invasive plant was documented, with bittersweet being by far the most abundant species – see **Table: Comparative SPECIES PRESENCE of non-native invasive plants across the watersheds.**

That said, there are important differences in the extent and severity of non-native invasive plants between the two watersheds. Indeed, non-native invasive plants are much more widespread and much more severe at the Mountain Street watershed. However, even if, by comparison, the level of infestation of non-native invasive plants at the Ryan and West-Whately watershed is less problematic, it is nonetheless very problematic in its own right. It is merely a question of degree.

Table - Comparative SPECIES PRESENCE of non-native invasive plants across the watersheds							
Species	# of plots (out of 318 plots total) where species occurred – combined w-sheds (a)	% of plots (out of 318 plots total) where species occurred – combined w-sheds (b)	% all plots with invasives that include this species -- combined w-sheds (c)	% of systematic plots (out of 255 plots total) where species occurred – Ryan and West-Whately w-shed (d)	% of systematic plots (out of 63 plots total) where species occurred – Mountain Street w-shed (e)	% all plots with invasives that include this species – Ryan and West-Whately w-shed (f)	% all plots with invasives that include this species – Mountain Street w-shed (g)
Oriental bittersweet	90	28%	51.1%	20%	62%	51.0%	51.3%
Japanese barberry	34	11%	19.3%	9%	17%	23.0%	14.5%
Multi-flora rose	22	7%	12.5%	3%	22%	8.0%	18.4%
Glossy buckthorn	9	3%	5.1%	1%	10%	3.0%	7.9%
Honey-suckle	9	3%	5.1%	3%	2%	8.0%	1.3%
Winged euonymous	6	2%	3.4%	2%	2%	5.0%	1.3%
Autumn olive	2	1%	1.1%	1%	0%	2.0%	0.0%
Privet	2	1%	1.1%	0%	3%	0.0%	2.6%
Cork	1	0%	0.6%	0%	2%	0.0%	1.3%
Norway maple	1	0%	0.6%	0%	2%	0.0%	1.3%
Total	176		100.0%			100.0%	100.0%

A *majority* of plots at the Mountain Street watershed had a presence of non-native invasive plants, while most plots at the Ryan and West-Whately watershed do not. In all, 71% of all plots at the Mountain Street watershed had a *presence* of non-native invasive plants, which is almost three times greater than the 27% for the Ryan and West-Whately watershed – see **Table: Comparative SEVERITY RANK of non-native invasive plants across the watersheds.**¹²

¹² Note: even though the level of infestation is much higher at the Mountain Street watershed than at the Ryan and West-Whately watershed, the level of 26% (i.e., 26% of all plots having some presence of non-

Table - Comparative SEVERITY RANK of non-native invasive plants across the watersheds							
Severity Rank at 318 Plots	Interpretation of Rank	% of plots with any invasive – Combined W-sheds	% of plots with BITTER-SWEET - Combined W-sheds	% of plots with any invasive – Ryan and West-Whately w-shed	% of plots with any invasive – Mountain Street w-shed	% of plots with BITTER-SWEET -- Ryan and West-Whately w-shed	% of plots with BITTER-SWEET -- Mountain Street w-shed
	Present	36%	28%	27%	71%	20%	62%
0	ABSENT / NONE DETECTED	64%	72%	73%	29%	80%	38%
1	EXTREMELY MINOR (< 1% cover)	14%	14%	11%	25%	12%	19%
2	MINOR AND READILY TREATABLE (1% - 5%)	9%	4%	9%	8%	4%	5%
3	MODERATE TO SEVERE – CANNOT READILY BE CONTROLLED (6%-90% cover in understory)	8%	7%	4.3%	24%	3%	24%
4	SEVERE (>90% invasives cover in understory, tall overstory intact)	3.8%	3.5%	1.6%	12.7%	1.2%	12.7%
5	NO LONGER A FOREST – IS IN NEED OF COMPLETE RESTORATION (100% invasives cover, no tall overstory)	0.3%	0.3%	0.0%	1.6%	0.0%	1.6%
Forestwide average rank		0.74	0.58	0.49	1.71	0.33	1.59
Percent of plots with rank 3-5		12.3%	11.0%	5.9%	38.1%	4.3%	38.1%

native invasive plants) at the Ryan and West-Whately watershed is still very high compared to the optimum level of 0% non-native invasive plants.

At both watersheds, bittersweet is the most prevalent non-native invasive plant species, being present at about half of all plots with invasives (51.1% of all occurrences forestwide, 51.0% of all occurrences at the Ryan and West-Whately watershed, and 51.3% of all occurrences at the Mountain Street watershed – see **Table: Comparative SPECIES PRESENCE of non-native invasive plants across the watersheds**. At both watersheds, barberry and multiflora rose are the 2nd and 3rd most abundant non-native invasive plant species.

The Mountain Street watershed has a number of other worrisome non-native invasive plants that *currently* are at low levels. These are: glossy buckthorn (which was present at 10% of all plots at Mountain Street compared to only 1% at Ryan and West-Whately), cork (aka. Amur cork), which was present at 2% of all plots at Mountain Street (compared to 0% at Ryan and West-Whately) and Norway maple, which was present at 2% of all plots at Mountain Street (compared to 0% at Ryan and West-Whately).¹³

Winged euonymous (aka. burning bush) was found at 2% of all plots at both watersheds. Meanwhile, autumn olive was found only at Ryan and West-Whately, at 1% of plots (and at 2% of all plots that have invasives). Autumn olive was found along and near Conway Road, in a dense and large patch near (above and below) the Ryan dam.

Similar to the presence of bittersweet at plots, bittersweet was also – far and away – the most widespread invasive found on an *as-encountered* basis across the watersheds. Bittersweet accounted for 64% of all invasives noted on an as-encountered basis at Ryan and West-Whately, compared to 42% at Mountain Street – see **Table: As-encountered occurrences of invasives (not at plots)**. The lower level at Mountain Street is unlikely to be due to a difference in *suitability* for bittersweet, but rather due to the comparably elevated levels of other invasives at Mountain Street, with barberry accounting for 27% of all occurrences at Mountain Street (compared to 15% for Ryan and West-Whately), and glossy buckthorn accounting for 6% at Mountain Street (compared to 0% for Ryan and West-Whately).

¹³ There is a minor presence of Norway maple at Ryan and West-Whately – within one of the red pine plantations north of the Ryan Reservoir – but it was not found at any of the 318 sample plots.

Table - As-encountered occurrences of non-native invasive plants (not at plots)				
Species	# of as-encountered occurrences – both w-sheds	% of all as-encountered occurrences – both w-sheds	% of as-encountered occurrences at Ryan and West-Whately w-shed only	% of as-encountered occurrences at Mountain Street w-shed only
Oriental bittersweet	509	52.5%	64%	42%
Japanese barberry	206	21.3%	15%	27%
Multi-flora rose	108	11.1%	9%	13%
Honeysuckle	46	4.7%	5%	4%
Glossy buckthorn	31	3.2%	0.0%	6.1%
Autumn olive	21	2.2%	3.1%	1.4%
Winged euonymous	9	0.9%	0.2%	1.6%
Cork tree	9	0.9%	0.0%	1.8%
Phragmites	8	0.8%	0.7%	1.0%
Privet	6	0.6%	0.7%	0.6%
Knotweed	6	0.6%	0.0%	1.2%
European buckthorn	3	0.3%	0.7%	0.0%
Black locust	3	0.3%	0.7%	0.0%
Norway maple	2	0.2%	0.2%	0.2%
Catalpa	1	0.1%	0.2%	0.0%
Garlic mustard	1	0.1%	0.2%	0.0%
Total	969	100%	100%	100%

The data show that the infestations of non-native invasive plants are much more *severe* at the Mountain Street watershed than at Ryan and West-Whately. The average severity rank for non-native invasive plants at the Mountain Street watershed was 1.71, which is a little more than three times the average rank of 0.49 for the Ryan and West-Whately watershed – see **Table: Comparative SEVERITY RANK of non-native invasive plants across the watersheds**. The difference between the two watersheds is even greater when looking only at bittersweet, which has a severity rank of 1.59 at the Mountain Street watershed, – *which is almost five times worse than the average rank of 0.33 for bittersweet at the Ryan and West-Whately watershed.*

The differences in severity rank overall and specifically for bittersweet appear most consequential when comparing the higher severity levels, i.e. levels 3-5 – see **Table: Comparative SEVERITY RANK of non-native invasive plants across the watersheds** (bottom row). Whereas at Ryan and West-Whately, plots with a severity rank in the 3-5 range account for “just” 5.9% of all plots, *such plots account for 38.1% of the total plots at Mountain Street!* When considering only bittersweet, the numbers remain similar, with 4.3% of all plots at Ryan and West-Whately watershed having a high degree of infestation (severity rank 3-5) and 38.1% of all plots at Mountain Street having a high degree of infestation!

Summary: Ryan and West-Whately and Mountain Street in comparison

With their diverse composition and complex structure, both watershed forests are wonderfully suited to providing a high level of water quality functions *at the current moment* – see **Table: Comparative strengths and vulnerabilities at the watersheds**. This will continue to be the case as these forests continue, foreseeably, to mature. Additionally, both forests contain a diversity of species that offers a broad capability to adapt as anticipated changes occur to the climate. Some adaptation potential may come from with the current common species as these are given a chance to regenerate and go through a survival and selection process in future climate conditions. Additional adaptation potential may come from some of the species that are currently uncommon. This may be especially true for the Mountain Street watershed, which harbors a number of currently uncommon species whose natural range reaches up from warmer climatic conditions to the south. Though the presence of these as a well-established native seed source could most directly serve the Mountain Street watershed forest going forward if it becomes more necessary to establish species that may be more adapted to anticipated climate change, the benefits of this diversity could also reach the Ryan and West-Whately watershed forest over time, either by a dedicated transfer or by natural spread.

It may come as a surprise to see the presence of red spruce and pitch pine to be counted among the strengths. Red spruce is often thought of as a species that is especially vulnerable to climate change, but, counterintuitively, despite climate change, red spruce appears at this time to be regaining parts of its former range which it had lost due to land use practices of the past including overharvesting.¹⁴ At this point, it is too soon to conclude that red spruce will not thrive in parts of the Northampton watershed forest, especially in parts of the Ryan and West-Whately watershed. If red spruce does survive, expand and thrive, it could provide an essential replacement or partial replacement for hemlock in riparian areas if hemlock continues to suffer under hemlock woolly adelgid and other pests and pathogens. Furthermore, red spruce is avoided by deer and moose. With its local genetic stock, it seems prudent and very low risk step to try to promote the perpetuation of red spruce at its current locations – see the Forestwide Diversity map: **Uncommon Tree Species – Red Spruce and Pitch Pine**.

¹⁴ Foster, Jane R., and Anthony W. D'Amato. "Montane forest ecotones moved downslope in northeastern USA in spite of warming between 1984 and 2011." *Global Change Biology* 21, no. 12 (2015): 4497-4507.

Likewise, pitch pine is known to thrive in settings with frequent, low-intensity wildfire. Though this is not the case currently in the Northampton watersheds, it is not out of the question that this could occur in the future, in which case it would be a benefit to have a fire-adapted conifer on site. As with red spruce, there is a real value in protecting and preserving genetic stock that is native to the Northampton watersheds. As with red spruce, it seems prudent and very low risk step to try to promote the perpetuation of pitch pine at its current locations – see the Forestwide Diversity map: **Uncommon Tree Species – Red Spruce and Pitch Pine.**

Table - Comparative strengths and vulnerabilities at the watersheds		
	Ryan and West-Whately watershed	Mountain Street watershed
Strength – Due to elevated or unique presence of a feature		
Maturing forest with complex structure and diverse species	✓	✓
Potential to benefit from further maturation of the forest	✓	✓
Diversity – pitch pine	✓	
Diversity – red spruce	✓	
Diversity – rich mesic hardwoods (bitternut hickory, basswood, etc.) and shagbark hickory	✓	
Diversity – central oak-hickory forest type		✓
Vulnerability – due to elevated reliance on or exposure to a feature		
Reliance on white pine		✓
Reliance on hemlock	✓	
Reliance on ash	✓	
Reliance on beech	✓	
Exposure to deer browse impacts	✓	✓
Competition from hayscented fern thickets	✓	✓
Competition from wild grape vines	✓	✗
Competition from bittersweet vines	✓	✗
Competition from other non-native invasive plants	✓	✗
Gap process failure	✓	✗
Note: ✓ = greater strength or vulnerability. A check for both watersheds means that the strength or vulnerability is comparable. An ✗ means an even greater level of vulnerability.		

But at the same time, both watershed forests will face major constraints in their ability to maintain water quality functions and to adapt over time. Some overstory species will face declines in health or even outright elimination due to pests and pathogens, and trees of all species will be knocked down in storms, etc., or otherwise be impacted by weather-driven events. As gaps open up in the canopy, the natural response of the forest will be to begin a process of filling those gaps with young trees. But a number of factors will work against the success of this natural process. In addition to high forestwide levels of deer

browse, which exerts a strong reducing effect both on the number of trees and on their diversity, in part by directly destroying desirable seedlings but also by supporting the growth of highly competitive native interfering vegetation such as hayscented fern, both forests have worrisome infestations of non-native invasive plants. By all measures, the Mountain Street watershed is at a much more extreme level of non-native invasive plant infestation, both in terms of extent and severity. But this fact should not obscure a clear understanding that the level of infestation at Ryan and West-Whately is already in and of itself very worrisome from a forest and a water quality perspective. If anything, the condition of Mountain Street watershed should serve as a canary in the coal mine of sorts pertaining to how things can progress – and how they will most-likely and automatically progress – unless successful counter-measures are devised and implemented. As things stand now, the process of regeneration failure described in this Forest Stewardship Plan under the name *gap process failure* is already evident in both watersheds – see **Table: Occurrences of gap process failure and partial success (as-encountered)**. A related process of partial success in regeneration – described in this Forest Stewardship Plan as *gap process partial success*, is also evident at both watersheds.

Table: Occurrences of gap process failure and partial success (as-encountered)			
	# of occurrences – Both watersheds	# of occurrences – Ryan and West-Whately watershed only	# of occurrences – Mountain Street watershed only
Gap process failure	66	39	27
Gap process partial success	28	22	6

By contrast, there are only two examples of truly successful regeneration. One is inside the Whately terrace deer enclosure at Ryan and West-Whately, and the other is on the east side of the Mountain Street reservoir inside a tumbled area of fallen and felled red pine. Both sites feature a deep, well-drained, gravelly-sandy site with no or minimal immediate presence of non-native invasive plants, hayscented fern or wild grape. Thus, both sites are exceptionally favorable to the establishment of young trees, including oaks. In both cases, oaks have regenerated well – red oak at the Ryan and West-Whately site, and both red oak and chestnut oak (plus sassafras) at the Mountain Street site.

Future forest trends: a mix of good and bad

Going forward over the next ten years covered by this Forest Stewardship Plan, and beyond, the watershed forest will continue to be shaped by a number of already-observable trends – some reassuring, others discouraging.

Continued maturation

In trying to present an accurate picture of the forest, this Forest Stewardship Plan has been compelled to present a lot of alarming information about the condition of the forest. However, if one leaves all of this aside for a moment and looks at the forest as we might wish to see it, then the prospects are very good. The watershed forest is well-established as a tall, mostly closed-canopied forest with large trees (and affiliated deep root systems) of a remarkable diversity of tree species, a reasonably well developed midstory, a thick layer of leaf litter, and reasonable levels of coarse woody debris and understory vegetation. In its present form, this is a forest that is providing a high level of water quality function. And, in its present form, this is a forest that could *continue* to provide a high level of water quality functions for a long time to come, indeed, indefinitely. As the forest continues to mature, there is even a potential for increased water quality functions as large trees become even larger and taller and ultimately contribute larger coarse woody debris over time and the layering of the canopy becomes more complex.

Accelerated mortality and poor health

During the past 10 years we have seen the dramatic decline of red pine in plantations across the DPW ownership. There was perhaps a small amount of consolation in the fact that the red pine was non-native and it was planted. But there have been significant impacts accompanying its loss, first and foremost the triggering of an extremely aggressive response of interfering vegetation, mostly bittersweet but also grape vines. Species-specific mortality and declining health is likely to increase over time. Currently, ash is predicted to be on the verge of near total elimination. And though it is not one of the most abundant trees (only 2.4% of live basal area), it plays an important role in riparian zones and on rich mesic sites. As ash declines in such sites, there is an elevated risk that bittersweet will invade (or that bittersweet will be released if it is already present) – see **Figures 6: Gap Process Failure: Example 2**.

It is very lamentable that the current diversity of species will continue to be compromised by pests and pathogens. The impact of this decline in the overstory will tend to be made much worse if the forest is unable to compensate for the loss of overstory trees with the establishment of viable regeneration. This phenomenon—referred to in this Forest Stewardship Plan as gap process failure—is discussed in the next section.

The challenge of rejuvenation: gap process failure

The forest maintains itself over time through a process of rejuvenation marked by the ongoing growth of new trees to take the place of other trees that have died. Similarly, in the case of logging, the new trees replace others that have been cut. These young trees are often referred to as *regeneration*. Current understanding of Northeastern temperate forests holds that it is through the formation of gaps in the pre-existing tree canopy by which a mature forest normally and naturally rejuvenates itself. Gaps can be created through the death of a single large tree, by a loss of multiple trees in a group, or by tree mortality at a larger scale. Natural gaps in the canopy are mainly formed by storms that break or blow down trees (especially wind storms of various kinds, but also ice or snow loading), by generally low-intensity ground fires that may kill some overstory trees in patches, by mortality due to pests and pathogens, or by outright senescence due to old

age. In addition to naturally-caused gaps, gaps – including gaps at very large scales – have also and can also be established in conjunction with logging and with historical land uses such as clearing for farming followed by subsequent abandonment. Triggered by increased sunlight reaching the forest floor in the gaps, and perhaps triggered as well by disruptions to the forest floor environment, pre-existing small trees may be released in gaps, and new trees can become established through seed. There can also be sprouting or re-sprouting of pre-existing hardwoods.

Currently, a new type of situation has emerged and has become very common in which gaps form but do not lead to the establishment of viable and desirable new trees. Instead, in these situations, the gap becomes filled with undesirable vegetation that does not rejuvenate or perpetuate the forest in ways that will maintain its complex structure and diverse composition. The cause(s) can include excessive browse by deer or competition from interfering plants, both native and non-native. Often, there are multiple causes operating in the same gap. Combinations can include deer browse plus the aggressive growth of hayscented fern, or the growth of bittersweet and grapes together; in some cases, all four of these factors can co-occur. The term *gap process failure* is used in this Forest Stewardship Plan to refer to and describe all of such situations in which – due to interfering factors – viable trees fail to become established in gaps – see **Figures 5 & 6: Examples of Gap Process Failure**. Gap process failure undermines both the future structure and the future diversity of the forest which, in turn, undermines the future water quality function potential of the forest.

In the course of carrying out the fieldwork for this Forest Stewardship Plan, a total of 66 instances of very obvious gap process failure were noted. These were found in a broad distribution across the forest; no area of the forest is immune – see **Gap Process Map**. This is not a systematic or exhaustive set of observations – the idea to separately track gap process failure as a phenomenon did not exist at the start of the fieldwork but rather arose by necessity out of it. However, a systematic assessment of gap process failure could certainly be done.

Instances of gap process failure were observed both in areas that had been managed (by logging) and in areas where no management has occurred in recent decades. In some cases, in managed areas, the management took place prior to the 2012 Forest Stewardship Plan (which, in turn, helped shape ideas about management at the time of the 2012 plan, including the key idea of avoiding management where non-native invasive plants were already established). In some cases, the management took place prior to Northampton DPW becoming owner of the property. In some cases, the management took place despite the awareness that regeneration would fail – this occurred in situations in which DPW was forced to respond to severe outbreaks of pests and pathogens (e.g., red pine scale in red pine plantations and white pine needle disease in white pine stands).

According to the notes taken in each documented case of gap process failure, bittersweet was the factor most commonly associated with an occurrence of gap process failure; it was associated with 71% of all occurrences – see **Table: Factors associated with gap process failure**. Grapes and hayscented fern were associated with 47% and 26% of all

occurrences of gap process failure, followed by barberry, mountain laurel and multiflora rose. It is assumed and understood the deer browse was impacting 100% of these instances. The extent to which bittersweet or grapes may be initially *triggering* a gap process failure, or, alternatively, may simply becoming *part* of a developing gap process failure, is not known at this time. But it is reasonable to assume that in a gap process that does have a presence of either bittersweet vines or grape vines, there is no automatic mechanism within the forest ecosystem that will tend to reduce that presence; to the contrary, once present at a disturbed site (i.e., a site with a canopy gap) there is a strong likelihood that the impact of bittersweet and grapes will only increase over time, leading ever close toward to instances of complete regeneration failure.

Table: Factors associated with gap process failure

Factor	# Occurrences	% of occurrences
Bittersweet	47	71%
Grapes	31	47%
Hayscented fern	17	26%
Barberry	10	15%
Mountain laurel	5	8%
Multiflora rose	5	8%
Browse by deer	assumed	100%

An important variation of the phenomenon of gap process failure is a situation in which trees *do* become established, but the *species diversity* of these trees represents a very narrow subset of the total diversity of trees found in the overstory. Or, alternatively, it is a situation in which trees become established in *part* of the gap, while the remainder of the gap fills with undesirable vegetation. For purposes of this Forest Stewardship Plan, this variation is referred to, literally, as *gap process partial success*. A total of 28 instances of gap process *partial success* were noted – see **Table: Factors associated with gap process partial success**.

Black birch saplings were the most common feature of partially successful gaps, occurring at 82% of locations. Hayscented fern was the second-most common feature, occurring at 32% of locations. It appeared that black birch is able to shade out hayscented fern, killing it, as long as the deer or moose do not browse the black birch too severely at first. Once hayscented fern becomes established in a thick mat, however, there does not seem to be any way for the birch to regain an advantage. Interestingly, both red oak seedlings and hemlock saplings were relatively common in partially successful gaps, though neither may be able to survive the onslaught of browsing. A number of other oak seedlings (white oak and chestnut oak) and maple saplings (sugar maple and red maple) were also observed. Notably, interfering vegetation was uncommon in partially successful gaps, with mountain laurel occurring at 11%, bittersweet and barberry at 4% each and grapes at 0% of partially successful gaps.

Table: Factors associated with gap process PARTIAL SUCCESS (28 occurrences)

Factor	# Occurrences	% of occurrences
Black birch saplings	23	82%
Hayscented fern	9	32%
Red oak seedlings	6	21%
Hemlock saplings	6	21%
Mountain laurel	3	11%
White pine saplings	3	11%
Chestnut oak seedlings	2	7%
White oak seedlings	1	4%
Sugar maple saplings	1	4%
Red maple saplings	1	4%
Bittersweet	1	4%
Barberry	1	4%
Grapes	0	0%
Browse by deer	assumed	100%

From looking at the **Overview Map – Gap process failure and partial success**, which shows 66 documented locations of gap process failure (and only 28 locations of gap process success), it is apparent that failures to regenerate are not limited to any particular section of the forest, but can occur anywhere. Occurrences of gap process failure and its close cousin gap process *partial* success should be of great concern in a watershed forest that relies on complex vertical structure to provide necessary water quality functions over time. And it is especially alarming when these become the new normal, as is the case here!

Summary: the risk of deterioration

With its vast extent of complex structure and species-diverse composition, the Northampton DPW watershed forest is currently providing a high level of water quality function. But this is at risk. Going forward, as the forest loses overstory trees at an accelerated rate due to pests, pathogens and storms and yet simultaneously is unable to rejuvenate itself with sufficient quantity of young trees of a sufficient diversity of species, the complex structure and diverse species composition described in this Forest Stewardship Plan will inevitably begin to transition to a forest with a simplified structure and an impoverished species mix which, ultimately, will lead to a reduced level of overall water quality function.

Key Findings and Management Overview

The challenge for water supply: maintenance, resilience and adaptation

The challenge facing the City of Northampton as a water supplier is to maintain the forest in a condition that provides a high degree of water quality function in the watershed forests over time even as the forest itself is subject to powerful forces of deterioration.

The severity of the challenge is underscored by the multiple pathways and mechanisms by which the forest can fail to rejuvenate and perpetuate, which is exemplified in numerous occurrences of gap-process failure. A passive approach of generally letting the forest continue to mature, relying on its inherent tendency to change slowly at large scales, will seem to be working in the short term but offers no protection against the longer-term, progressive deterioration that will be driven by interfering factors. That said, an active, head-on approach that seeks to encourage resilience and promote adaptation by directly countering interfering factors may only yield partial success, especially at a meaningful scale. This may be especially true if key tools are not available to directly counter the threats that have been identified. But even if all currently-available tools are employed at a large scale, the challenge will remain significant.

Maintaining the watershed forest in a desirable condition in the future clearly depends on the ability of a full diversity of young trees to become established and thrive in response to – or despite – the events and conditions of the present and future. The ability of the forest to provide water quality functions in the future forest depends on the ongoing establishment of an adequate quantity and diversity of young trees to replace existing trees that die.

If it were possible to predictably and reliably regenerate a diverse mix of tree species, then one could consider adding to the current complexity and, potentially, the resiliency and adaptability of the forest by establishing patches of young trees of diverse species interspersed within the established, mature forest. In this case, one could use regeneration methods to maintain species diversity (of tree species and wildlife) and simultaneously encourage the establishment of those species – including uncommon species – that are already present (such as mixed oaks and hickories) that are thought to be better, potentially, prepared for anticipated climate change. Opportunities to do this could be carefully planned and implemented at convenient times and in a suitable distribution across the watershed forest. Indeed, just a decade ago, the Forest Stewardship Plan was prepared on the prevailing and optimistic view that the watershed forest could be managed in this way and even produce timber and provide a broad diversity of forested habitats – including early-successional habitats – that could sustain a broad array of wildlife while first and foremost maintaining the key watershed functions of the forest. Now, just ten years later, the picture is much less optimistic, and the focus has already shifted to anticipating and directly combatting factors that directly threaten the core water quality functions of the forest.

We know that the current forest is well-suited as it is now to providing the water quality services we rely on in the near term. But there is a clear risk that this will become less true over time. We know that an increasing number of tree-health issues are affecting trees in the current canopy and midstory. These impacts will only increase over time. At the same time, we know that a resilient forest's natural response to such health issues affecting established trees is to develop a species-diverse mix of new, site-adapted trees for future overstories. Also, we know that as storms naturally occur, snapping or blowing down trees in the current canopy, or as severe droughts occur, the forest will, naturally, attempt to replace the storm-affected or drought-affected trees with new, site-adapted

native trees. This response mechanism will be automatically triggered all the more if changes in the climate lead to an increase in the frequency or severity of storms or drought.

Yet we also know that the current forest contains tree species diversity—especially species of oaks and hickory that are at the northern end of their natural ranges—that may be beneficial in adapting to changing climate. If trees in the current overstory begin to experience extreme stress due to climate change, or as climate change triggers the spread of new pests, pathogens and diseases spread to the Northampton DPW watershed forest, or intensifies the impacts of those already present, the forest’s natural mechanism of adaptation is to capitalize on existing seed and propagule sources from a diverse array of native trees to develop new trees that are adapted to the site and to the prevailing climate.

In fact, the creation of gaps in the canopy by the natural processes described above can stimulate rejuvenation and diversity in the forest. The capability of the forest over time to provide new trees for naturally-occurring gaps is the basis for the perpetuation of the forest and has by and large given is the forest of today (only a small fraction of the forest was planted).

In this light, the rejuvenating and diversifying benefits of gaps in the forest are also the motivation for the application of silviculture in a watershed forest. Here, as well, the success of the silviculture hinges on the forest’s natural tendency and ability to provide young trees to fill the gaps created intentionally through the application of silviculture.

In theory, the forest is able to respond to any loss of current, established trees by replacing those trees with new trees. But it can only do this through the mechanism of regeneration, i.e., the process of establishing new trees. Unfortunately, as is already plainly in evidence now, the forest’s ability to develop new trees for future overstories is coming under enormous stress and is greatly compromised. This is especially true in terms of the species-diversity of the young trees the forest is currently able to establish. Increasingly, this is even becoming true for any and all trees (**see Figure: Gap process failure**).

Major Tables, Figures, Maps for Overview

Tables, figures and maps that are not embedded in the preceding text are contained in the following section.

Overview Tables

Forestwide Overstory Table 1 – Basic forest parameters at systematic plots (n = 318) Overstory Species (or midstory)	Diversity group	Total Live & Dead Basal Area (BA) Per Acre (sq ft)	LIVE BA	% of total LIVE BA	Running Total % of Live BA (a)	Trees per acre	Live trees per acre	% of Live trees per acre	Running Total % of live trees per acre (b)	Dead trees per acre	Diameter (in.) (QMD)
Pine WHITE	Common	29.4	26.5	19.4%	19.4%	19.1	13.6	5%	5%	5.5	16.8
Birch black	Common	23.1	21.5	15.7%	35.2%	62.0	60.1	23%	28%	1.9	8.3
Hemlock (midst.)	Common midst.	17.7	13.5	9.9%	45.0%	59.3	47.7	18%	47%	11.6	7.4
Maple red	Common	17.0	15.1	11.0%	56.1%	39.7	34.9	13%	60%	4.7	8.9
Oak RED	Common	16.9	16.4	12.0%	68.0%	9.6	9.2	4%	64%	0.4	17.9
Hemlock	Common	11.9	10.1	7.4%	75.4%	8.0	6.9	3%	66%	1.0	16.6
Maple sugar	Common	11.2	11.1	8.1%	83.5%	20.6	20.4	8%	74%	0.1	10.0
Birch paper	Common	4.7	2.9	2.1%	85.6%	8.3	4.2	2%	76%	4.1	10.1
Birch yellow	Common	4.4	3.9	2.9%	88.5%	16.5	14.5	6%	81%	2.0	7.0
Ash white	Common	4.2	3.3	2.4%	90.9%	5.7	4.3	2%	83%	1.4	11.6
Beech	Common	3.6	3.0	2.2%	93.1%	8.7	8.1	3%	86%	0.5	8.8
Cherry black	Common	2.8	2.1	1.6%	94.7%	6.7	4.5	2%	88%	2.2	8.7
Beech (midst.)	Common midst.	1.6	1.6	1.2%	95.9%	17.7	17.7	7%	95%	0.0	4.1
Hickory shagbark	Uncommon	0.9	0.9	0.6%	96.5%	1.3	1.3	0%	95%	0.0	11.2
Oak chestnut	Uncommon	0.8	0.6	0.5%	97.0%	0.9	0.7	0%	96%	0.1	12.6
Ironwood	Uncommon midst.	0.6	0.6	0.5%	97.4%	5.4	5.4	2%	98%	0.0	4.6
Oak scarlet	Uncommon	0.6	0.6	0.5%	97.9%	0.4	0.4	0%	98%	0.0	17.8
Hickory bitternut	Uncommon	0.5	0.5	0.4%	98.3%	2.9	2.9	1%	99%	0.0	5.6
Hickory pignut	Uncommon	0.4	0.4	0.3%	98.5%	0.7	0.7	0%	99%	0.0	10.1
Poplar bigtooth	Uncommon	0.3	0.3	0.2%	98.7%	0.3	0.3	0%	99%	0.0	11.9
Basswood	Uncommon	0.3	0.3	0.2%	98.9%	0.4	0.4	0%	99.5%	0.0	11.5
Fir balsam (midst.)	Uncommon midst.	0.1	0.1	0.1%	99.0%	0.4	0.4	0%	99.6%	0.0	8.0
Oak white	Uncommon	0.1	0.1	0.1%	99.1%	0.1	0.1	0%	99.6%	0.0	16.0
Other*	NA	0.00	0.0	0.00%	99.1%	0.0	0.0	0%	99.6%	0.0	0.0
Black ash	Uncommon		0.0	0.0%	99.1%			0%	99.6%		
Black oak	Uncommon		0.0	0.0%	99.1%			0%	99.6%		
Cottonwood	Uncommon		0.0	0.0%	99.1%			0%	99.6%		
Elm	Uncommon		0.0	0.0%	99.1%			0%	99.6%		
Fir balsam	Uncommon		0.0	0.0%	99.1%			0%	99.6%		
Red spruce (midst.)	Uncommon midst.		0.0	0.0%	99.1%			0%	99.6%		
Pin cherry	Uncommon		0.0	0.0%	99.1%			0%	99.6%		
Pitch pine	Uncommon		0.0	0.0%	99.1%			0%	99.6%		
Red spruce	Uncommon		0.0	0.0%	99.1%			0%	99.6%		
Sassafras	Uncommon		0.0	0.0%	99.1%			0%	99.6%		
Tulip poplar	Uncommon		0.0	0.0%	99.1%			0%	99.6%		
<i>Pine red</i>	<i>Plantation</i>	2.3	0.9	0.6%	99.7%	2.5	0.7	0.29%	99.9%	1.7	12.9
<i>Scots pine</i>	<i>Plantation</i>	0.1	0.1	0.1%	99.8%	0.1	0.1	0.03%	100.0%	0.0	16.0
<i>Norway spruce</i>	<i>Plantation</i>	0.3	0.3	0.2%	100.0%	0.1	0.1	0.04%	100.0%	0.0	20.1
Total		155.7	136.6	100.0%		297.2				37.4	9.8
TOTAL - LIVE ONLY		136.6				259.7	259.7	100%			9.8

*"Other" is an unexplained artefact of the data processing. Basal area (BA) is in square feet per acre (BA is a measure of site occupancy), diameter (size) is average tree size or stand diameter (MSD) (quadratic mean stand diameter by species in inches).

Forestwide Overstory Table 2 – Species presence and abundance at systematic plots (n = 318) Overstory Species (or midstory)	Diversity group	Average Abundance LEVEL** (range = 0 - 3)	% of Plots PRESENT (a)	% of Plots ABSENT	LEVEL1 – present (% of plots 1 tree seen)	LEVEL2 – common (% of plots 2-5 trees seen)	LEVEL3 – abundant (% of plots ≥ 6 trees seen) (b)	Add # of separate sightings (as- encountered) (a sighting may include multiple trees) (c)
Birch black	Common	2.03	83%	17%	10%	26%	47%	0
Maple red	Common	1.69	79%	21%	14%	38%	26%	0
Oak RED	Common	1.48	69%	31%	16%	28%	25%	0
Pine WHITE	Common	1.48	61%	39%	8%	17%	35%	0
Hemlock (midst.)	Common midst.	1.30	77.6%	22%	25%	52%	0%	0
Beech (midst.)	Common midst.	1.23	75.0%	25%	28%	47%	0%	0
Hemlock	Common	1.12	49%	51%	8%	20%	21%	0
Maple sugar	Common	0.86	45%	55%	14%	20%	10%	0
Birch paper	Common	0.75	42%	58%	18%	15%	9%	0
Beech	Common	0.75	42%	58%	18%	16%	8%	0
Birch yellow	Common	0.64	37%	63%	15%	16%	6%	0
Ash white	Common	0.64	38%	62%	18%	15%	5%	0
Cherry black	Common	0.53	31%	69%	15%	10%	6%	0
Hickory bitternut	Uncommon	0.11	8%	92%	5%	3%	0%	130
Hickory shagbark	Uncommon	0.09	6%	94%	3%	2%	1%	104
Oak chestnut	Uncommon	0.08	4%	96%	2%	1%	1%	59
Poplar bigtooth	Uncommon	0.08	4.7%	95%	2%	2%	1%	39
Oak scarlet	Uncommon	0.07	3.5%	97%	1%	2%	1%	44
Hickory pignut	Uncommon	0.05	2.2%	98%	0%	1%	1%	59
Basswood	Uncommon	0.04	2.2%	98%	1%	1%	0%	43
Oak white	Uncommon	0.03	3.1%	97%	3%	0%	0%	34
Pitch pine	Uncommon	0.02	1.3%	99%	0%	1%	0%	37
Red spruce (midst.)	Uncommon midst.	0.02	0.9%	99.1%	0%	1%	0%	5
Fir balsam (midst.)	Uncommon midst.	0.01	0.6%	99.4%	0%	1%	0%	0
Elm	Uncommon	0.01	0.6%	99%	0%	0%	0%	6
Black ash	Uncommon	0.01	0%	100%	0%	0%	0%	1
Black oak	Uncommon	0.01	0.6%	99%	1%	0%	0%	12
Pin cherry	Uncommon	0.01	0.6%	99%	1%	0%	0%	1
Red spruce	Uncommon	0.00	0.3%	99.7%	0.3%	0.0%	0.0%	7
Ironwood	Uncommon	0.00						56
Other*	NA	0.00						0
Cottonwood	Uncommon							3
Fir balsam	Uncommon							0
Sassafras	Uncommon							1
Tulip poplar	Uncommon							1
Norway spruce	Plantation	0.03	1%	99%	0%	1%	1%	0
Pine red	Plantation	0.03	1%	99%	0%	1%	1%	0
Scots pine	Plantation	0.03	1%	99%	0%	0%	1%	0
Total								642

*"Other" is an unexplained artefact of the data processing. **Abundance level: At each plot, for each overstory tree species, it was determined whether the species was absent, present, or abundant within the entire extent of what could be viewed from the plot center. This is not a fixed distance and depends on visibility factors at the site. For example, if an observer can see approximately 150' in all directions, then about 1.5 acres is captured. If an overstory species could not be seen, it was marked absent and given a value of 0. If only a single individual was observed, it was considered present and a value of 1 was assigned. If 2-5 individuals were observed, the species was considered common and a value of 2 was assigned. A value of 3 was assigned for observations of 6 or more individuals; in this case, the species was considered abundant.

Forestwide Overstory Table 3 – Wood volumes Overstory and Midstory Species at systematic plots (n = 318)	Volume of usable timber (Mbf/ac)	Additional stem volume (cords per acre)	Cord- equivalent wood volume per acre (MBF X 2 + cords)	% of total Cord- equivalent wood volume (MBF X 2 + cords)	Running Total % of Cord- equivalent wood volume (a)
Pine WHITE	4.40	3.4	12.2	33.1%	33%
Oak RED	1.82	1.3	4.9	13.3%	46%
Hemlock	1.08	1.3	3.4	9.2%	56%
Birch black	0.75	3.1	4.6	12.4%	68%
Maple red	0.50	2.4	3.3	9.1%	77%
Maple sugar	0.49	1.5	2.5	6.7%	84%
Ash white	0.25	0.4	0.9	2.5%	86%
Birch paper	0.15	0.4	0.7	1.9%	88%
Cherry black	0.14	0.3	0.5	1.5%	90%
Pine red	0.13	0.1	0.3	0.9%	91%
Birch yellow	0.09	0.4	0.6	1.6%	92%
Norway spruce	0.06	0.0	0.1	0.3%	93%
Oak scarlet	0.06	0.1	0.2	0.5%	93%
Beech	0.06	0.4	0.5	1.4%	95%
Hickory bitternut	0.04	0.0	0.1	0.3%	95%
Other*	0.03	0.1	0.2	0.4%	95%
Hemlock (midst.)	0.02	0.9	1.0	2.7%	98%
Poplar bigtooth	0.02	0.0	0.1	0.2%	98.2%
Oak chestnut	0.02	0.1	0.1	0.4%	98.6%
Hickory pignut	0.01	0.1	0.1	0.2%	98.8%
Hickory shagbark	0.01	0.2	0.2	0.5%	99.3%
Beech (midst.)	0.00	0.2	0.2	0.5%	99.9%
Basswood	0.00	0.0	0.0	0.0%	99.9%
Fir balsam (midst.)	0.00	0.0	0.0	0.0%	99.9%
Ironwood	0.00	0.0	0.0	0.1%	100.0%
Scots pine	0.00	0.0	0.0	0.00%	
Oak white	0.00	0.0	0.0	0.00%	
Black ash			0.0	0.00%	
Black oak			0.0	0.00%	
Cottonwood			0.0	0.00%	
Elm			0.0	0.00%	
Fir balsam			0.0	0.00%	
Red spruce (midst.)			0.0	0.00%	
Pin cherry			0.0	0.00%	
Pitch pine			0.0	0.00%	
Red spruce			0.0	0.00%	
Sassafras			0.0	0.00%	
Tulip poplar			0.0	0.00%	
	10.14	16.6	36.9	100%	

**Other" is an unexplained artefact of the data processing. Timber volume (in thousand board feet per acre, International ¼" rule), cords of stemwood per acre (1 cord = 128 cubic feet of wood, bark and air) including stemwood or significant branchwood above sawlogs but not including other topwood. Cord equivalent wood volume, or total stem biomass, is calculated as follows: Mbf X 2 + cords.

Overview Table 1:Core forest parameters by watershed

Ryan & West-Whately

Statistical parameters (a)

Sampling Statistics	All Saw timber (MBF)	All Cord products	LIVE Basal Area (sq-ft/ ac)	TOTAL LIVE Trees per Acre
Mean	9.4	17.7	140.4	263.9
Variability (+/- % Sampling Error of Mean at 90% confidence level)	9.6%	7.2%	5.5%	12.8%
Lower end of range (at 90% confidence level)	8.5	16.5	133	230
Upper end of range (at 90% confidence level)	10.3	19.0	148	298
Apprx pts deeded for ≤ 10% Sampling error	240	135	79	436
Coeffient of variation	93%	70%	54%	126%
Parameters	# Acres: 2,522.20		# Plots: 255	
Sampling intensity	9.9 ac/plot			

Mountain Street

Statistical parameters (a)

Sampling Statistics	All Saw (MBF)	All Cords products	BA	TPA
Mean	13.1	11.9	121.3	244.0
Variability (+/- % Sampling Error of Mean at 90% confidence level)	18.9%	17.2%	11.0%	39.8%
Lower end of range (at 90% confidence level)	10.6	9.8	108	147
Upper end of range (at 90% confidence level)	15.5	13.9	135	341
Apprx pts deeded for ≤ 10% Sampling error	222	185	75	1,111
Coeffient of variation	90%	82%	52%	201%
Parameters	# Acres: 650.80		# Plots: 63	
Sampling intensity	10.3 ac/plot			

Site occupancy by trees and size (b)

Species as Observed at 255 Plots	LIVE Basal Area (sq-ft/ ac)	% of LIVE BA	Running total % of LIVE BA	TOTAL LIVE Trees per Acre	Avg. Diameter (in.) (QMD)
Birch black	22.1	15.8%	15.8%	56.0	8.5
Pine WHITE	21.0	15.0%	30.7%	11.4	18.4
Oak RED	17.7	12.6%	43.4%	9.8	18.3
Maple red	16.2	11.5%	54.9%	29.1	10.1
Hemlock midstory	15.2	10.8%	65.7%	55.4	7.1
Maple sugar	12.1	8.6%	74.3%	24.4	9.5
Hemlock	11.9	8.5%	82.8%	8.2	16.3
Birch yellow	4.5	3.2%	86.0%	16.9	7.0
Ash white	3.9	2.8%	88.8%	5.2	11.8
Beech	3.8	2.7%	91.5%	10.2	8.2
Birch paper	3.1	2.2%	93.7%	4.8	11.0
Cherry black	2.4	1.7%	95.4%	5.1	9.2
Beech midstory	1.7	1.2%	96.6%	13.0	4.9
Pine red	1.1	0.8%	97.4%	0.9	14.7
Hickory shagbark	0.9	0.7%	98.1%	1.5	10.8
hophornbeam	0.8	0.6%	98.7%	6.7	4.6
Hickory bitternut	0.6	0.4%	99.1%	3.7	5.6
Norway spruce	0.3	0.2%	99.3%	0.1	20.1
Poplar bigtooth	0.3	0.2%	99.6%	0.4	11.9
Basswood	0.3	0.2%	99.8%	0.4	11.5
Scots pine	0.2	0.1%	99.9%	0.1	16.0
Fir balsam	0.2	0.1%	100.0%	0.4	8.0
Total Live Only	140.4	100%		263.7	9.9
Dead Only	19.6			39.7	
Total Live & Dead	160.0			298.8	9.8
Dead as % of Total	12.3%			13.3%	
Combined hemlock overstory and midstory		19%		64	

Site occupancy by trees and size (b)

Species as Observed at 63 Plots	LIVE Basal Area (sq-ft/ ac)	% of LIVE BA	Running total % of LIVE BA	TOTAL LIVE Trees per Acre	Avg. Diameter (in.) (QMD)
Pine WHITE	48.9	40.3%	40.3%	22.6	19.9
Birch black	19.0	15.7%	56.0%	76.4	6.8
Maple red	10.8	8.9%	64.9%	58.4	5.8
Oak RED	10.8	8.9%	73.8%	7.1	16.7
Maple sugar	7.0	5.8%	79.6%	4.3	17.2
Hemlock midstory	6.3	5.2%	84.8%	16.7	8.3
Oak scarlet	3.2	2.6%	87.4%	1.8	17.8
Oak chestnut	3.2	2.6%	90.1%	3.7	12.5
Hemlock	2.5	2.1%	92.1%	1.7	16.6
Birch paper	1.9	1.6%	93.7%	2.0	13.2
Hickory pignut	1.9	1.6%	95.3%	3.4	10.1
Birch yellow	1.3	1.0%	96.3%	5.1	6.8
Cherry black	1.3	1.0%	97.4%	2.1	10.6
Beech midstory	1.3	1.0%	98.4%	36.4	2.5
Oak white	0.6	0.5%	99.0%	0.5	16.0
Hickory shagbark	0.6	0.5%	99.5%	0.6	14.0
Ash white	0.6	0.5%	100.0%	0.7	13.0
			100.0%		
			100.0%		
			100.0%		
			100.0%		
Total Live Only	121.3	100%		243.6	9.6
Dead Only	17.1			25.5	
Total Live & Dead	138.4			266.9	
Dead as % of Total	12.4%			9.6%	
Combined hemlock overstory and midstory		7%		18	

Wood Volumes (c)

Species as Observed at 255 Plots	Volume of usable timber per acre (Mbf/ac)	TOTAL Volume of usable timber (Mbf)	Additional stem volume (cords per acre)	TOTAL Additional stem volume (cords)	Cord-equivalent wood volume per acre (MBF X 1.5 + cords)
Pine WHITE	3.2	7,986	3.1	7,840	7.9
Oak RED	2.0	5,016	1.4	3,555	4.4
Birch black	0.8	1,915	3.3	8,393	4.5
Hemlock	1.3	3,206	1.5	3,770	3.4
Maple red	0.5	1,371	2.6	6,457	3.4
Maple sugar	0.5	1,318	1.8	4,451	2.5
Hemlock midstory	0.0	56	1.1	2,680	1.1
Birch yellow	0.1	294	0.5	1,233	0.7
Ash white	0.3	780	0.5	1,216	0.9
Birch paper	0.2	404	0.4	1,094	0.7
Beech	0.1	174	0.5	1,297	0.6
Cherry black	0.1	359	0.3	747	0.5
Pine red	0.2	417	0.1	202	0.3
Beech midstory	0.0	0	0.2	567	0.2
Hickory shagbark	0.0	0	0.2	477	0.2
Hickory bitternut	0.0	113	0.1	147	0.1
Norway spruce	0.1	192	0.0	12	0.1
Poplar bigtooth	0.0	69	0.1	128	0.1
hophornbeam	0.0	0	0.1	150	0.1
Basswood	0.0	0	0.1	167	0.1
Scots pine	0.0	30	0.0	78	0.0
Fir balsam	0.0	0	0.0	74	0.0
Watershed Total	9.4	23,699	17.7	44,734	31.8

Wood Volumes (c)

Species as Observed at 63 Plots	Volume of usable timber per acre (Mbf/ac)	TOTAL Volume of usable timber (Mbf)	Additional stem volume (cords per acre)	TOTAL Additional stem volume (cords)	Cord-equivalent wood volume per acre (MBF X 1.5 + cords)
Pine WHITE	9.3	6,075	4.5	2,945	18.5
Birch black	0.7	474	2.0	1,298	3.1
Oak RED	1.1	748	0.7	469	2.4
Maple sugar	0.4	239	0.4	287	1.0
Maple red	0.3	202	1.5	976	2.0
Hemlock midstory	0.0	18	0.4	270	0.5
Oak scarlet	0.3	197	0.4	256	0.8
Oak chestnut	0.1	50	0.6	362	0.7
Hemlock	0.3	186	0.3	180	0.7
Hickory pignut	0.1	46	0.3	165	0.4
Birch paper	0.1	79	0.3	192	0.5
Cherry black	0.1	82	0.2	104	0.3
Birch yellow	0.0	0	0.0	31	0.0
Oak white	0.1	54	0.0	15	0.1
Hickory shagbark	0.1	43	0.1	48	0.2
Ash white	0.0	18	0.1	68	0.1
Beech midstory	0.0	0	0.1	63	0.1
Watershed Total	13.1	8,511	11.9	7,730	31.5

Forest Overstory by Watershed Table 2A - Species composition and diversity

Species -- Ryan and West-Whately watershed -- Species presence and abundance at systematic plots (n = 255) and as-encountered	Diversity group	AVG ABUNDANCE LEVEL at PLOTS	PRESENT at PLOTS	# of as-encountered sightings (a sighting may include multiple trees) (d)	Species -- Mountain Street watershed -- Species presence and abundance at systematic plots (n = 63) and as-encountered	Diversity group	AVG ABUNDANCE LEVEL at PLOTS	PRESENT at PLOTS	# of as-encountered sightings (a sighting may include multiple trees) (d)
Birch black	Common	2.00	83%		Birch black	Common	2.17	84%	
Maple red	Common	1.67	77%		Pine WHITE	Common	2.02	76%	
Oak RED	Common	1.60	74%		Maple red	Common	1.81	84%	
Beech (midst.)	Common midst.	1.41	85%		Oak RED	Common	1.00	52%	
Hemlock (midst.)	Common midst.	1.38	82%		Hemlock (midst.)	Common midst.	1.00	59%	
Pine WHITE	Common	1.35	57%		Maple sugar	Common	0.89	48%	
Hemlock	Common	1.28	56%		Cherry black	Common	0.45	28%	
Maple sugar	Common	0.86	45%		Hemlock	Common	0.44	21%	
Beech	Common	0.85	47%		Birch paper	Common	0.44	29%	
Birch paper	Common	0.83	45%		Beech (midst.)	Common midst.	0.44	32%	
Ash white	Common	0.71	42%		Birch yellow	Common	0.41	22%	
Birch yellow	Common	0.70	40%		Beech	Common	0.32	22%	
Cherry black	Common	0.54	32%		Ash white	Common	0.32	21%	
Hickory bitternut	Uncommon	0.13	9%	115	Oak chestnut	Uncommon	0.40	21%	59
Hickory shagbark	Uncommon	0.10	6%	87	Hickory pignut	Uncommon	0.25	11%	56
Ironwood	Uncommon			44	Oak scarlet	Uncommon	0.35	17%	43
Basswood	Uncommon	0.05	3%	36	Oak white	Uncommon	0.17	16%	34
Pitch pine	Uncommon	0.03	2%	36	Hickory shagbark	Uncommon	0.08	6%	17
Poplar bigtooth	Uncommon	0.07	4%	25	Hickory bitternut	Uncommon	0.02	2%	15
Red spruce	Uncommon	0.00	0%	7	Poplar bigtooth	Uncommon	0.11	8%	14
Red spruce (midst.)	Uncommon midst.	0.02	1.2%	5	Black oak	Uncommon	0.03	3.2%	12
Hickory pignut	Uncommon	0.00	0%	3	Ironwood	Uncommon			12
Cottonwood	Uncommon			1	Basswood	Uncommon	0.00	0%	7
Oak scarlet	Uncommon	0.00	0%	1	Elm	Uncommon	0.02	2%	6
Sassafrass	Uncommon			1	Cottonwood	Uncommon			2
Tulip poplar	Uncommon			1	Black ash	Uncommon	0.03	2%	1
Black ash	Uncommon	0.00	0%	0	Pin cherry	Uncommon	0.00	0%	1
Black oak	Uncommon	0.00	0%	0	Pitch pine	Uncommon	0.00	0%	1
Oak chestnut	Uncommon	0.00	0%	0	Fir balsam	Uncommon			0
Elm	Uncommon	0.01	0%	0	Fir balsam (midst.)	Uncommon midst.	0.00	0%	0
Fir balsam	Uncommon			0	Other*	NA			0
Fir balsam (midst.)	Uncommon midst.	0.02	0.8%	0	Red spruce (midst.)	Uncommon midst.	0.00	0.0%	0
Other*	NA			0	Red spruce	Uncommon	0.00	0%	0
Pin cherry	Uncommon	0.01	1%	0	Sassafrass	Uncommon			0
Oak white	Uncommon	0.00	0%	0	Tulip poplar	Uncommon			0
Norway spruce	Plantation	0.04	2%		Norway spruce	Plantation	0.00	0%	
Pine red	Plantation	0.02	1%		Pine red	Plantation	0.06	3%	
Scots pine	Plantation	0.04	1%		Scots pine	Plantation	0.00	0%	

Note: Unlike species information based on basal area i.e. prism plots, abundance as used in this table is based on sighting at any distance from plot center (see methods) and is independent of diameter. As-encountered data is based on sightings of the species at any location *other than* at plots.

Forest Overstory by Watershed Table 2B - Detailed species composition and diversity

Species -- Ryan and West- Whately watershed -- Species presence and abundance at systematic plots (n = 255) and as- encountered	ABSENT at PLOTS	LEVEL1 – present (% of plots 1 tree seen)	LEVEL2 – common (% of plots 2-5 trees seen)	LEVEL3 – abundant (% of plots ≥ 6 trees seen) (b)	Species -- Mountain Street watershed -- Species presence and abundance at systematic plots (n = 63) and as- encountered	ABSENT at PLOTS	LEVEL1 – present (% of plots 1 tree seen)	LEVEL2 – common (% of plots 2-5 trees seen)	LEVEL3 – abundant (% of plots ≥ 6 trees seen) (b)
Birch black	17%	11%	26%	46%	Birch black	16%	5%	25%	54%
Maple red	23%	14%	38%	26%	Pine WHITE	24%	6%	14%	56%
Oak RED	26%	17%	28%	29%	Maple red	16%	16%	40%	29%
Beech (midst.)	15%	29%	55%	0%	Oak RED	48%	14%	29%	10%
Hemlock (midst.)	18%	26%	55%	0%	Hemlock (midst.)	41%	19%	41%	0%
Pine WHITE	43%	9%	18%	30%	Maple sugar	52%	14%	25%	8%
Hemlock	44%	9%	22%	25%	Cherry black	72%	13%	13%	2%
Maple sugar	55%	15%	19%	11%	Hemlock	79%	3%	11%	6%
Beech	53%	19%	18%	10%	Birch paper	71%	16%	10%	3%
Birch paper	55%	18%	16%	11%	Beech (midst.)	68%	20%	12%	0%
Ash white	58%	19%	17%	6%	Birch yellow	78%	10%	6%	6%
Birch yellow	60%	16%	19%	5%	Beech	78%	13%	10%	0%
Cherry black	68%	16%	9%	7%	Ash white	79%	11%	8%	2%
Hickory bitternut	91%	5%	3%	0%	Oak chestnut	79%	8%	6%	6%
Hickory shagbark	94%	3%	2%	1%	Hickory pignut	89%	2%	5%	5%
Ironwood					Oak scarlet	83%	3%	11%	3%
Basswood	97%	1%	1%	0%	Oak white	84%	14%	2%	0%
Pitch pine	98%	0%	1%	0%	Hickory shagbark	94%	5%	2%	0%
Poplar bigtooth	96%	2%	2%	1%	Hickory bitternut	98%	2%	0%	0%
Red spruce	100%	0.4%	0.0%	0.0%	Poplar bigtooth	92%	4.8%	3.2%	0.0%
Red spruce (midst.)	99%	0%	1%	0%	Black oak	97%	3%	0%	0%
Hickory pignut	100%	0%	0%	0%	Ironwood				
Cottonwood					Basswood	100%	0%	0%	0%
Oak scarlet	100%	0%	0%	0%	Elm	98%	2%	0%	0%
Sassafrass					Cottonwood				
Tulip poplar					Black ash	98%	0%	2%	0%
Black ash	100%	0%	0%	0%	Pin cherry	100%	0%	0%	0%
Black oak	100%	0%	0%	0%	Pitch pine	100%	0%	0%	0%
Oak chestnut	100%	0%	0%	0%	Fir balsam				
Elm	100%	0%	0%	0%	Fir balsam (midst.)	100%	0%	0%	0%
Fir balsam					Other*				
Fir balsam (midst.)	99%	0%	1%	0%	Red spruce (midst.)	100%	0%	0%	0%
Other*					Red spruce	100%	0%	0%	0%
Pin cherry	99%	1%	0%	0%	Sassafrass				
Oak white	100%	0%	0%	0%	Tulip poplar				
Norway spruce	98%	0%	1%	1%	Norway spruce	100%	0%	0%	0%
Pine red	99%	0%	0%	1%	Pine red	97%	0%	3%	0%
Scots pine	99%	0%	0%	1%	Scots pine	100%	0%	0%	0%

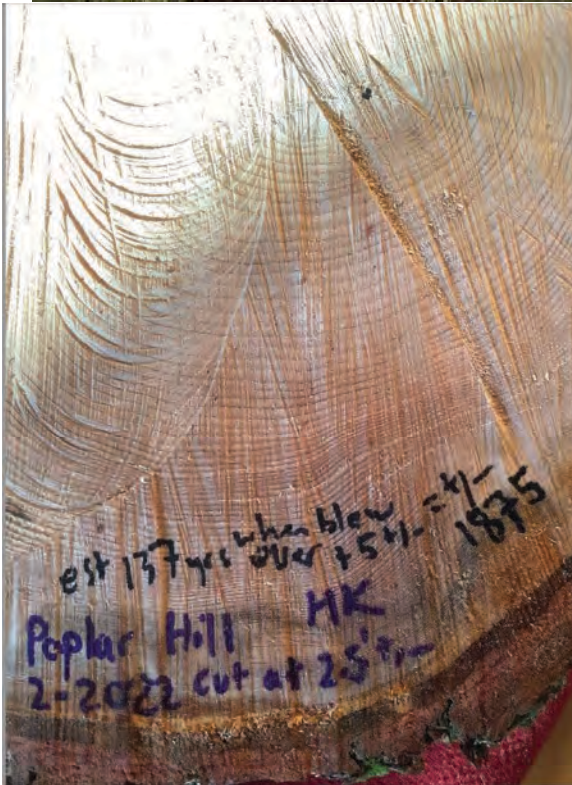
Note: Unlike species information based on basal area i.e. prism plots, abundance as used in this table is based on sighting at any distance from plot center (see methods) and is independent of diameter.

Overview Figures

Figure 1: Natural Aging and Disturbance in an Old Hemlock Grove (Dating to ca. 1875)



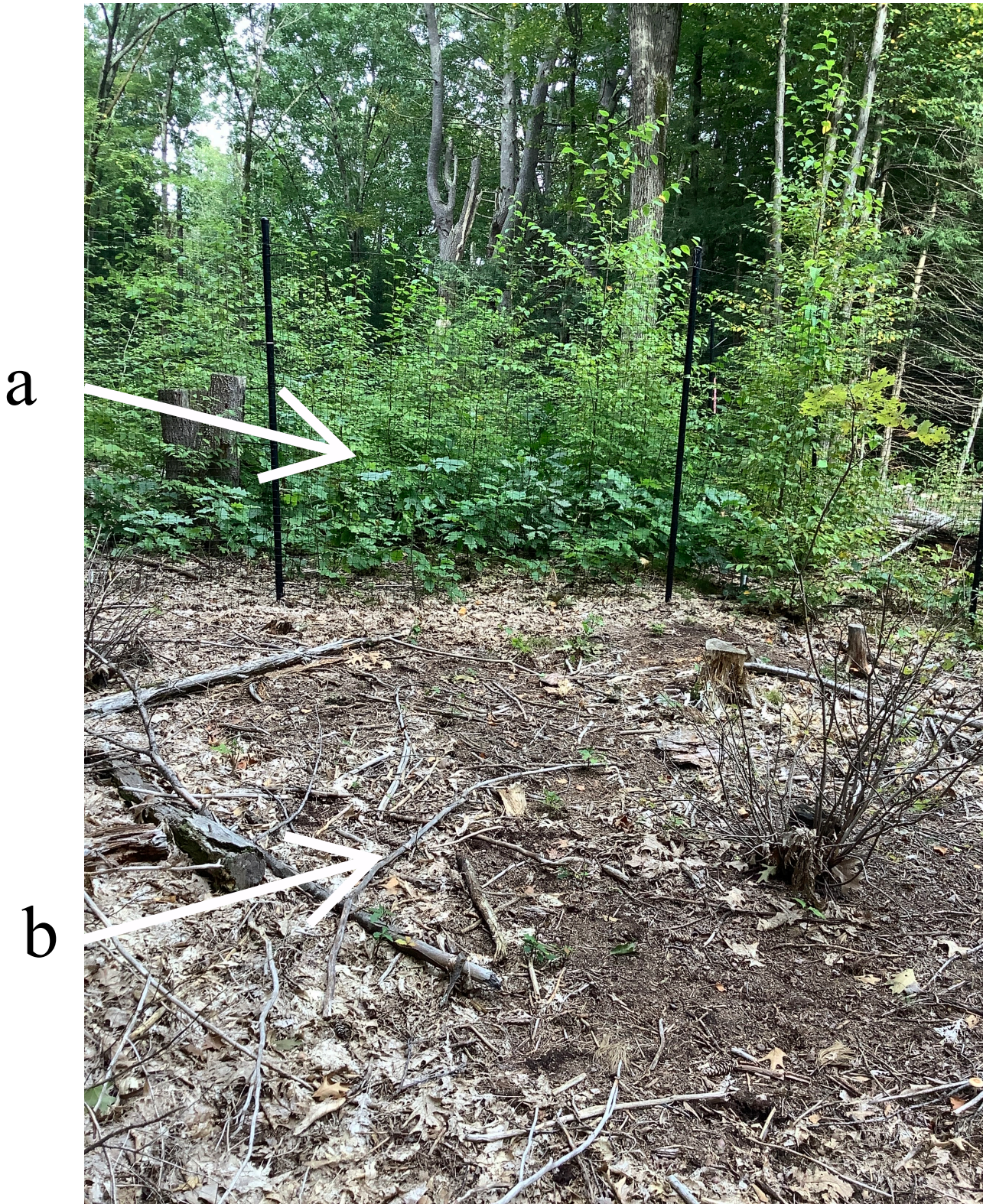
1a. Left: This example of mature hemlock forest is found on Poplar Hill (Stand 20, Ryan & West-Whately). As some trees have prevailed to become large and old, others have succumbed to wind or other disturbances (notice the snapped-off stem to the right of the main stem). 1b. Below: some of these mature hemlocks blew down (by uprooting) in one of the many storms over the past few years.



1c. This slice shown above was cut from the tree in the foreground in the picture on the right on 2/9/2022. The slice was cut at a height of about 3 feet above the root flare. Estimated age based on rings: 137 years. This suggests that the hemlock grove originated in about 1875, before the City began using this forest as a source of drinking water.



Figure 2a: Example of browse impacts on young trees (regeneration)



This picture shows the stark contrast in regeneration outcomes following a silvicultural harvest in 2014. In area (b), there are almost no young trees. In area (a), there is an abundance of young oaks and black birch. Each area received the same treatment. The difference in outcomes is explained by the impact of deer browse. In area (b), deer have normal access to the understory. By contrast, deer cannot access area (a) due to a 30'X30' experimental enclosure fence installed by Harvard Forest staff in 2017. The picture was taken in September, 2021, four growing seasons after the enclosure fence was installed.

Figure 2b: Detail of browse impacts on young trees (regeneration)

These pictures present details of the site shown in Fig. 2a. Picture (a) to the right shows an example of a healthy, thriving red oak seedling that is protected from deer browse by the exclosure mesh fence. The ability to grow healthy young trees of a full diversity of native tree species--such as the red oak shown here--is essential to ensuring water quality over the long term.

(a)



(b)



Picture (b) to the left shows the typical situation for a young oak tree that is exposed to excessive feeding by deer. This seedling growing just outside the exclosure is in poor health and is likely to continue to be browsed by deer until it ultimately dies. Excessive feeding by deer results when there is a high population of deer relative to their habitat needs; this has a profoundly negative impact on the forest.

Figure 2c. Negative Impacts of Deer Browsing Impacts on the Watershed Forest

To the right: One of the rarest occurrences to be seen across more than 3,000 acres of DPW watershed forest is a tall oak sapling that has escaped deer browse. This tree is part of a small cluster of tall oak saplings found in the dying red pine stand on the east side of the Mountain Street Reservoir in Stand 3. The only other occurrence of tall oak saplings within the forest was inside the fenced deer exclosure in Whately, east of the Ryan Reservoir in Stand 19. Though large oaks are a prominent feature and are abundant in the overstory, the number of young oaks ready to take their place is diminishingly small.



To the left: A very typical view of an oak seedling that has been browsed back to a few scraggly branches. In essence, it has been mutilated by deer, which bite off the tops of tree seedlings of species they prefer. Oaks are known for their ability to resprout, but then, at their current population levels, the deer tend to return and browse the same seedlings again and again. Eventually, the oak seedlings run out of energy and succumb, ceding the growing space to less desirable vegetation such as black birch or, worse, mountain laurel or hayscented fern.

Figure 2d: Initial response of oak seedlings to protection from browse impacts at two experimental enclosure sites

NASH HILL - 2018											
Seedling Species	BROWSED			NOT BROWSED			Seedling Species	BROWSED		NOT BROWSED	
	Stems per-acre (>6")	Avg Ht (in)*	Avg Ht (in)	Stems per-acre	Avg Ht (in)	Avg Ht (in)		Stems per-acre (>6")	Avg Ht (in)*	Stems per-acre	Avg Ht (in)
Acer sacharum	1480	9.7	6.7	80	6.7	6.7	Acer sacharum	0	-	0	-
Fagus grandifolia	80	18.5	39.1	1440	39.1	39.1	Fagus grandifolia	40	80	360	91
Acer rubrum	120	6.4	7.0	80	7.0	7.0	Acer rubrum	40	30	520	30.7
Carya cordiformis	200	7.3	8.0	120	8.0	8.0	Carya cordiformis	80	9	80	31.5
Quercus rubra (red oak)	160	8.4	24.9	320	24.9	24.9	Quercus rubra (red oak)	120	12	520	62.0
Fraxinus americana	360	9.7	26.0	40	26.0	26.0	Fraxinus americana	0	-	0	-
Betula lenta	1120	29.1	46.2	600	46.2	46.2	Betula lenta	920	84	2200	144
Acer pennsylvanicum	1000	45.5	44.1	440	44.1	44.1	Acer pennsylvanicum	440	84	760	144
Ulmus americana	0	-	16.4	160	16.4	16.4	Ulmus americana	0	-	0	-
Prunus pennsylvanica	0	-	32.7	160	32.7	32.7	Prunus pennsylvanica	0	-	120	47
Total	4520			3440			Total	1640		4560	

WHATELY ROAD - 2018											
Seedling Species	BROWSED			NOT BROWSED			Seedling Species	BROWSED		NOT BROWSED	
	Stems per-acre (>6")	Avg Ht (in)*	Avg Ht (in)	Stems per-acre	Avg Ht (in)	Avg Ht (in)		Stems per-acre (>6")	Avg Ht (in)*	Stems per-acre	Avg Ht (in)
Quercus rubra (red oak)	720	11.15	26.4	2360	26.4	26.4	Quercus rubra (red oak)	3400	11.3	4040	58.0
Betula lenta	80	8.14	40.4	1120	40.4	40.4	Betula lenta	280	23.7	1560	72
Prunus pennsylvanica	0	3.67	9.6	120	9.6	9.6	Prunus pennsylvanica	0	-	0	-
Acer rubrum	440	27.30	0.0	0	0.0	0.0	Acer rubrum	0	-	0	-
Total	1240			3600			Total	3680		5600	

NASH HILL - 2021											
Seedling Species	BROWSED			NOT BROWSED			Seedling Species	BROWSED		NOT BROWSED	
	Stems per-acre (>6")	Avg Ht (in)*	Avg Ht (in)	Stems per-acre	Avg Ht (in)	Avg Ht (in)		Stems per-acre (>6")	Avg Ht (in)*	Stems per-acre	Avg Ht (in)
Quercus rubra (red oak)	1760	10.7	26.2	1340	26.2	26.2	Quercus rubra (red oak)	1760	11.4	2280	58.5

* This is an average of the height of the three tallest trees of each species

This table shows changes in seedling abundance and height after four growing seasons at two sites which each featured both a 10m X 10m deer and moose enclosure and an adjacent unprotected control plot. Red oak is highlighted in green. One key conclusion is that red oak (Quercus rubra) is not only more abundant when protected from browse (see "not browsed" columns), but it is also much taller (approximately two and a half to five times taller). The red oak seedlings protected from browse impacts are rapidly growing toward future overstory status, more than doubling in height in just three growing seasons, while the oaks that are exposed to ambient levels of browse impacts are barely growing taller or are even stagnating. 2021 data gathered by Johanna Stacy. 2018 data gathered by Jason Aylward.

Figure 3a: Oriental Bittersweet -- a Non-Native Invasive Vine That Chokes Out The Growth of Desirable Young Trees



This thick understory of oriental bittersweet vines has taken over the understory of an area of forest near the Water Treatment Plant (Stand 8). Formerly a red pine plantation, this area is now a novel forest type - a savanna of hardwoods, especially black birch, with a thick understory of bittersweet. Photo taken early fall, 2021.

Figure 3b: Oriental Bittersweet -- a Non-Native Invasive Vine That Can Grow to Large Size and Interfere With The Growth of the Forest



This established black cherry tree is swamped with mature bittersweet vines. The cherry tree is already half dead (this may be unrelated to the vines). When this tree dies and fall, the new opening in the forest will be taken over by bittersweet, preventing the growth of new trees, leading to a deterioration of the watershed forest. Photo taken fall, 2022, in Stand 1 at the Mountain Street Reservoir.

Figure 4: Watershed forest areas maintained by mowing as a partial response to non-native invasive plants



4a. (left) This former red pine plantation near the Water Treatment Plant has been converted to a mowed savanna of hardwood trees that is unable to regenerate new trees or develop a layered midstory canopy due to the persistent presence of bittersweet. This is not a type of forest that is ideal for water quality purposes. Nonetheless, this option seems better than simply letting bittersweet run amok.



4b. (above) Bittersweet setting fruit at the edge of a mowed area near the Water Treatment Plant. Mowing can reduce bittersweet in large swaths of land but there will always be an edge requiring further treatment.



4c. (left) Bittersweet thriving at the edge of a mowed area near the Water Treatment Plant. The area in the right side of the picture is a mowed former red pine plantation. The area to the left of it is along a stone wall that cannot be easily mowed or cut.

Figure 5: Gap Process Failure Example 1: White pine blowdown (over multiple storms) and continued infestation by oriental bittersweet vines and Amur cork trees



5a. (above) Stand 4, Mountain Street Reservoir. In recent years, successive storms (see lighter and darker wood from blowdown clean up), the period of severe white pine decline driven by white pine needle disease, and logging in response to that, have contributed to increasing amounts of light reaching the forest floor and triggering a growth of invasives. Bittersweet is (as expected) prevalent in this mix (not shown in this picture). Amur cork was not anticipated but unfortunately is present and is becoming widely established. With storms, pests and pathogens, there is no way to prevent light from increasing over time and stimulating the growth of invasives. At most, the maintenance of shade is a short- and medium-term strategy to delay the ultimate need to bring non-native invasive plants to an acceptable level. Due to storms, pests, pathogens and other factors, the shade of the current overstory cannot be sustained indefinitely. Shade can only be sustained by the continuous ingrowth of new trees, but invasive plants and excessive deer browse, often combined with hayscented fern and/or grape vines, frequently lead to a failure of young trees to become established.



5b. (above right) Stand 4, Mountain Street Reservoir. Lower stem and root system of an Amur cork tree after just two growing seasons. This is the first known infestation on active DPW watershed land. Based on initial observations, this invasive exotic tree has the potential to become a significant nuisance. At a young age they can be hand-pulled, but soon will likely be too big for that.

Figure 6: Gap Process Failure Example 2: Loss of overstory shade (due to a pest, emerald ash borer) with unchecked rampant growth of oriental bittersweet



Above left: Group of tall white ash succumbing to emerald ash borer and already being climbed by bittersweet, which is taking advantage of the increased light -- all the green leaves seen are bittersweet -- see black arrow.

Above right: As the ash trees here die due to emerald ash borer, the increase in sunlight reaching the forest floor is releasing bittersweet that was already present at a low level in the understory. Now, with the added sunlight, the bittersweet is aggressively climbing the dead and fallen trees (see white arrows), forming an overwhelming mat of vines that prevents new trees from growing, while also producing fruit that will cause a spread of bittersweet to still other areas. This is an example of an area of forest whose watershed function forest is severely degraded and only getting worse due to the unchecked growth of bittersweet.

Figure 7: Hayscented fern, an example of native interfering vegetation

Picture (a) below shows a typical example of a hayscented fern thicket that is preventing other vegetation, including young trees, from growing. These fern thickets are rightly described as "recalcitrant" and initially form in conjunction with excessive feeding by deer, which eliminates other vegetation, including blackberries, that would otherwise shade out and kill the fern. Deer do not currently feed on hayscented fern at current population levels. The prevalence of fern thickets at the Quabbin was a major factor leading to the initiation of deer hunting there in 1990, which continues to this day.

a



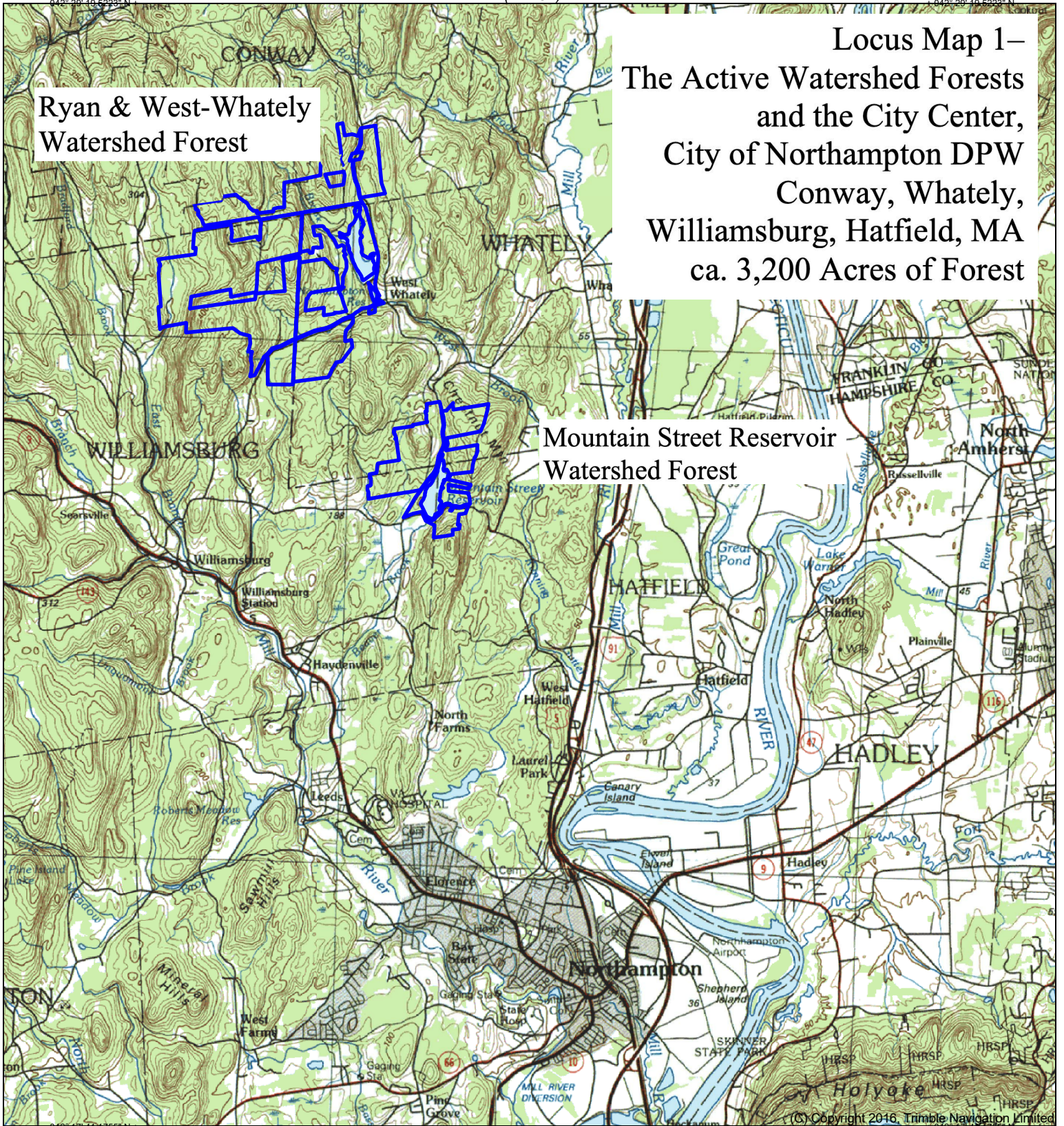
b



c

Picture (b) shows pipsissewa, an understory plant that can be smothered by hayscented fern, reducing species diversity. Picture (c) shows a heavily browsed oak seedling amidst a thicket of hayscented fern that the deer have avoided. Over time, as the hayscented fern and elevated levels of deer browse persist, the forest loses species diversity and young trees needed for future watershed forest function.

Overview Maps



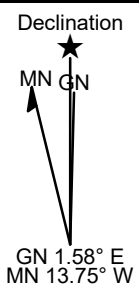
Ryan & West-Whately Watershed Forest

Locus Map 1—
 The Active Watershed Forests
 and the City Center,
 City of Northampton DPW
 Conway, Whately,
 Williamsburg, Hatfield, MA
 ca. 3,200 Acres of Forest

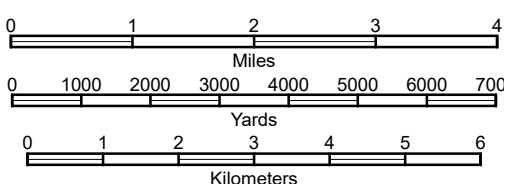
Mountain Street Reservoir Watershed Forest

(WATERBURY)

Produced by Trimble Terrain Navigator Pro
 Topography based on USGS 1:100,000
 Maps
 North American 1983 Datum (NAD83)
 To place on the predicted North American
 1927 move the projection lines 10M N and
 38M E



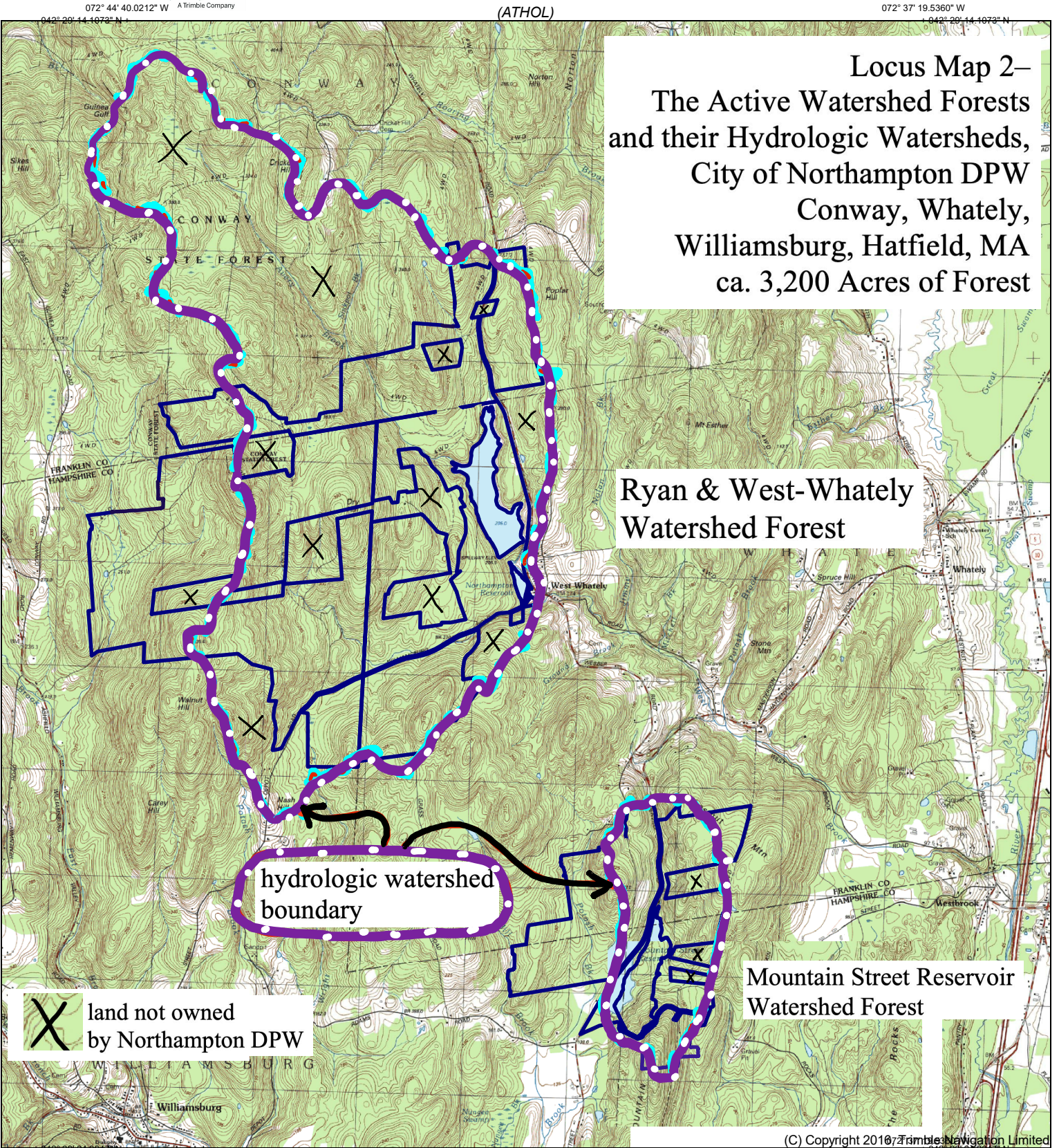
(HARTFORD)
 SCALE 1:100000



CONTOUR INTERVAL 33 FT

Map by Michael Mauri, L.F.
 20 West St. S. Dfld., MA 01373
 (413) 665-6829 based on
 parcel shapefile provided
 by Northampton DPW on 2-15-2023,
 3-2023

Printed: Mon Mar 20, 2023 072° 31' 27.3463" W
 042° 29' 19.5223" N



**Locus Map 2—
The Active Watershed Forests
and their Hydrologic Watersheds,
City of Northampton DPW
Conway, Whately,
Williamsburg, Hatfield, MA
ca. 3,200 Acres of Forest**

**Ryan & West-Whately
Watershed Forest**

**Mountain Street Reservoir
Watershed Forest**

**X land not owned
by Northampton DPW**

**hydrologic watershed
boundary**

(HOLYOKE) 072° 44' 40.0212" W

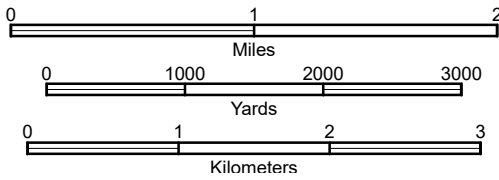
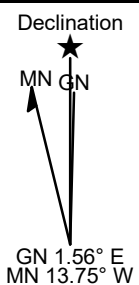
(HOLYOKE) SCALE 1:50000

(HOLYOKE)

Produced by Trimble Terrain Navigator Pro
Topography based on USGS 1:25,000
Maps

North American 1983 Datum (NAD83)

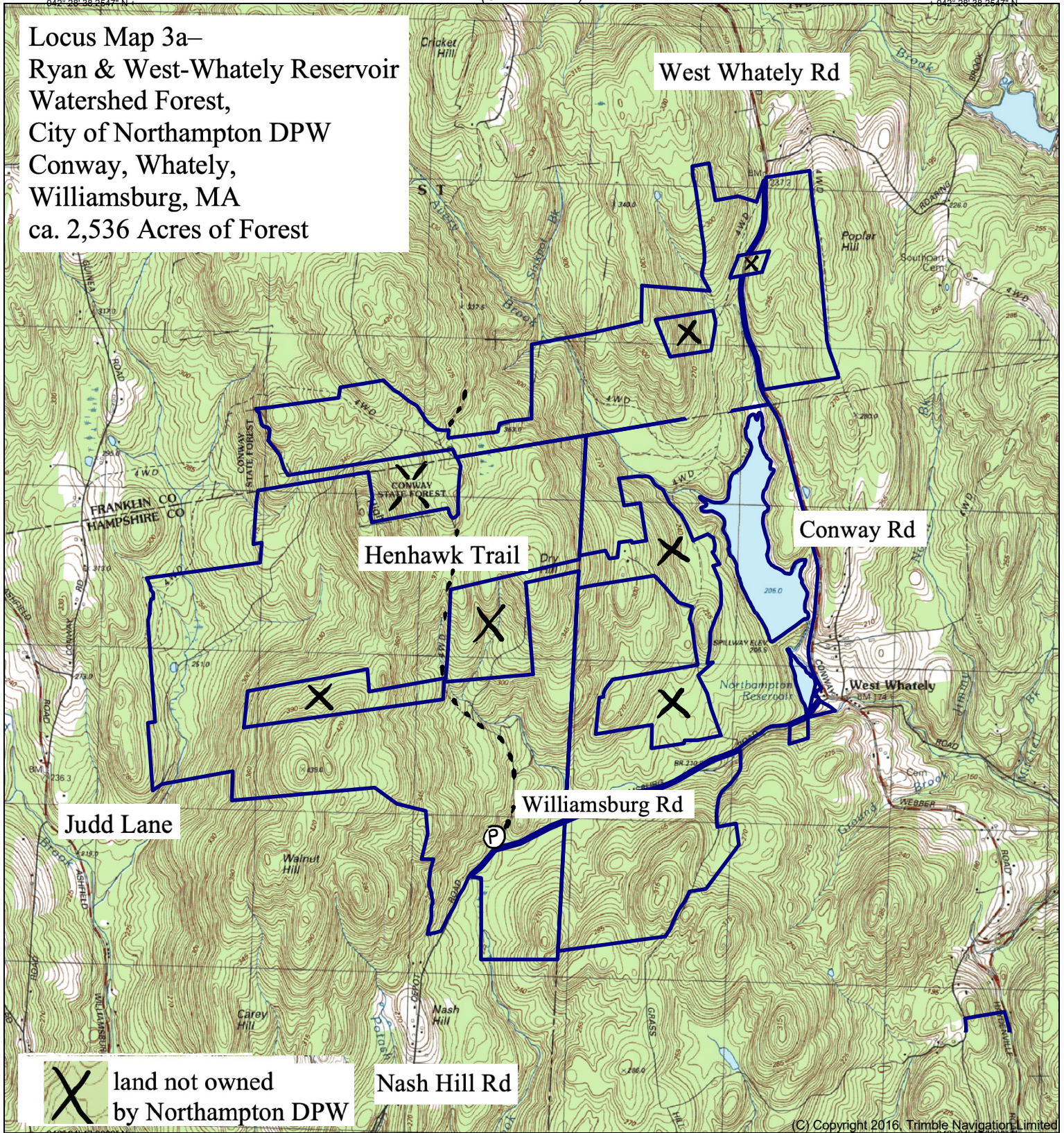
To place on the predicted North American
1927 move the projection lines 10M N and
38M E



Map by Michael Mauri, L.F.
20 West St. S. Dfld., MA 01373
(413) 665-6829 based on
parcel shapefile provided
by Northampton DPW on 2-15-2023,
3-2023

(C) Copyright 2016 Trimble Navigation Limited
Printed: Mon Mar 20, 2023

**Locus Map 3a—
Ryan & West-Whately Reservoir
Watershed Forest,
City of Northampton DPW
Conway, Whately,
Williamsburg, MA
ca. 2,536 Acres of Forest**



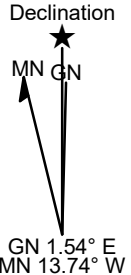
X land not owned by Northampton DPW

(CHESTER)

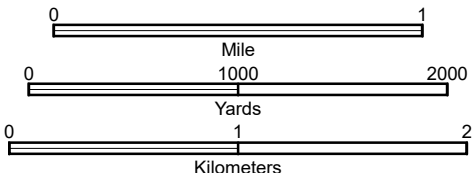
Produced by Trimble Terrain Navigator Pro
Topography based on USGS 1:25,000
Maps

North American 1983 Datum (NAD83)

To place on the predicted North American
1927 move the projection lines 10M N and
38M E



(EASTHAMPTON)
SCALE 1:33000



CONTOUR INTERVAL 10 FT

(C) Copyright 2016, Trimble Navigation Limited
Printed: Mon Mar 20, 2023 072° 39' 51.9329" W 042° 28' 38.2547" N

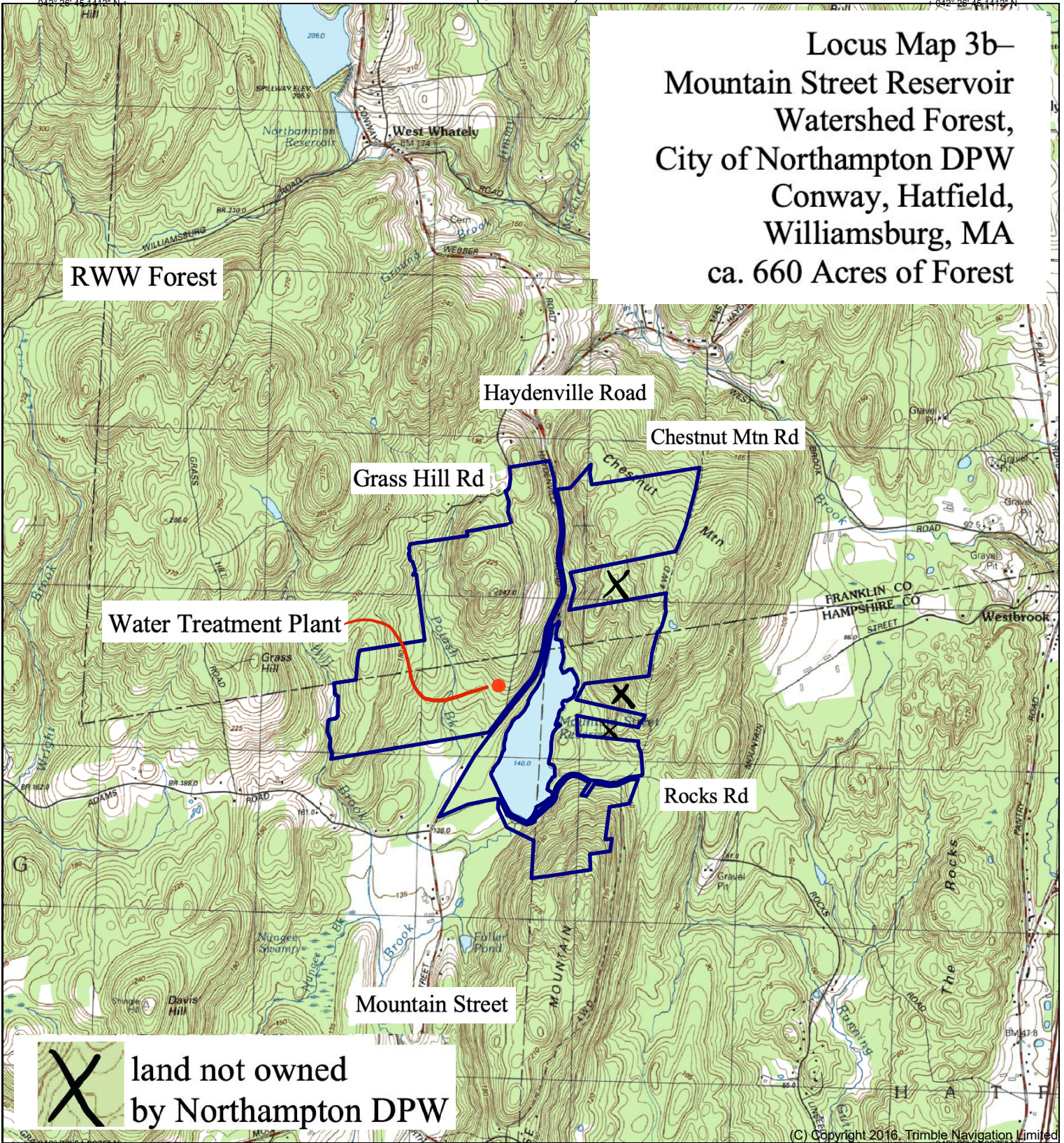
(BELCHERTOWN)

Map by Michael Mauri, L.F.
20 West St. S. Dfld., MA 01373
(413) 665-6829 based on
parcel shapefile provided
by Northampton DPW on 2-15-2023,
3-2023

(GREENFIELD)

042° 26' 45.1412" N

**Locus Map 3b—
 Mountain Street Reservoir
 Watershed Forest,
 City of Northampton DPW
 Conway, Hatfield,
 Williamsburg, MA
 ca. 660 Acres of Forest**



RWW Forest

Haydenville Road

Chestnut Mtn Rd

Grass Hill Rd

Water Treatment Plant

Rocks Rd

Mountain Street

X land not owned
 by Northampton DPW

(C) Copyright 2016, Trimble Navigation Limited
 Printed: Mon Mar 20, 2023

(CHESTER)
 072° 42' 36.9105" W

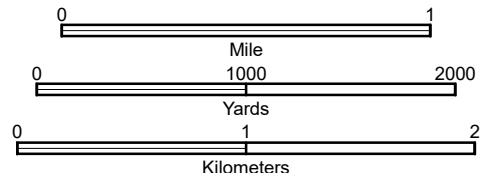
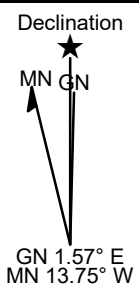
(EASTHAMPTON)
 SCALE 1:33000

072° 37' 47.4687" W
 (BELCHERTOWN)

Produced by Trimble Terrain Navigator Pro
 Topography based on USGS 1:25,000
 Maps

North American 1983 Datum (NAD83)

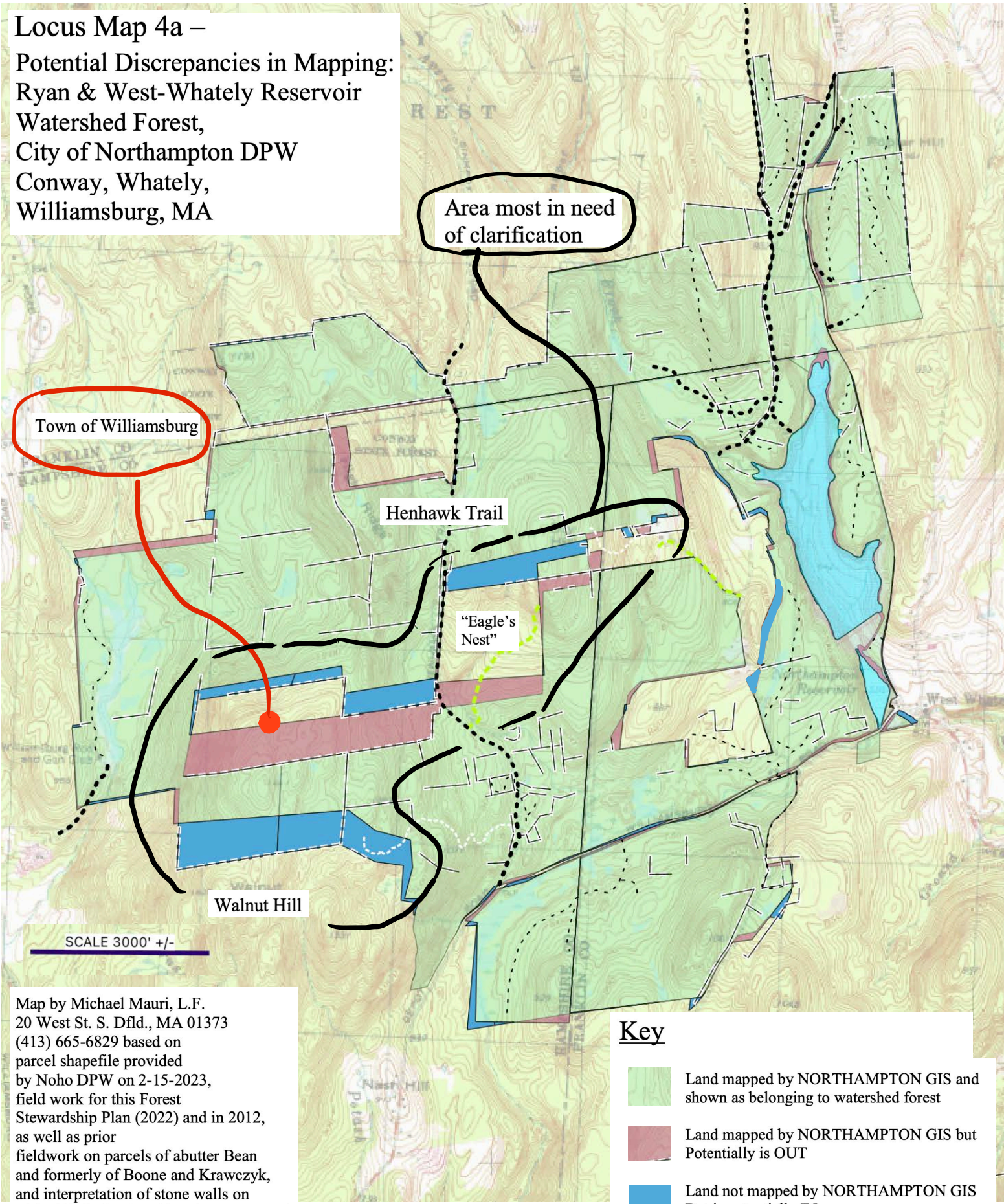
To place on the predicted North American
 1927 move the projection lines 10M N and
 38M E



CONTOUR INTERVAL 10 FT

Map by Michael Mauri, L.F.
 20 West St. S. Dfld., MA 01373
 (413) 665-6829 based on
 parcel shapefile provided
 by Northampton DPW on 2-15-2023,
 3-2023

**Locus Map 4a –
Potential Discrepancies in Mapping:
Ryan & West-Whately Reservoir
Watershed Forest,
City of Northampton DPW
Conway, Whately,
Williamsburg, MA**



Area most in need of clarification

Town of Williamsburg

Henhawk Trail

"Eagle's Nest"

Walnut Hill

SCALE 3000' +/-

Map by Michael Mauri, L.F.
20 West St. S. Dfld., MA 01373
(413) 665-6829 based on
parcel shapefile provided
by Noho DPW on 2-15-2023,
field work for this Forest
Stewardship Plan (2022) and in 2012,
as well as prior
fieldwork on parcels of abutter Bean
and formerly of Boone and Krawczyk,
and interpretation of stone walls on
Lidar hillshade view (data from MA GIS)
3-2023

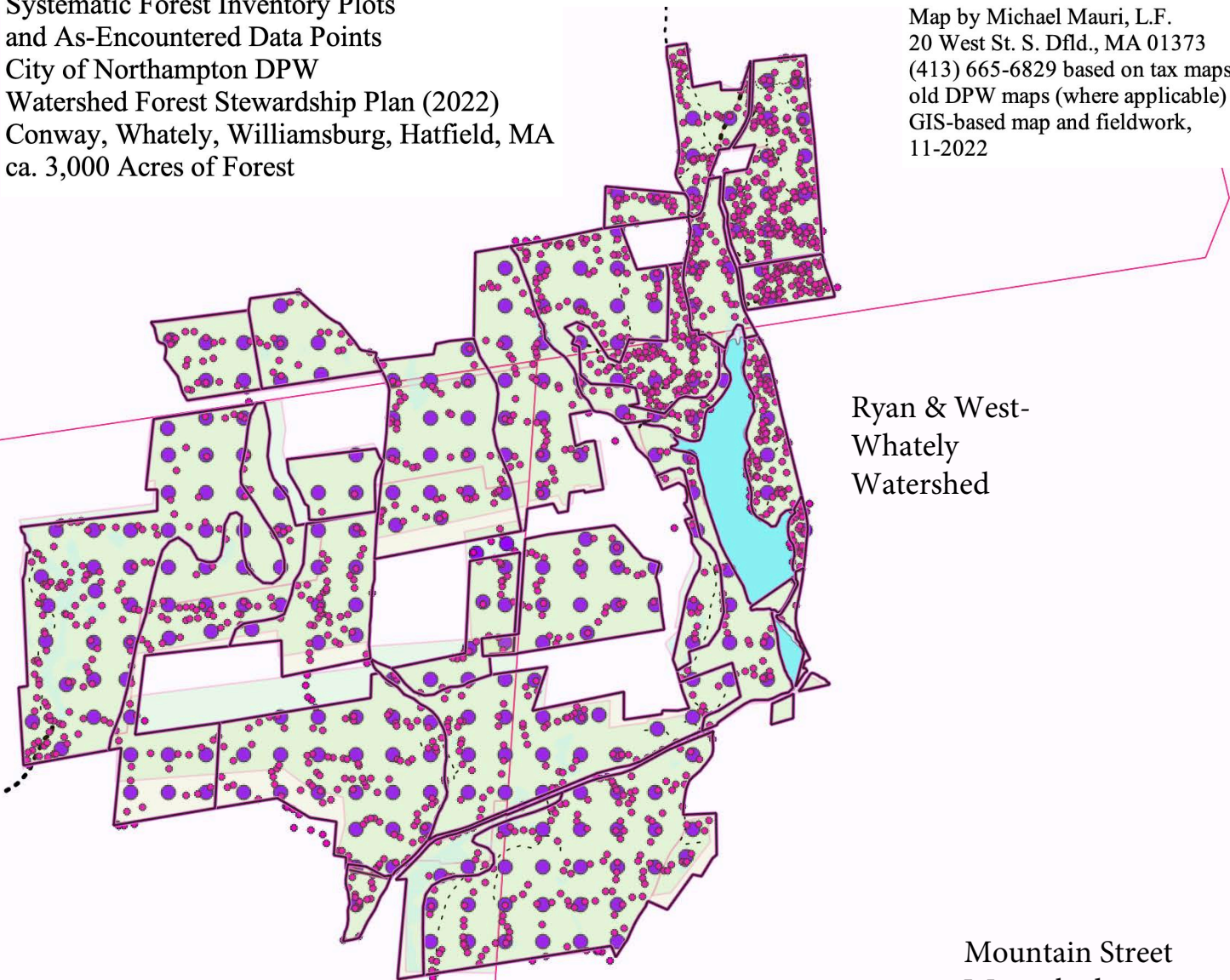
Key

- Land mapped by NORTHAMPTON GIS and shown as belonging to watershed forest
- Land mapped by NORTHAMPTON GIS but Potentially is OUT
- Land not mapped by NORTHAMPTON GIS But is potentially IN

Methods Map 1:

Systematic Forest Inventory Plots
and As-Encountered Data Points
City of Northampton DPW
Watershed Forest Stewardship Plan (2022)
Conway, Whately, Williamsburg, Hatfield, MA
ca. 3,000 Acres of Forest

Map by Michael Mauri, L.F.
20 West St. S. Dfld., MA 01373
(413) 665-6829 based on tax maps
old DPW maps (where applicable)
GIS-based map and fieldwork,
11-2022



Ryan & West-Whately Watershed

Mountain Street Watershed

Key



Location of systematic plots (n = 318)



Locations of as-encountered points (n = 2,242)

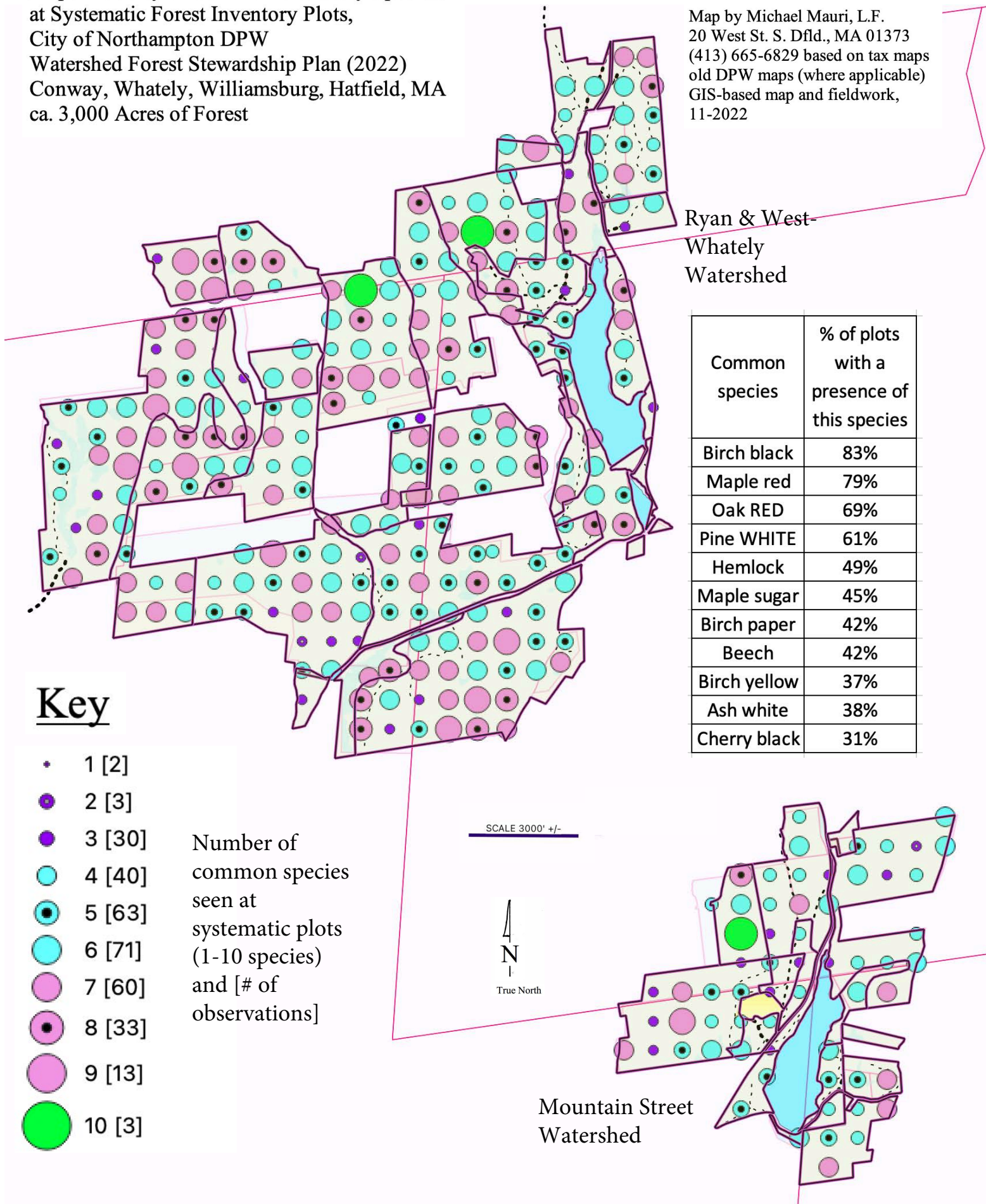
SCALE 3000' +/-



Water Treatment Plant (yellow)

Map: Diversity of Common Overstory Species:
 at Systematic Forest Inventory Plots,
 City of Northampton DPW
 Watershed Forest Stewardship Plan (2022)
 Conway, Whately, Williamsburg, Hatfield, MA
 ca. 3,000 Acres of Forest

Map by Michael Mauri, L.F.
 20 West St. S. Dfld., MA 01373
 (413) 665-6829 based on tax maps
 old DPW maps (where applicable)
 GIS-based map and fieldwork,
 11-2022



Ryan & West-
 Whately
 Watershed

Common species	% of plots with a presence of this species
Birch black	83%
Maple red	79%
Oak RED	69%
Pine WHITE	61%
Hemlock	49%
Maple sugar	45%
Birch paper	42%
Beech	42%
Birch yellow	37%
Ash white	38%
Cherry black	31%

Key

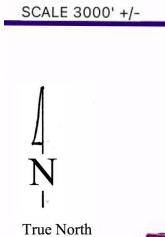
- 1 [2]
 - 2 [3]
 - 3 [30]
 - 4 [40]
 - 5 [63]
 - 6 [71]
 - 7 [60]
 - 8 [33]
 - 9 [13]
 - 10 [3]
- Number of common species seen at systematic plots (1-10 species) and [# of observations]

SCALE 3000' +/-



Mountain Street
 Watershed

Map: Presence and Abundance of Uncommon Overstory Species:
 at Systematic Forest Inventory Plots
 and As-Encountered Data Points
 City of Northampton DPW
 Watershed Forest Stewardship Plan (2022)
 Conway, Whately, Williamsburg, Hatfield, MA
 ca. 3,000 Acres of Forest



Map by Michael Mauri, L.F.
 20 West St. S. Dfld., MA 01373
 (413) 665-6829 based on tax maps
 old DPW maps (where applicable)
 GIS-based map and fieldwork,
 11-2022

Ryan & West-
 Whately
 Watershed

Poplar Hill

Walnut Hill

Grass Hill

UNCOMMON species	# of sightings of this species*
Hickory bitternut	130
Hickory shagbark	66
Oak chestnut	59
Hickory pignut	59
Ironwood	56
Oak scarlet	44
Basswood	43
Poplar bigtooth	40
Pitch pine	37
Oak white	34
Black oak	12
Red spruce	7
Elm	6
Cottonwood	3
Black ash	1
Pin cherry	1
Sassafras	1
Tulip poplar	1
Fir balsam	0

*Multiple trees seen in close proximity are counted as a single sighting

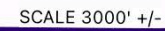
Key

- 0 [233]
- 1 [60]
- 2 [19]
- 3 [4]
- 4 [2]

Number of UNcommon species seen at systematic plots (1-4 species) and [# of observations]

At 233 of 318 systematic plots, no uncommon tree species were seen.

Number of as-encountered sightings with one or more uncommon species [n=600]



Laurel Mountain

Chestnut Mtn

Mountain Street Watershed

Horse Mtn

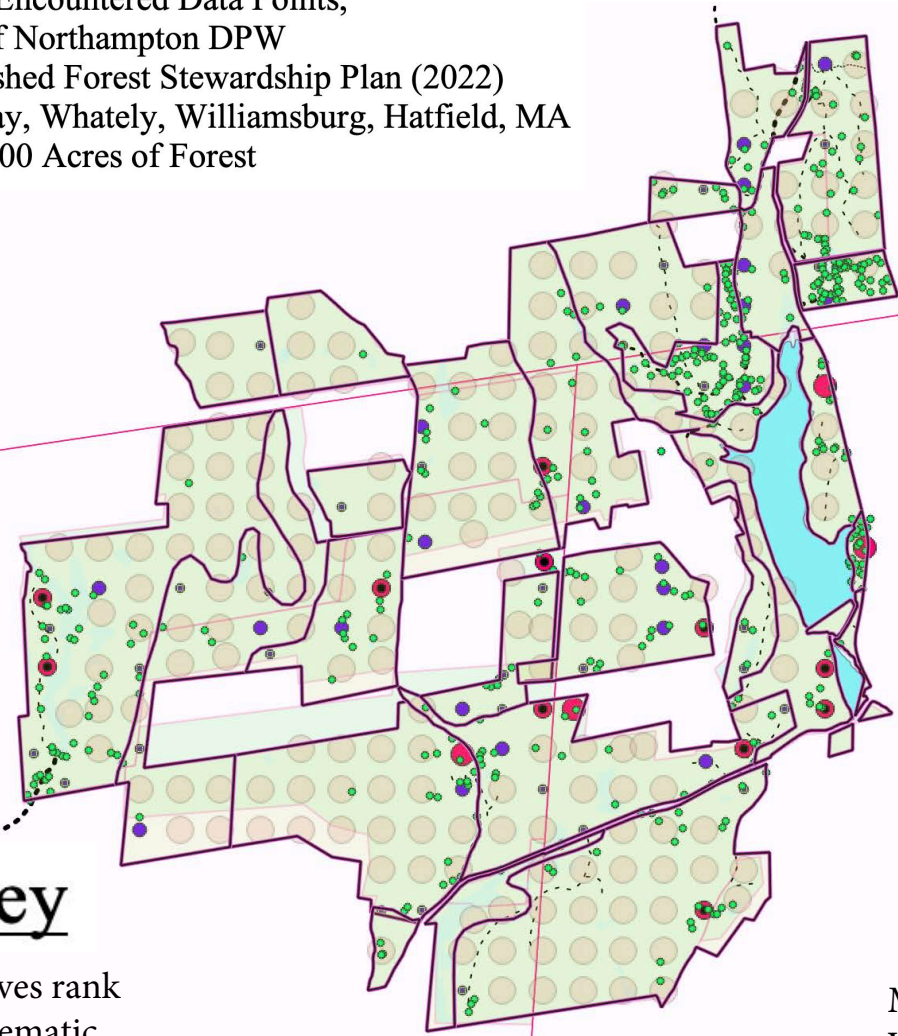
A total of 600 sightings of uncommon tree species outside of systematic plots are shown. Some other sightings are not shown.

Non-Native Invasive Plant Map 1:
Occurrence of Non-Native Invasive Plants
at Systematic Forest Inventory Plots
& As-Encountered Data Points,
City of Northampton DPW
Watershed Forest Stewardship Plan (2022)
Conway, Whately, Williamsburg, Hatfield, MA
ca. 3,000 Acres of Forest



Map by Michael Mauri, L.F.
 20 West St. S. Dfld., MA 01373
 (413) 665-6829 based on tax maps
 old DPW maps (where applicable)
 GIS-based map and fieldwork,
 11-2022

Ryan & West-
 Whately
 Watershed



SCALE 3000' +/-

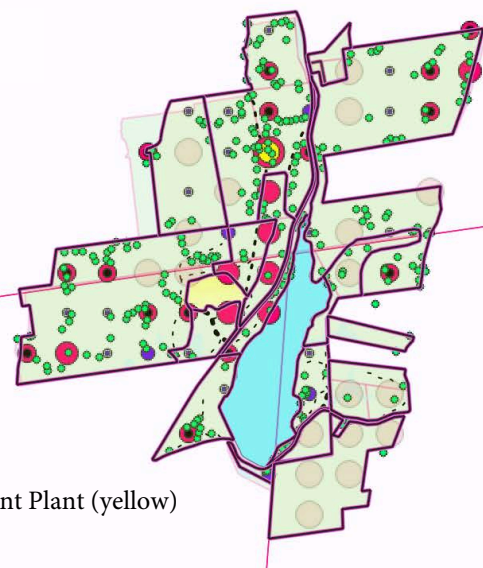
Key

Invasives rank
 at systematic
 plots [=n]

-  1 [45]
-  2 [29]
-  3 [26]
-  4 [12]
-  5 [1]
-  0 [205]

Interpretation of Non-native Invasive Plant Rank	
0	ABSENT / NONE DETECTED
1	EXTREMELY MINOR (< 1% cover)
2	MINOR AND READILY TREATABLE (1% - 5%)
3	MODERATE TO SEVERE – CANNOT READILY BE CONTROLLED (6%-90% cover in understory)
4	SEVERE (>90% invasives cover in understory, tall overstory intact)
5	NO LONGER A FOREST – IS IN NEED OF COMPLETE RESTORATION (100% invasives cover, no tall overstory)

Mountain Street
 Watershed



Water Treatment Plant (yellow)



Location of as-
 encountered invasives
 (n = 719)

See

**Non-Native Invasive Plant Map 2:
Occurrence of BITTERSWEET
at Systematic Forest Inventory Plots
& As-Encountered Data Points,
City of Northampton DPW
Watershed Forest Stewardship Plan (2022)
Conway, Whately, Williamsburg, Hatfield, MA
ca. 3,000 Acres of Forest**

Map by Michael Mauri, L.F.
20 West St. S. Dfld., MA 01373
(413) 665-6829 based on tax maps
old DPW maps (where applicable)
GIS-based map and fieldwork,
11-2022

Ryan & West-
Whately
Watershed



SCALE 3000' +/-

Key

Bittersweet rank at
systematic plots [=n]

- 0 [228]
- 1 [43]
- 2 [12]
- 3 [23]
- 4 [11]
- 5 [1]

- 1 [120]
- 2 [97]
- 3 [180]
- 4 [51]
- 5 [60]

Bittersweet rank at
as-encountered
points [=n]

Interpretation of Non-native Invasive Plant Rank	
0	ABSENT / NONE DETECTED
1	EXTREMELY MINOR (< 1% cover)
2	MINOR AND READILY TREATABLE (1% - 5%)
3	MODERATE TO SEVERE – CANNOT READILY BE CONTROLLED (6%-90% cover in understory)
4	SEVERE (>90% invasives cover in understory, tall overstory intact)
5	NO LONGER A FOREST – IS IN NEED OF COMPLETE RESTORATION (100% invasives cover, no tall overstory)

Mountain Street
Watershed



Map: Gap Process Failure and Partial Success
 Showing documented locations of gap process failure and partial success,
 City of Northampton DPW
 Watershed Forest Stewardship Plan (2023)
 Conway, Whately, Williamsburg, Hatfield, MA
 ca. 3,000 Acres of Forest



Map by Michael Mauri, L.F.
 20 West St. S. Dfld., MA 01373
 (413) 665-6829 based on tax maps
 old DPW maps (where applicable)
 GIS-based map and fieldwork,
 11-2022

Ryan & West-Whately Watershed

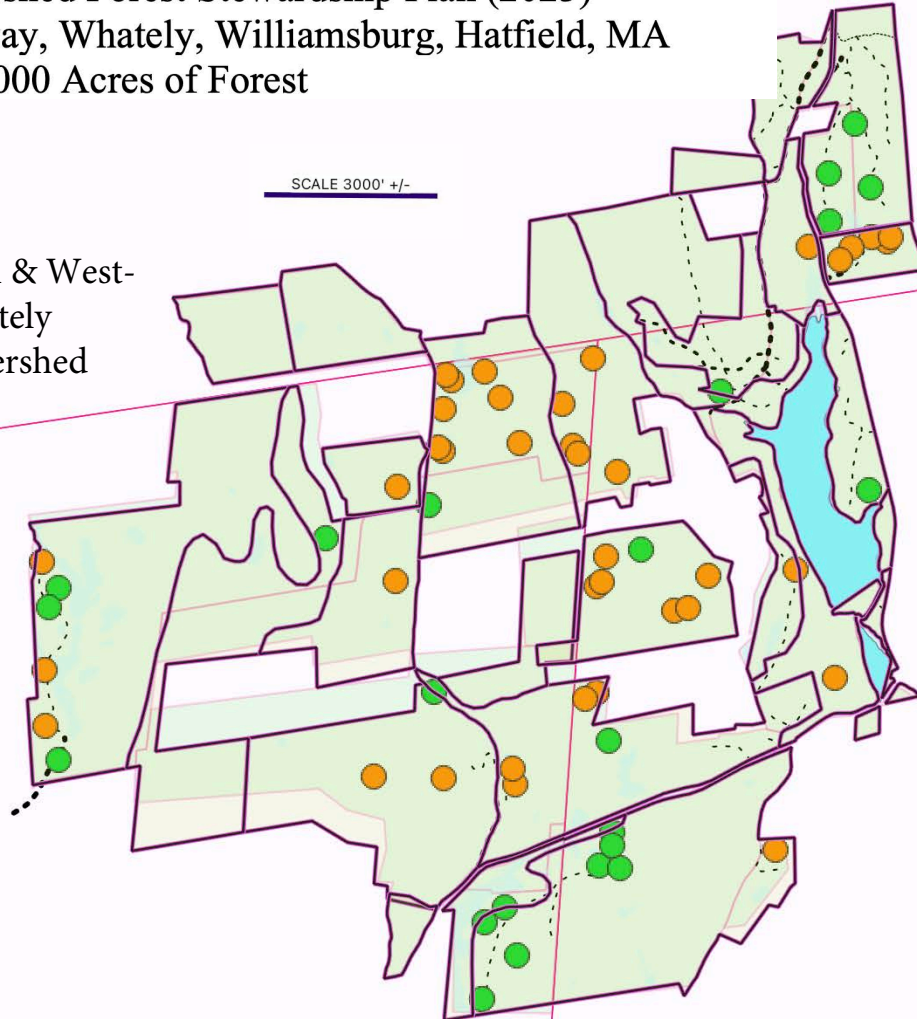


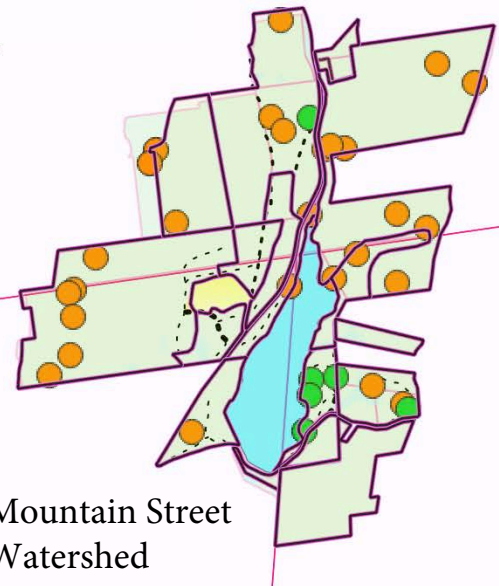
Table: Factors associated with gap process PARTIAL SUCCESS (28 occurrences)

Factor	# Occurrences	% of occurrences
Black birch saplings	23	82%
Hayscented fern	9	32%
Red oak seedlings	6	21%
Hemlock saplings	6	21%
Mountain laurel	3	11%
White pine saplings	3	11%
Chestnut oak seedlings	2	7%
White oak seedlings	1	4%
Sugar maple saplings	1	4%
Red maple saplings	1	4%
Bittersweet	1	4%
Barberry	1	4%
Grapes	0	0%
Browse by deer	assumed	100%

Table: Factors associated with gap process failure

Factor	# Occurrences	% of occurrences
Bittersweet	47	71%
Grapes	31	47%
Hayscented fern	17	26%
Barberry	10	15%
Mountain laurel	5	8%
Multiflora rose	5	8%
Browse by deer	assumed	100%

SCALE 3000' +/-



Mountain Street Watershed

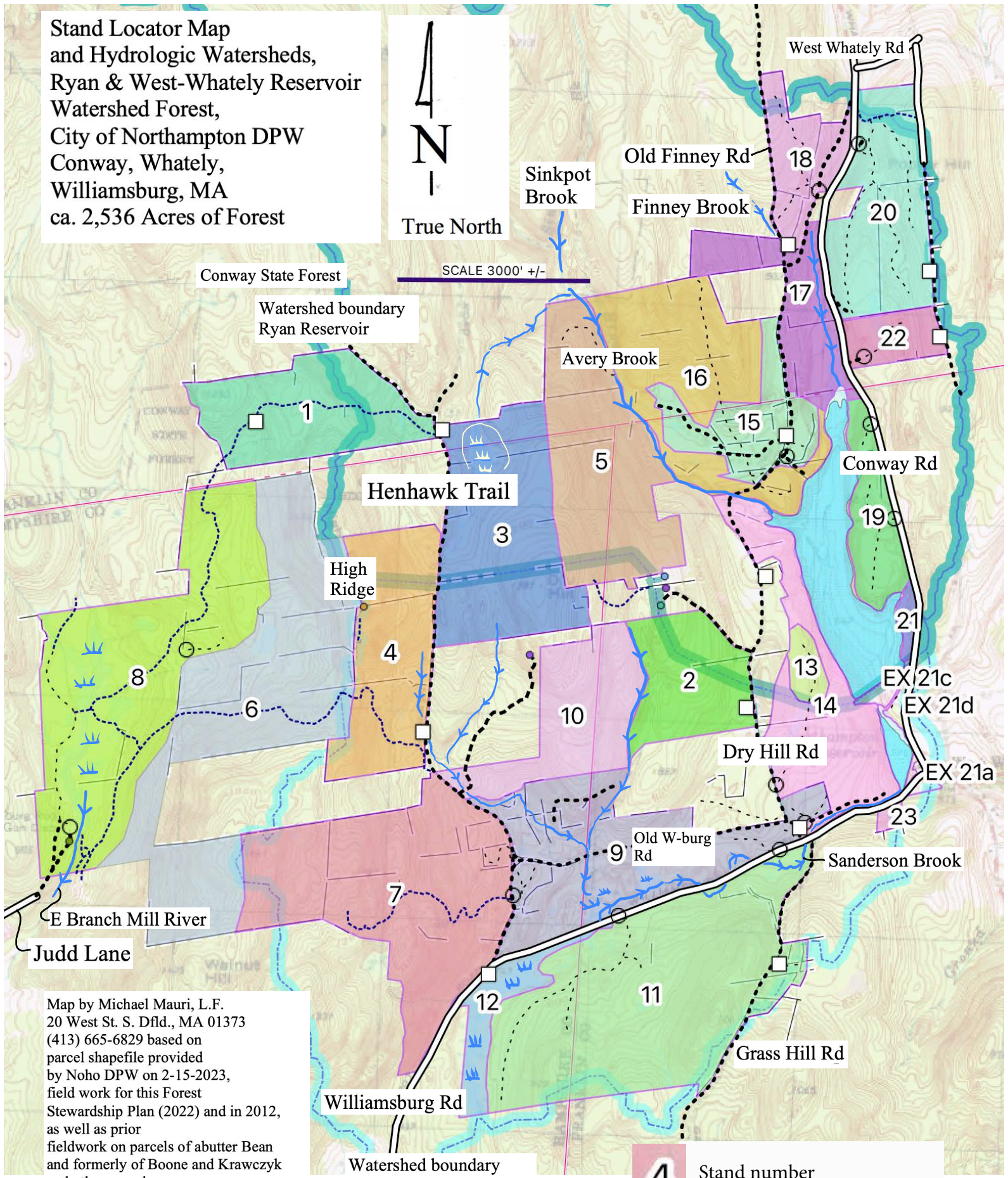
Key [# of occurrences]

- GAP PROCESS FAILURE [66]
- GAP PROCESS PARTIAL SUCCESS [28]

**Stand Locator Map
and Hydrologic Watersheds,
Ryan & West-Whately Reservoir
Watershed Forest,
City of Northampton DPW
Conway, Whately,
Williamsburg, MA
ca. 2,536 Acres of Forest**



SCALE 3000' +/-



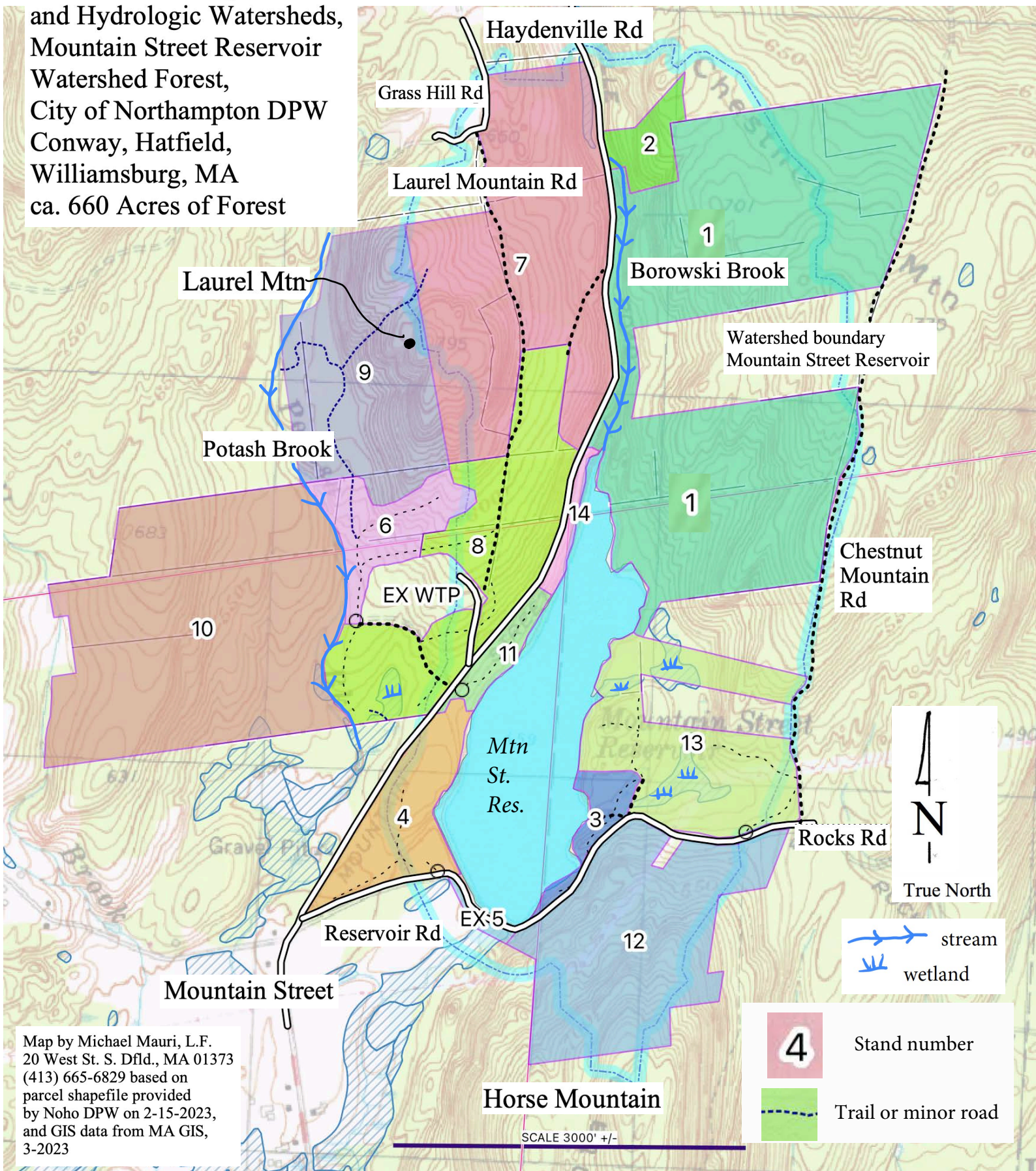
Map by Michael Mauri, L.F.
20 West St. S. Dfld., MA 01373
(413) 665-6829 based on
parcel shapefile provided
by Noho DPW on 2-15-2023,
field work for this Forest
Stewardship Plan (2022) and in 2012,
as well as prior
fieldwork on parcels of abutter Bean
and formerly of Boone and Krawczyk
and other parcels,
and interpretation of stone walls on
Lidar hillshade view (data from MA GIS)
3-2023

Watershed boundary
West Whately Reservoir

- stream
- wetland
- cellar hole

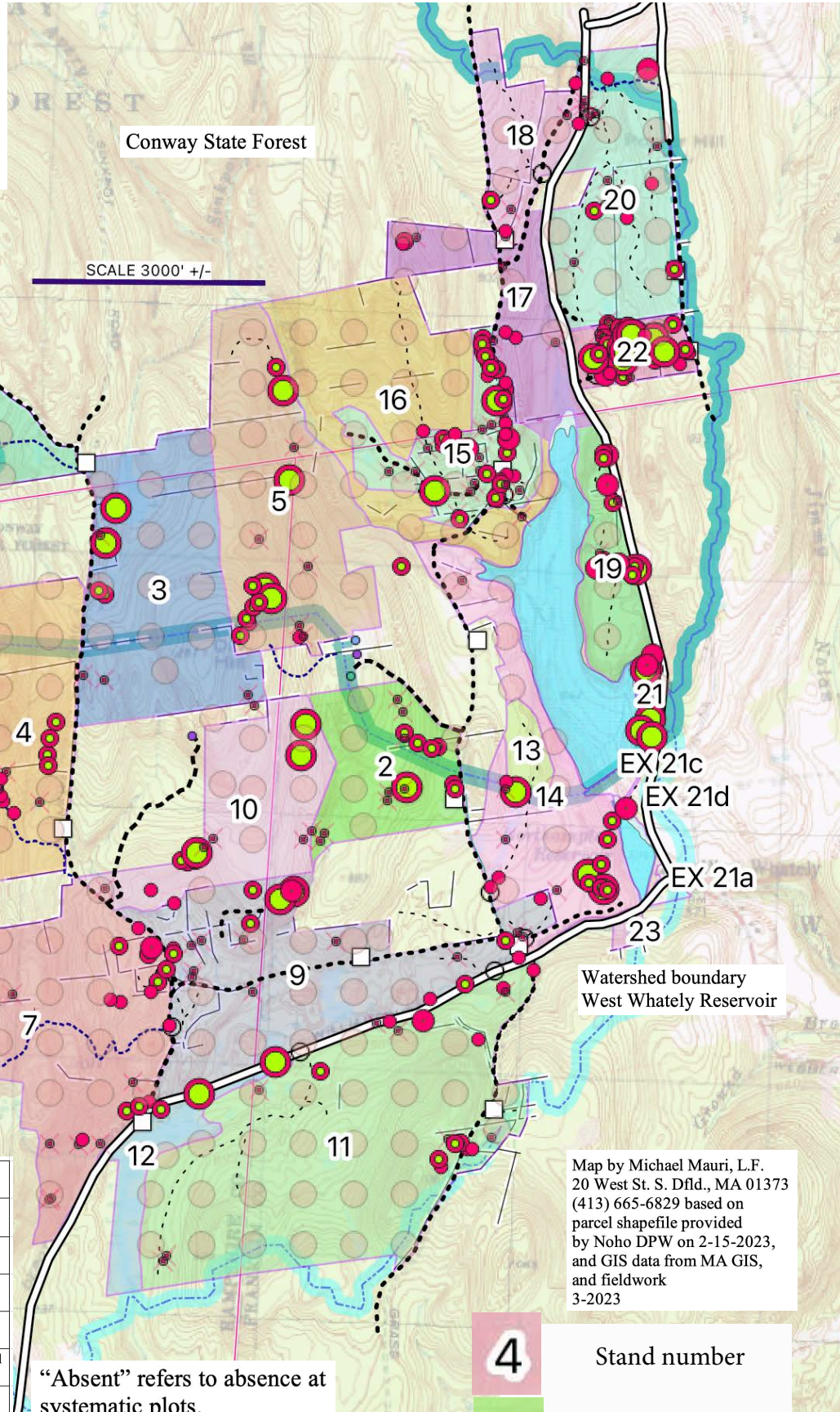
- Stand number
- Trail or minor road

**Stand Locator Map
and Hydrologic Watersheds,
Mountain Street Reservoir
Watershed Forest,
City of Northampton DPW
Conway, Hatfield,
Williamsburg, MA
ca. 660 Acres of Forest**



Map by Michael Mauri, L.F.
20 West St. S. Dfld., MA 01373
(413) 665-6829 based on
parcel shapefile provided
by Noho DPW on 2-15-2023,
and GIS data from MA GIS,
3-2023

Occurrence of BITTERSWEET
 at Systematic Forest Inventory Plots
 & As-Encountered Data Points,
 Ryan & West-Whately Reservoir
 Watershed Forest,
 City of Northampton DPW
 Conway, Whately,
 Williamsburg, MA
 ca. 2,536 Acres of Forest



Watershed boundary
Ryan Reservoir

SCALE 3000' +/-

Conway State Forest

Watershed boundary
West Whately Reservoir

EX/21c
EX 21d
EX 21a

Severity Rank at Location	Interpretation
0	ABSENT / NONE DETECTED
1	EXTREMELY MINOR
2	MINOR BUT READILY TREATABLE
3	MODERATE TO SEVERE – CANNOT READILY BE CONTROLLED
4	SEVERE (invasives dominate understory, tall overstory intact)
5	NO LONGER A FUNCTIONING FOREST (invasives are the overstory)

Map by Michael Mauri, L.F.
 20 West St. S. Dfld., MA 01373
 (413) 665-6829 based on
 parcel shapefile provided
 by Noho DPW on 2-15-2023,
 and GIS data from MA GIS,
 and fieldwork
 3-2023

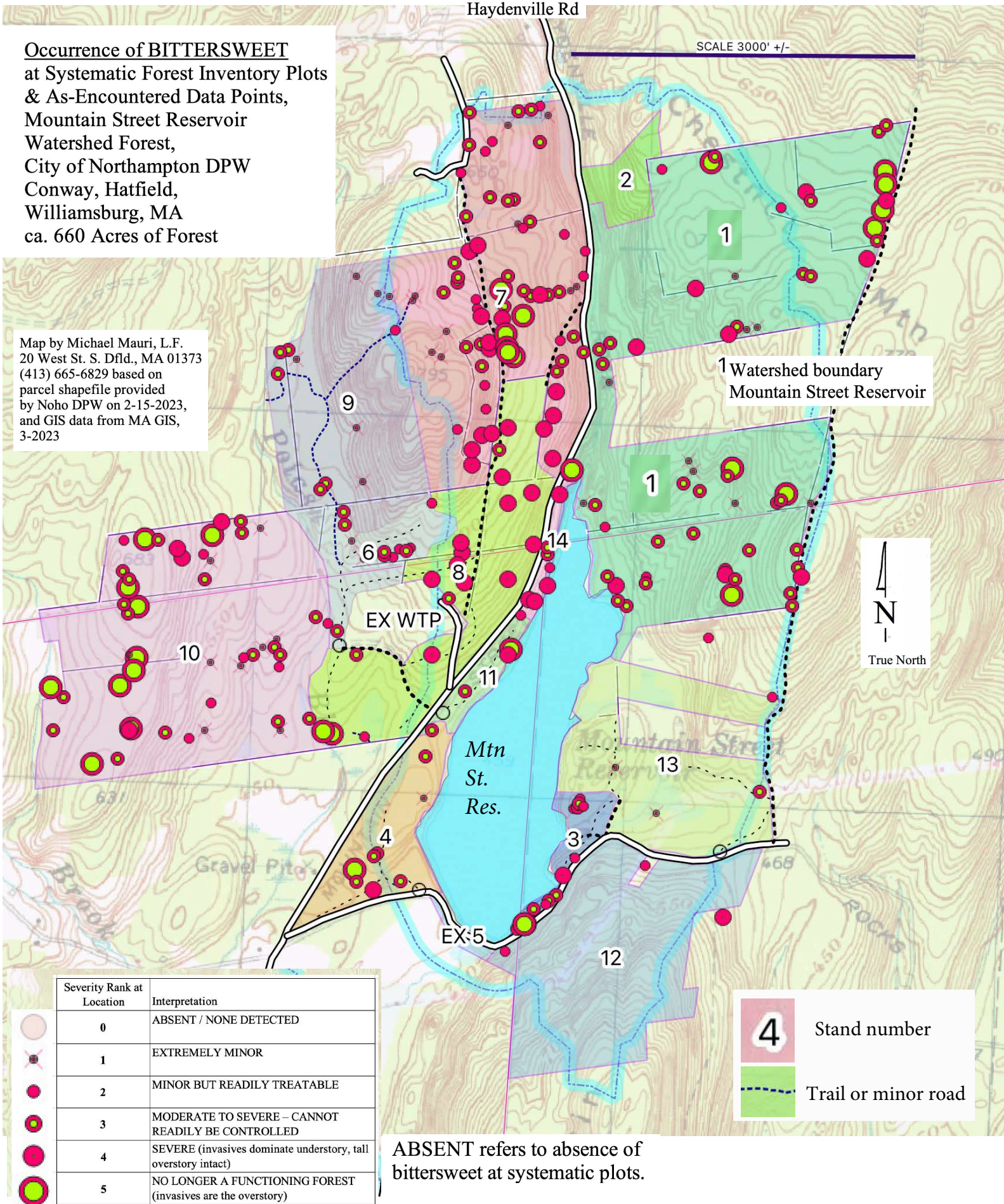
“Absent” refers to absence at
systematic plots.

4 Stand number

Trail or minor road

Occurrence of BITTERSWEET
 at Systematic Forest Inventory Plots
 & As-Encountered Data Points,
 Mountain Street Reservoir
 Watershed Forest,
 City of Northampton DPW
 Conway, Hatfield,
 Williamsburg, MA
 ca. 660 Acres of Forest

Map by Michael Mauri, L.F.
 20 West St. S. Dfld., MA 01373
 (413) 665-6829 based on
 parcel shapefile provided
 by Noho DPW on 2-15-2023,
 and GIS data from MA GIS,
 3-2023



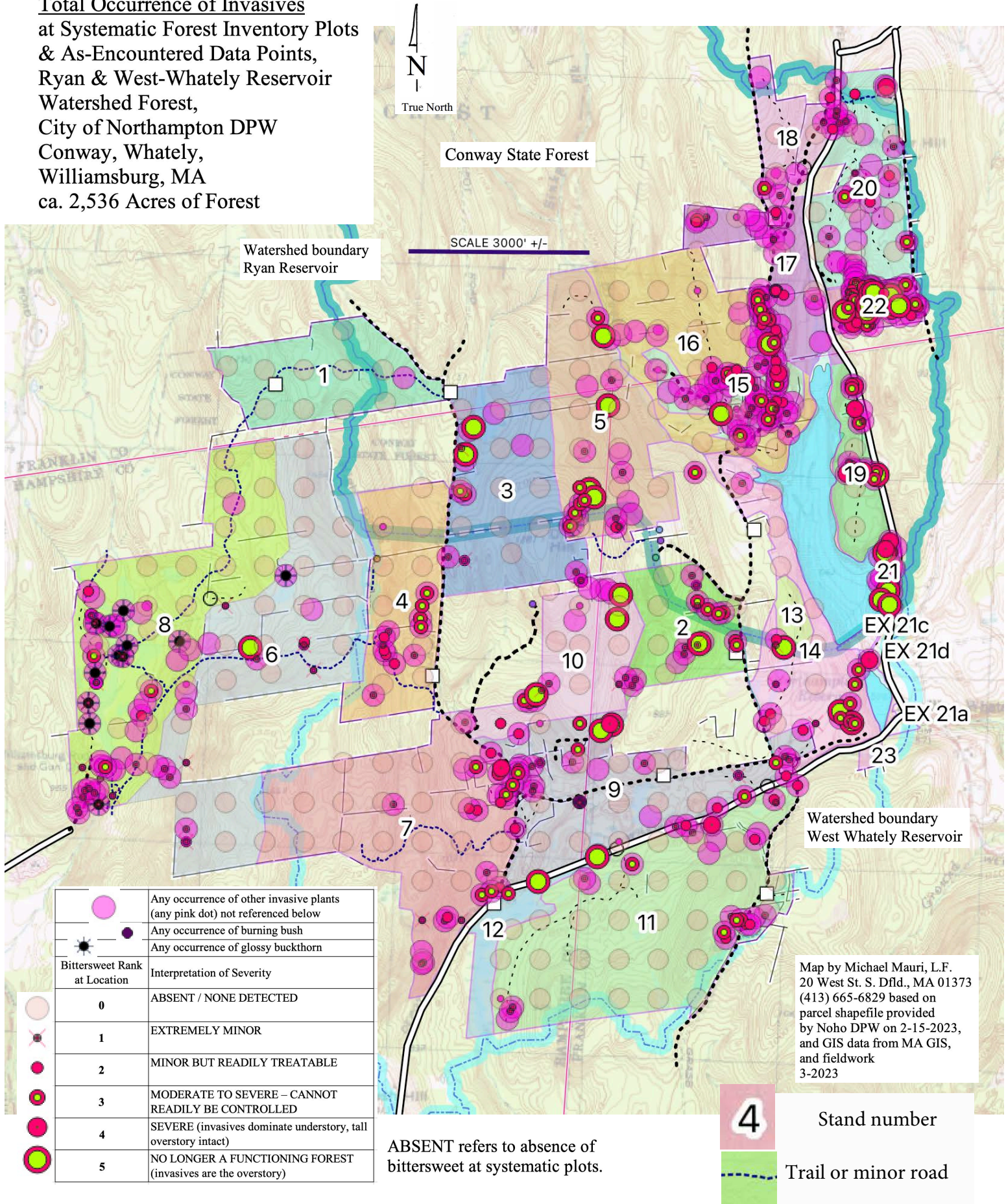
Severity Rank at Location	Interpretation
0	ABSENT / NONE DETECTED
1	EXTREMELY MINOR
2	MINOR BUT READILY TREATABLE
3	MODERATE TO SEVERE – CANNOT READILY BE CONTROLLED
4	SEVERE (invasives dominate understory, tall overstory intact)
5	NO LONGER A FUNCTIONING FOREST (invasives are the overstory)

4 Stand number

Trail or minor road

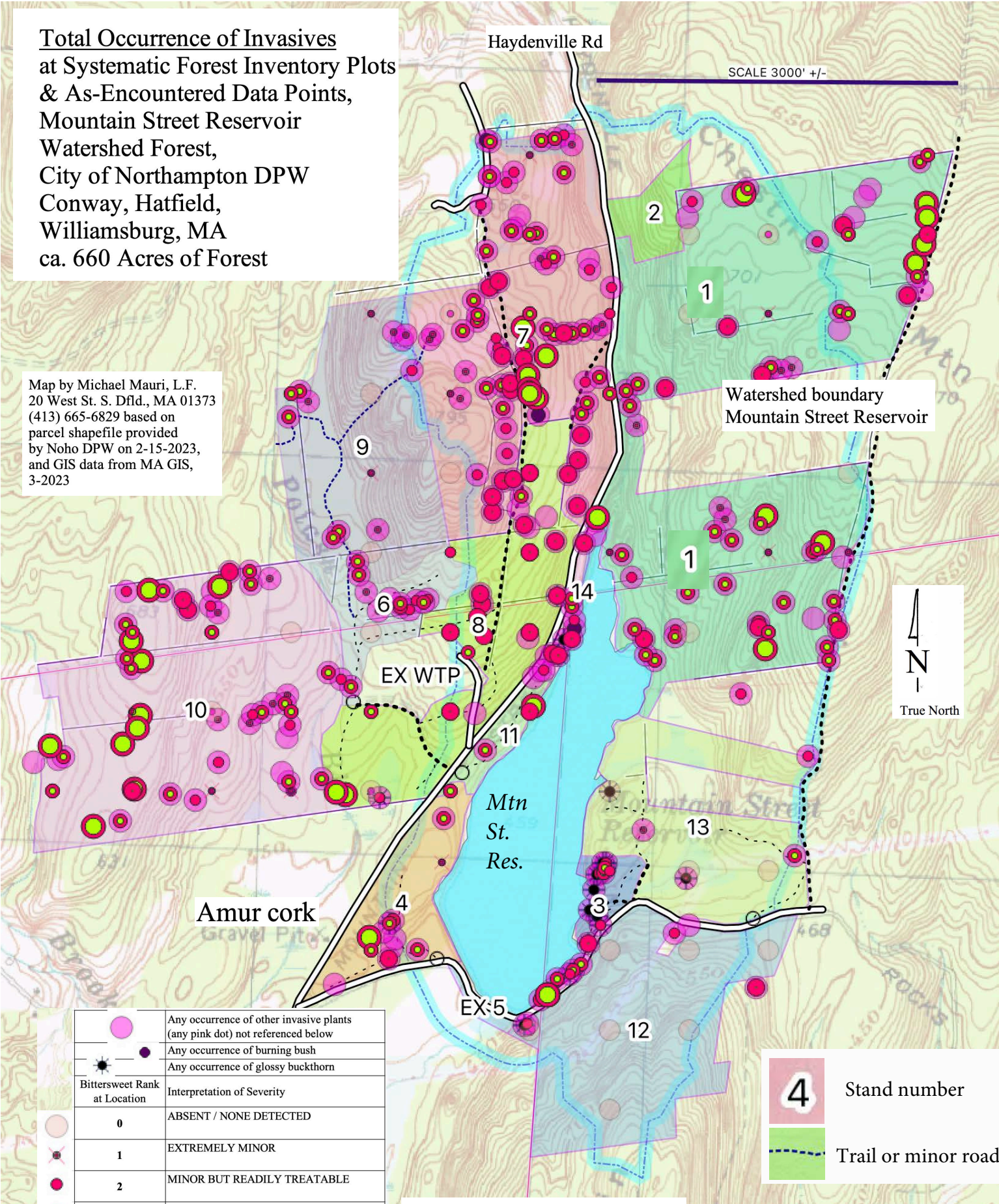
ABSENT refers to absence of bittersweet at systematic plots.

**Total Occurrence of Invasives
at Systematic Forest Inventory Plots
& As-Encountered Data Points,
Ryan & West-Whately Reservoir
Watershed Forest,
City of Northampton DPW
Conway, Whately,
Williamsburg, MA
ca. 2,536 Acres of Forest**



**Total Occurrence of Invasives
at Systematic Forest Inventory Plots
& As-Encountered Data Points,
Mountain Street Reservoir
Watershed Forest,
City of Northampton DPW
Conway, Hatfield,
Williamsburg, MA
ca. 660 Acres of Forest**

Map by Michael Mauri, L.F.
20 West St. S. Dfld., MA 01373
(413) 665-6829 based on
parcel shapefile provided
by Noho DPW on 2-15-2023,
and GIS data from MA GIS,
3-2023



SCALE 3000' +/-

Watershed boundary
Mountain Street Reservoir



Amur cork

Mtn
St.
Res.

EX WTP

Haydenville Rd

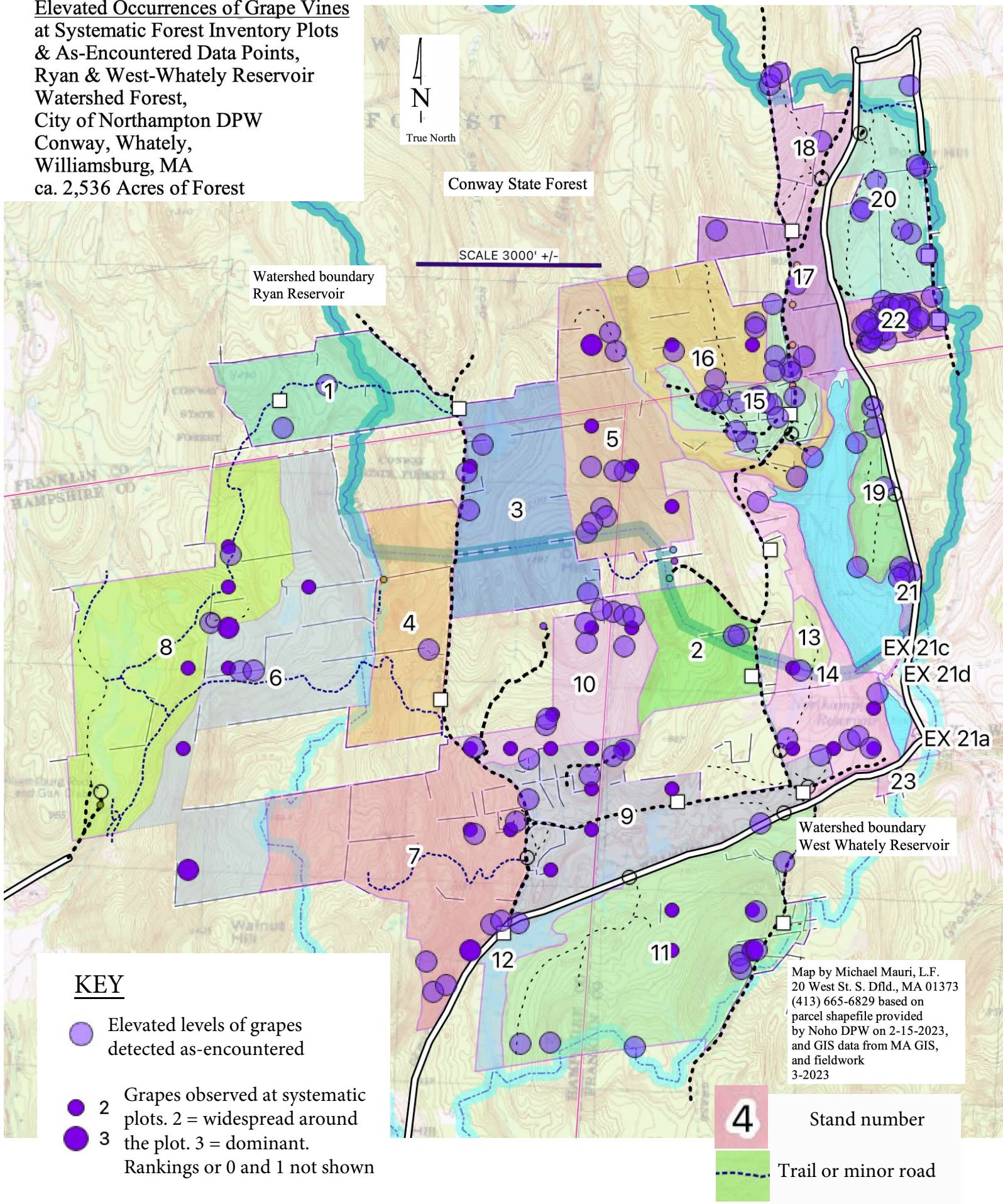
	Any occurrence of other invasive plants (any pink dot) not referenced below
	Any occurrence of burning bush
	Any occurrence of glossy buckthorn
Bittersweet Rank at Location	Interpretation of Severity
	0 ABSENT / NONE DETECTED
	1 EXTREMELY MINOR
	2 MINOR BUT READILY TREATABLE
	3 MODERATE TO SEVERE – CANNOT READILY BE CONTROLLED
	4 SEVERE (invasives dominate understory, tall overstory intact)
	5 NO LONGER A FUNCTIONING FOREST (invasives are the overstory)

Stand number

Trail or minor road

ABSENT refers to absence of bittersweet at systematic plots.

Elevated Occurrences of Grape Vines at Systematic Forest Inventory Plots & As-Encountered Data Points, Ryan & West-Whately Reservoir Watershed Forest, City of Northampton DPW Conway, Whately, Williamsburg, MA ca. 2,536 Acres of Forest



Conway State Forest

SCALE 3000' +/-

Watershed boundary
Ryan Reservoir

EX 21c
EX 21d

EX 21a

Watershed boundary
West Whately Reservoir

KEY

- Elevated levels of grapes detected as-encountered
- 2 Grapes observed at systematic plots. 2 = widespread around the plot. 3 = dominant. Rankings or 0 and 1 not shown
- 3

4 Stand number

Trail or minor road

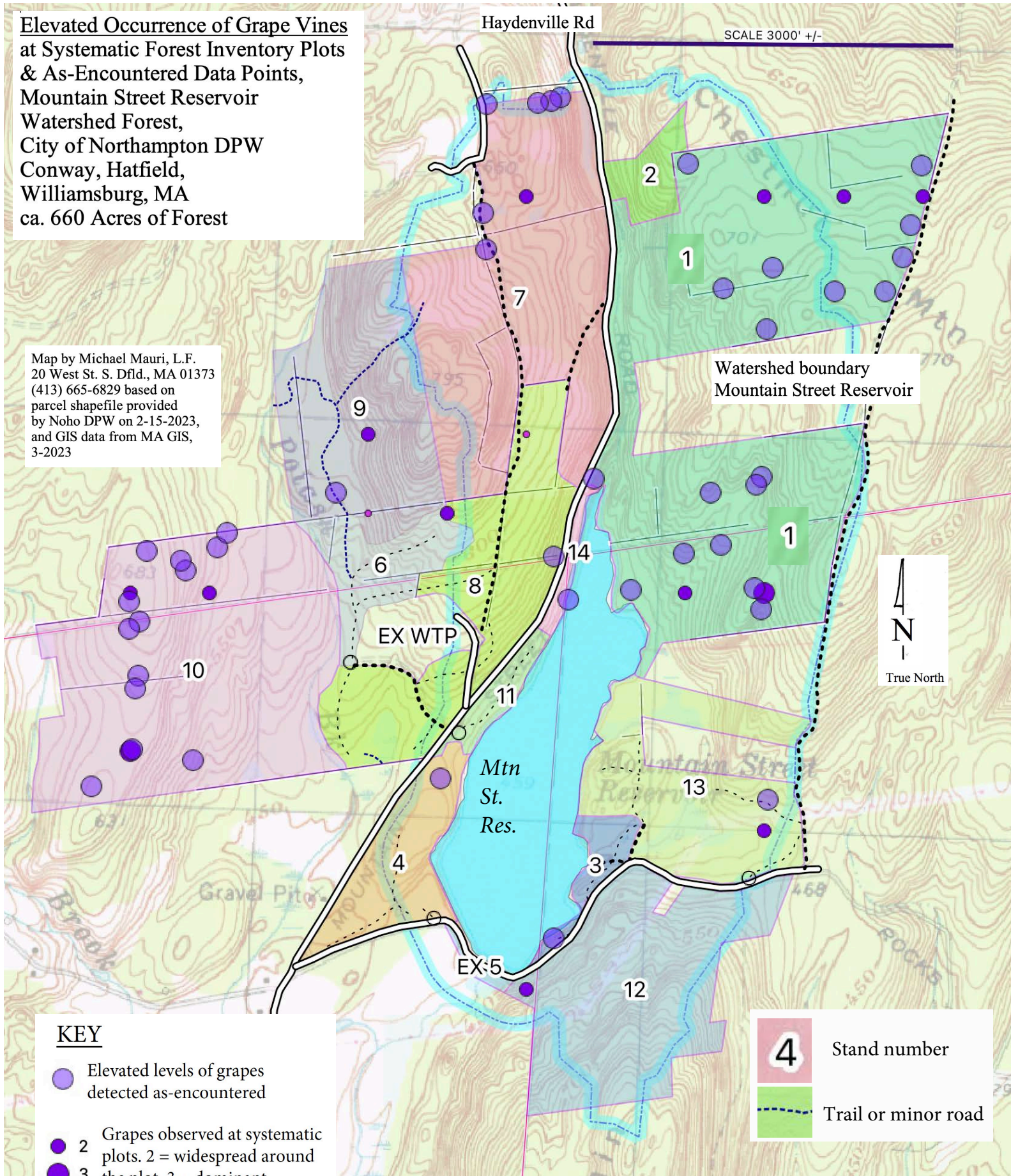
Map by Michael Mauri, L.F.
20 West St. S. Dfld., MA 01373
(413) 665-6829 based on
parcel shapefile provided
by Noho DPW on 2-15-2023,
and GIS data from MA GIS,
and fieldwork
3-2023

**Elevated Occurrence of Grape Vines
at Systematic Forest Inventory Plots
& As-Encountered Data Points,
Mountain Street Reservoir
Watershed Forest,
City of Northampton DPW
Conway, Hatfield,
Williamsburg, MA
ca. 660 Acres of Forest**

Map by Michael Mauri, L.F.
20 West St. S. Dfld., MA 01373
(413) 665-6829 based on
parcel shapefile provided
by Noho DPW on 2-15-2023,
and GIS data from MA GIS,
3-2023

Haydenville Rd




SCALE 3000' +/-





Watershed boundary
Mountain Street Reservoir



KEY

-  Elevated levels of grapes detected as-encountered
 -  2 Grapes observed at systematic plots. 2 = widespread around the plot. 3 = dominant.
 -  3
- Rankings or 0 and 1 not shown

	Stand number
	Trail or minor road

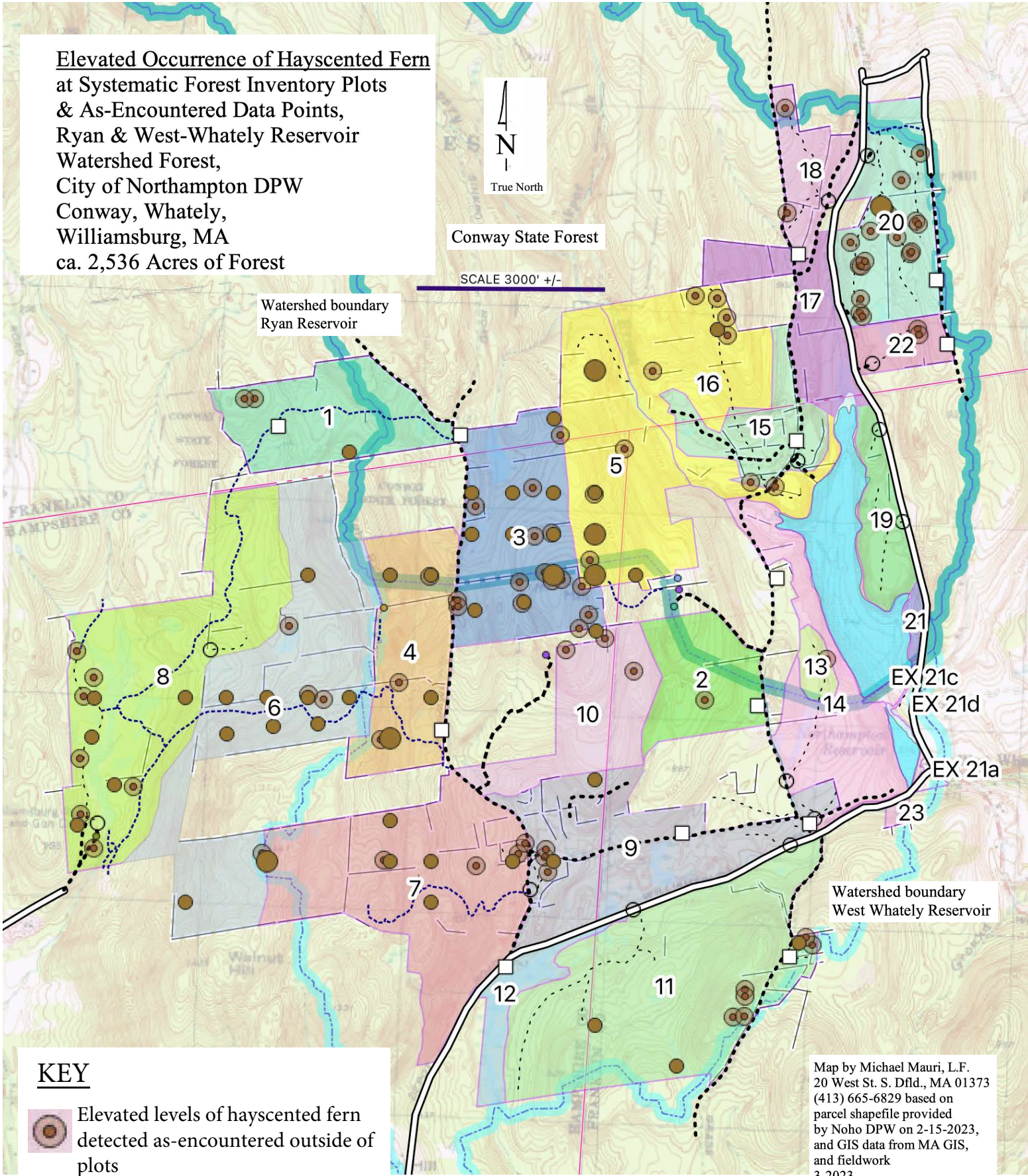
**Elevated Occurrence of Hayscented Fern
at Systematic Forest Inventory Plots
& As-Encountered Data Points,
Ryan & West-Whately Reservoir
Watershed Forest,
City of Northampton DPW
Conway, Whately,
Williamsburg, MA
ca. 2,536 Acres of Forest**




Conway State Forest


SCALE 3000' +/-


Watershed boundary
Ryan Reservoir





KEY

 Elevated levels of hayscented fern detected as-encountered outside of plots

 Hayscented fern observed at systematic plots. 2 = widespread around the plot. 3 = dominant. Rankings or 0 and 1 not shown



 4 Stand number

 Trail or minor road

Map by Michael Mauri, L.F.
20 West St. S. Dfld., MA 01373
(413) 665-6829 based on
parcel shapefile provided
by Noho DPW on 2-15-2023,
and GIS data from MA GIS,
and fieldwork
3-2023

Elevated Occurrence of Hayscented Fern
 at Systematic Forest Inventory Plots
 & As-Encountered Data Points,
 Mountain Street Reservoir
 Watershed Forest,
 City of Northampton DPW
 Conway, Hatfield,
 Williamsburg, MA
 ca. 660 Acres of Forest

Map by Michael Mauri, L.F.
 20 West St. S. Dfld., MA 01373
 (413) 665-6829 based on
 parcel shapefile provided
 by Noho DPW on 2-15-2023,
 and GIS data from MA GIS,
 3-2023




Haydenville Rd



SCALE 3000' +/-

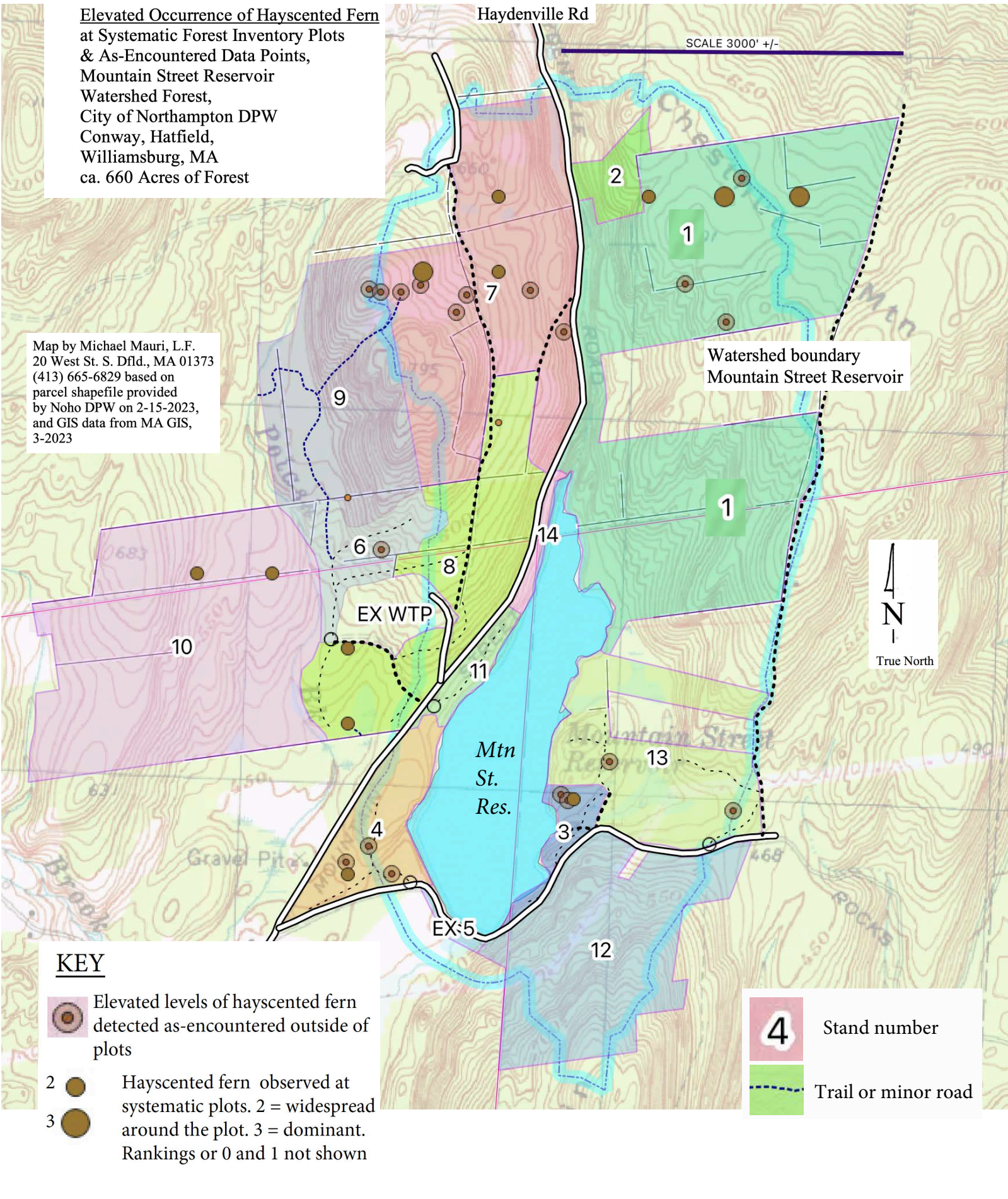
Watershed boundary
 Mountain Street Reservoir



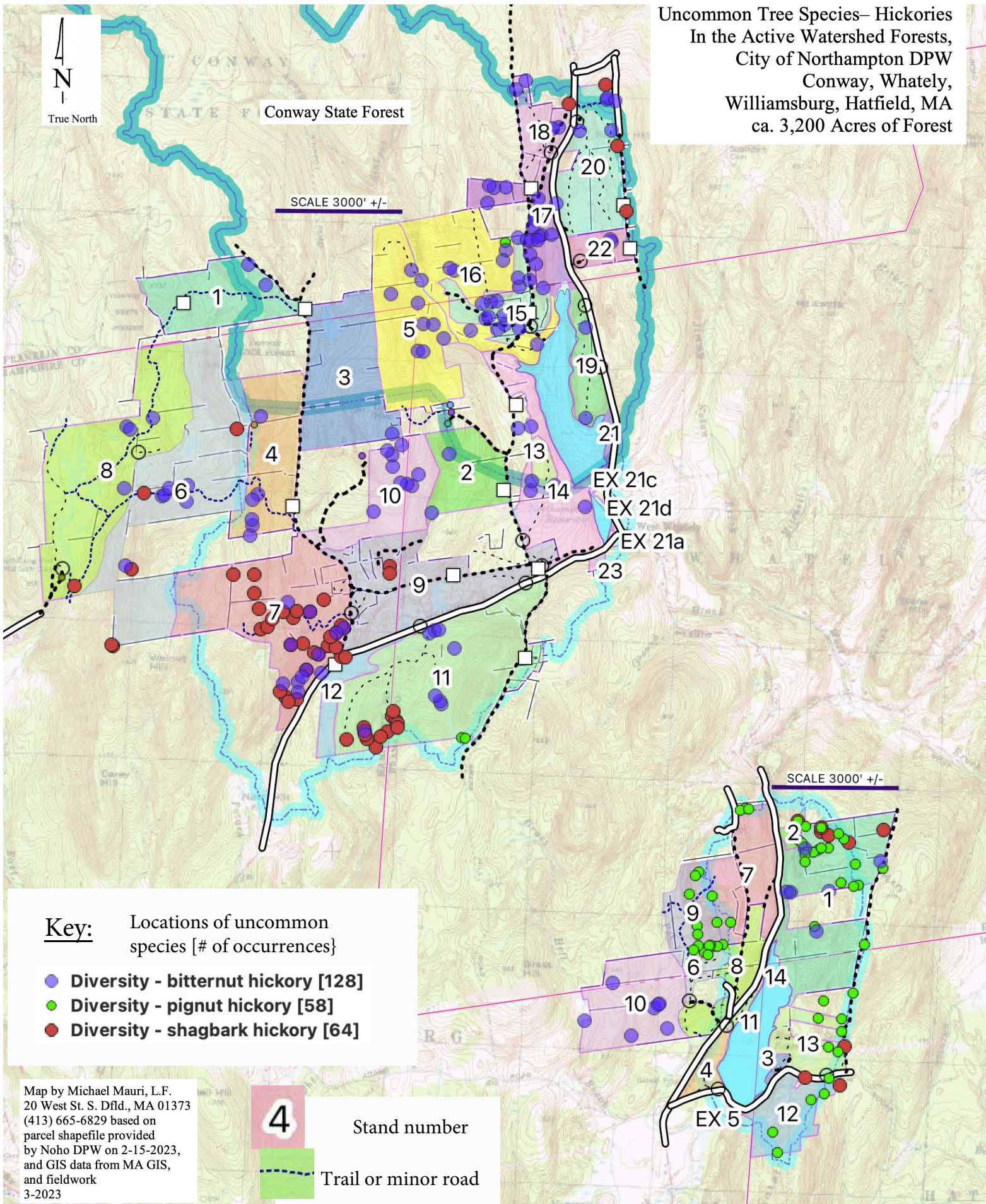
KEY

-  Elevated levels of hayscented fern detected as-encountered outside of plots
-  Hayscented fern observed at systematic plots. 2 = widespread around the plot. 3 = dominant. Rankings or 0 and 1 not shown
-  Hayscented fern observed at systematic plots. 2 = widespread around the plot. 3 = dominant. Rankings or 0 and 1 not shown

-  Stand number
-  Trail or minor road



Uncommon Tree Species– Hickories
 In the Active Watershed Forests,
 City of Northampton DPW
 Conway, Whately,
 Williamsburg, Hatfield, MA
 ca. 3,200 Acres of Forest



Key: Locations of uncommon species [# of occurrences]

- Diversity - bitternut hickory [128]
- Diversity - pignut hickory [58]
- Diversity - shagbark hickory [64]

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 and GIS data from MA GIS,
 and fieldwork
 3-2023

4

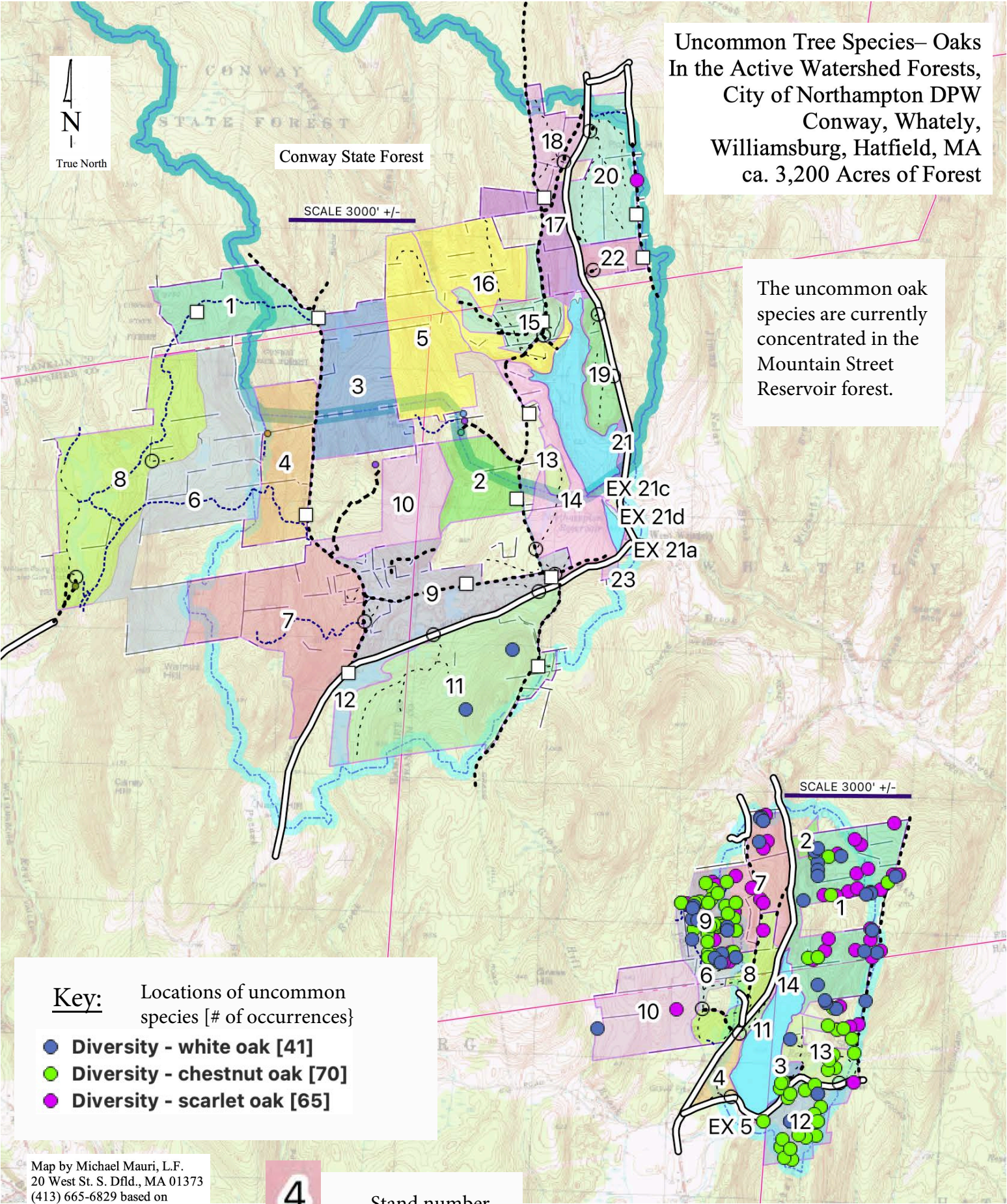
Stand number



Trail or minor road

**Uncommon Tree Species– Oaks
In the Active Watershed Forests,
City of Northampton DPW
Conway, Whately,
Williamsburg, Hatfield, MA
ca. 3,200 Acres of Forest**

The uncommon oak species are currently concentrated in the Mountain Street Reservoir forest.



Key: Locations of uncommon species [# of occurrences]

- **Diversity - white oak [41]**
- **Diversity - chestnut oak [70]**
- **Diversity - scarlet oak [65]**

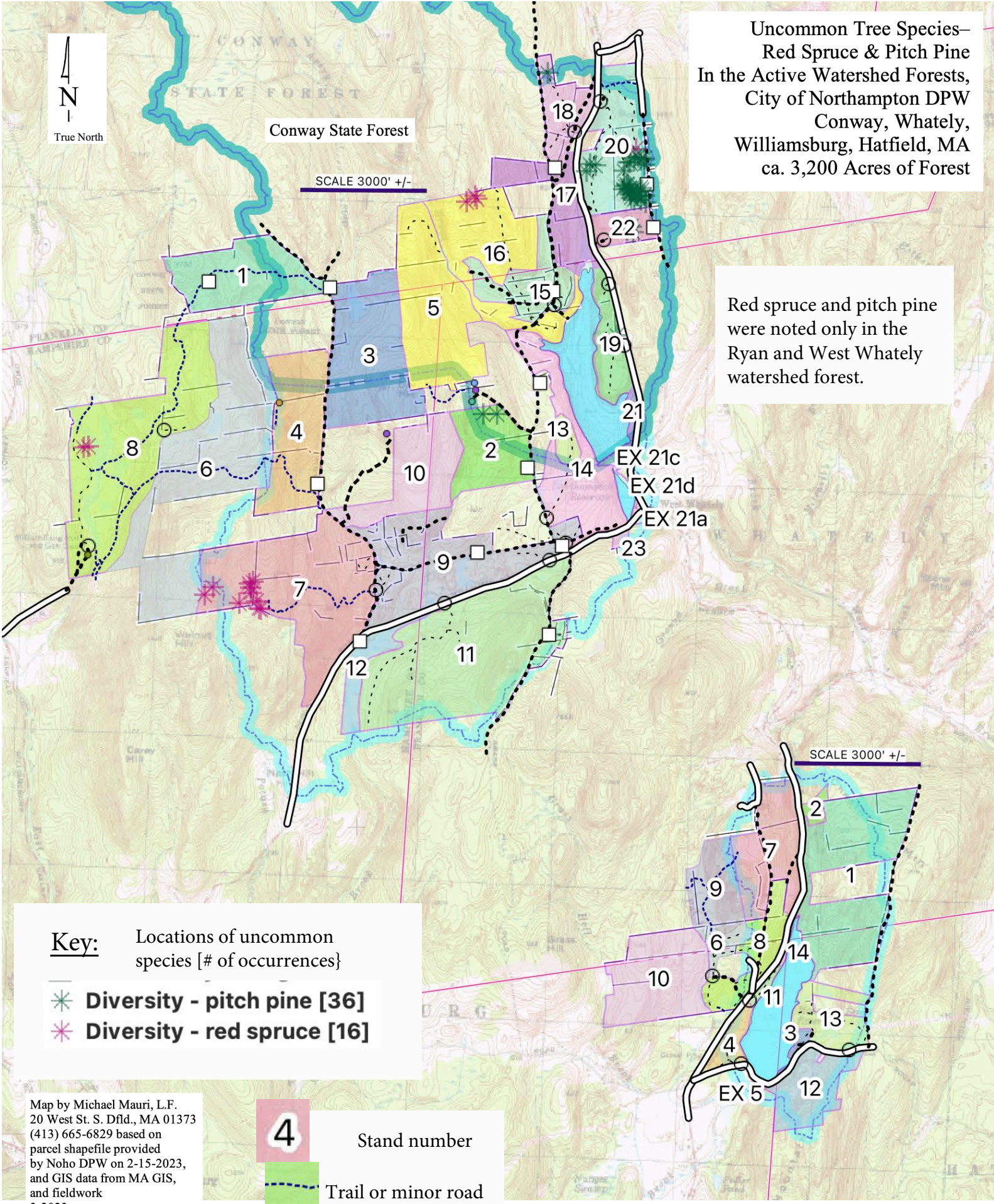
4 Stand number

--- Trail or minor road

Map by Michael Mauri, L.F.
20 West St. S. Dfld., MA 01373
(413) 665-6829 based on parcel shapefile provided by Noho DPW on 2-15-2023, and GIS data from MA GIS, and fieldwork 3-2023

Uncommon Tree Species—
Red Spruce & Pitch Pine
In the Active Watershed Forests,
City of Northampton DPW
Conway, Whately,
Williamsburg, Hatfield, MA
ca. 3,200 Acres of Forest

Red spruce and pitch pine
were noted only in the
Ryan and West Whately
watershed forest.



Key: Locations of uncommon species [# of occurrences]

- ✱ **Diversity - pitch pine [36]**
- ✱ **Diversity - red spruce [16]**

4 Stand number

Trail or minor road

Map by Michael Mauri, L.F.
20 West St. S. Dfld., MA 01373
(413) 665-6829 based on
parcel shapefile provided
by Noho DPW on 2-15-2023,
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3-2023

Methods used to gather data for the Forest Stewardship Plan

The intention was to gather data in a way that reveals important trends such as overall forest composition, structure, wood volumes and tree health while also providing sufficient detail such as biodiversity (e.g., tree species diversity) and active threats (e.g. non-native invasive plants, etc.).

Data was gathered under three primary headings, with a few add-on components, as follows: pre-available data, systematic plot-level data gathered in the field, and “as-encountered” data observed in locations in between systematic plots in the field.

Systematic data provides a non-biased typical overview of the forest. As-encountered data provides a mechanism to capture relevant data that would otherwise be lost to systematic sampling, which may be especially valuable for features that are not widely or regularly distributed, such as diversity (tree species), and in some cases as a check on the systematic data (for example, regarding the occurrence of non-native invasive plants).

Types of data

Pre-available data

This was primarily in the form of GIS parcel layers provided by DPW as well as GIS layers obtained from MA GIS. These layers were accessed and worked with in QGIS version 3.10.8-A, an open-source GIS software. DPW provided the project ownership shape (i.e., boundary layer) that was used to define the bounds of the active watershed forest project area. Other data was obtained from the USDA NRCS (soil data), directly from MA GIS, including wetland layers, topography, and Lidar, and from USGS Topo maps, older DPW maps (including maps from the 2012 Forest Stewardship Plans), and other sources as needed.

Data from previous field work (plans, appraisals, etc.)

As needed, data was drawn from previous Forest Stewardship Plans and timber appraisals prepared for Northampton DPW since 2012. These generally pertained to parcels acquired by Northampton DPW since the preparation of the Forest Stewardship Plans in 2012.

Systematic data: tree- and plot-level data gathered in the field

Individual tree-level data and plot-level forest composition and forest condition data were gathered along a non-biased, *systematic* grid of points. These points were taken from a 10-acre grid established by M.M. in GIS for the entire active watershed forest. On a 10-acre grid the plots are spaced about 666' apart. Plot centers were transferred to field-based maps on Avenza Pro, an iPad-based app, and located on the ground using the iPad's in-built GPS. In the field, a plot center was considered “arrived at” as soon as the blue location dot appearing on the Avenza Pro map on the iPad was shown as entirely inside the plot location dot on the map. Typically, the next footfall was considered to be

the plot center and was marked by a heel scratch in the leaf litter, which was adequate for the data gathering at that plot. Most plots were visited only once. Plot data was gathered from January to October, 2022. In all, 318 plots were systematically sampled.

Most of the systematic tree-level and plot-level data, including field notes and pictures, was recorded in Forest Metrix, an iPad-based forestry application based in Filemaker Go. The data gathered at each plot was of two, complementary types: tree-level data (i.e. measurements and observations of individual trees selected by a non-biased process, explained below), and plot-level data (i.e. observations and impressions of the immediate and wider surroundings of the plot center that could be seen from any given plot) and is discussed in greater detail below. In this system, the tree-level data is processed and exported from the iPad as an Excel file that is then further processed in an Excel report engine as Excel report outputs that form the basis for subsequent analysis. This type of data includes tree species and size, canopy position, wood volumes, etc., that form the typical quantitative basis of a forestry assessment. The plot-level data is not further processed by Forest Metrix but is merely exported as Excel files to be processed directly by the user. The plot level data was processed in Excel and was also imported into QGIS for spatial analysis and portrayal in maps (cf. any of the theme maps showing systematic plot-level data).

The data gathered systematically at plots is discussed in greater detail below in the Forest Inventory Methods section.

“As-encountered” data gathered in the field and recorded with iPad-based GPS

With georeferenced maps created on the QGIS desktop and loaded into the iPad-based Avenza Maps Pro to take into the field, I was able to gather and record additional information as encountered (i.e. while walking non-linearly through the woods between points). This data (mostly point data but also occasionally line data) was exported to the desktop and then imported into the desktop GIS for subsequent analysis and mapping (cf. any of the maps showing “as-encountered” data). One or more observations were recorded at 2,242 of these as-encountered points.

For the locations of both systematic and as-encountered data gathering, see **Methods Map 1: Systematic Forest Inventory Plots and As-Encountered Data Points**.

Other Sources

No other significant external sources were consulted. However, there have been significant planning and management activities conducted since 2011 that resulted in accumulated experience and knowledge of the forest that was drawn upon for this plan.

Forest Inventory Methods

At each of the 318 systematic sample plots, a dual inventory method was used that combined a tree-level, prism-plot basal area cruise with a plot-based observational inventory designed for use in GIS.

Tree-level data - prism plot inventory

At each plot, from the plot center, a traditional prism cruise was used to select which trees to measure (note: in actuality it was an angle-gauge cruise using a Cruz-All angle gauge with BAF = 40, but this is generally referred to as a prism cruise nonetheless). In order to capture the full occupation of the forest in all strata, any live or dead standing tree ≥ 1 " diameter, if selected by the prism, was included. The distance to borderline trees was checked with a laser rangefinder (to confirm whether they were in or out). No correction for made for slope. Prism data is the data that is used to calculate the basic forestry parameters basal area, average diameter, trees per acre, and per-acre and total volumes by species at the plot-level. These data are used to calculate parameters at the forest level and subsets such as the stand-level. In all, 1,238 trees were measured in this manner, including 152 dead trees, for an average of about 3.9 trees per plot.

For all trees selected by this process, species was recorded, diameter was measured (in inches using a diameter stick or, if too large, by measuring tape), a canopy position status was assigned based on visual inspection, and an assessment of individual tree health was made (see Table a below). The largest diameter measured at a plot was 58", the smallest was 2".

Additionally, a product class and length were assigned for as many as three separate segments of each tree (see Table b below). Product height or length was largely determined by visual estimation but was supported by check measurements if needed with a laser rangefinder (TruPulse 200 Rangefinder/Hypsometer).

The product-class list included a mix of economic products (e.g., sawtimber) and functional/ecological "products" or niches such as live cavity trees or midstory tolerant trees (typically limited to beech or hemlock), which play a special ecological role.

On an optional basis, when good lines of sight were available, total tree heights were measured. This was done more out of curiosity than for any management purpose. Because most of the data was gathered during leaf-on conditions, there were rarely good lines of sight. In the end, total tree heights at systematic pots were measured for 15 trees. These heights ranged from 78' to 124'. A few heights were measured on an as-encountered basis, with the tallest being 140'. Generally, in order for a tree height to be measured, it needed to seem tall compared to the general species run. Heights for these tall trees are summarized below.

- White pine: 108' – 140'
- Hemlock: 86'– 96'
- Sugar maple: 100'
- White ash: 99'

- Black birch: 78' – 83'
- Red oak: 83' (note: due to its crown spread, red oak is especially hard to measure in a leaf-on condition in the forest; it is to be assumed that some red oaks reach a height comparable to sugar maple and ash)

The intent of gathering this data was to accurately portray the diversity, abundance, condition, size and volume of the trees in the active watershed forest. The processed results of the prism plot tree-level inventory data are reported in **Overstory Composition Tables 1 & 3**. This data was used to create the basic stand descriptor data used in each stand description header (basal area, average diameter, Mbf per acre, etc.).

Table a: Tree Status and Condition Attributes used for each prism plot tree

Canopy Status	Dom, Co-dom, Suppressed, Viable regeneration, Snag,	Dom (Dominant) is free to grow on ≥ 2 sides, Co-dom (Co-dominant) may only be free to grow (FTG) one one side but at least above, suppressed is completely overtopped or barely FTG above, Viable regeneration is not overtopped or is sufficiently shade tolerant to survive indefinitely. A snag is any standing dead or very-nearly dead tree. By definition, a co-dom is <i>crowded</i> as judged in the field.
Apparent Health	POOR - STRUGGLING POOR - HK THIN CROWNS POOR - WP THIN CROWNS OR SAP DRIP POOR - CANKER POOR - EAB POOR - STORM/TOP DAMAGE POOR - ROT IN STEM POOR - VINES SNAP NORMAL-VIGOROUS Uncertain Drought? NA	This is a best judgement made in the field.
Form	POOR FORM CABBAGE OLD OR NEW EPICORMIC TIP PARTIAL LIGHTNING LOGGING SCAR Scar / seam Old or weathered Released midstory Sweep from wind HOLLOW NA	This is used to call out a prominent defect or aspect; use NA if no particular attribute is noteworthy. "Cabbage" refers to white pines with multiple, extremely twisted trunks.

Table b: Product Attributes used for each prism plot tree

First Product Length		Visual for most trees but use laser to check any heights as needed. Unit of length is 16'.
First Product type	Sawlog, Pallet, Wood, Pulp, Growing stock, Midstory tolerant, Cavity live, Relic, Snag, Misc,	"Product" classification is prioritized by highest economic function first, then ecological function. E.g. a section will be classified as "saw" if it has sawtimber, even if the tree also has a live cavity above. Sawlog is a reasonable quality sawlog that would be normally and readily salable in recent or potential markets; pallet is a rough sawlog that clearly does not belong in the general run of sawlogs; upper pallet is only used for pallet above a sawlog, wood is firewood, upper cords is wood or pulp above a sawlog or pallet or is cordwood or pulpwood of markedly inferior quality (i.e. firewood suitable for processors would be called "wood" whereas firewood needing to be cut up and split piece by piece would be called "upper cords", growing stock is a small tree with potential to become a sawlog, midstory tolerant is a shade-tolerant tree that has spread its crown and can persist in the midstory, cavity live is a rough tree with significant rot, defect or actual cavity that has no product value, relic is a tree that is clearly from an earlier land-use or an earlier forest cohort, a snag is dead or essentially dead, misc. is any tree not fitting in above categories such as a 4" striped maple.
Second Product Length		Unit of length is 16'.
Second Product type	Upper pallet, upper cords	Optional: only use this if there is economically viable roundwood (i.e. from a round stem or large branch that could form a stick or log) above the lower product call as follows: upper pallet is pallet above a sawlog, upper cords is wood or pulp above a sawlog or pallet. The upper pallet (e.g. white pine) is not required to have any economic value at this time as long as it could be sawed for boards.
Third Product Length		Unit of length is 16'.
Third Product type	upper cords	Optional: only use this if there is clearly identifiable roundwood above the lower product call; upper cords can be large branchwood in red oak if these occur in relatively straight 8' sections with a tip clearly ≥ 4 " diameter, or can refer to some of the multiple stems on rough white pine. Upper cords is partly a means to capture roundwood biomass with a value in water quality protection and does not have to have a practical economic value, although it may have one.

Statistical reliability of the systematic tree-level data

With a sample size of 318 points, a high degree of reliability was achieved – see Table: Statistical reliability of the data. There is a high degree of confidence (90%) that the mean basal area of 155.7 is within +/- 4.4% of the true mean. Likewise, there is a high degree of confidence (90%) that the estimated average of total cord products is within +/- 7.2% of the true mean, and the estimated average timber volume is within +/- 8.6% of the true mean.

Table: Statistical reliability of the tree-level data

Stand Acres:	3000	# Points	318
Sampling Statistics		-	-
Conf. Level: 90%	All Saw (MBF)	All Cords products	Basal Area
Mean	10.1	16.6	155.7
Approximate number of points needed to be within +/- 10% of the true mean	237	166	63
CV	93%	78%	48%
St Dev	9.4	12.9	74.7
Standard Error	0.5	0.7	4.2
CI Lower	9.3	15.4	148.8
CI Upper	11.0	17.8	162.6
% Sampling Error (+/-)	8.6%	7.2%	4.4%

Other plot-level data (see Tables a-e)

At each plot, in addition to measurements taken on selected trees, the general forest conditions in the vicinity of the plot were assessed using the entirety of the visible field. Anything that could be seen from the center of the plot or from any point within several steps of the center of the plot could be included. Most of the data was gathered beginning during leaf-on conditions, which did restrict visibility into the distance, but afforded a good look at understory conditions.

Plot-level data may add important information about overstory species diversity that is not captured in the basal area sampling. At each plot, for each overstory tree species, it was determined whether the species was absent, present, or abundant within the entire extent of what could be viewed from the plot center. This is not a fixed distance and depends on visibility factors at the site. For example, if an observer can see approximately 150' in all directions, then about 1.5 acres is captured. If an overstory species could not be seen, it was marked *absent* and given a value of 0. If only a single individual was observed, it was considered *present* and a value of 1 was assigned. If 2-5 individuals were observed, the species was considered *common* and a value of 2 was assigned. A value of 3 was assigned for observations of 6 or more individuals; in this case, the species was considered *abundant*.

The absent-present-abundant data is intended to capture larger trends such as forest composition that, it can sometimes seem, are not always adequately captured at the narrower prism-plot level. This may be especially important for uncommon species. The thinking here is that, by sheer virtue of being present, even at a distance, a tree may influence outcomes at or near the plot center, i.e. seed from the tree may be available for the establishment of seedlings. The presence and abundance data is shown in **Overstory composition Table 2**.

The absent-present-abundant data also lends itself to spatial portrayal and reflects perhaps more closely the impression one would have when walking about and surveying the forest. Indeed, while prism-based data is essential in assessing tree attributes as they are aggregated and averaged over a large area, the as-seen-from-plot-center plot-level data provides a better handle on the *spatial distribution* of each species. The plot-level data is meant to be used in conjunction with, and as an enhancement to, the prism plot data described above.

Numerous other types of data were gathered within the extent of the visible field at the plot level, including information about forest structure, regeneration, non-native invasive plants, etc. – see Tables a-e.

There was an option to take freehand notes at each point, as needed, and record this within the Forest Metrix software.

The results of the forest inventory are used in the forest overview (see The Forest in detail) as well as in the Stand Descriptions.

Table C: Plot-Level Data

Category	Type of Data	Explanation/Comment
Canopy height	0 0-10 10-<20 20-<50 50-<100 >100'	Choose closest match. This refers to the height of the dominant canopy trees.
FOREST STRUCTURE	Mature-closed canopy NO layers Mature-closed canopy + under or mid LAYERS Irregular mature canopy small openings Irregular mature canopy large openings nearby (>1/3 ac) Uniform early-successional trees (<30') Tall closed-canopy REGEN (>30') Complex E-S w/ retention of mature features upland forbs & shrubs shrubby wetland beaver meadow Shallow marsh with mature forest shoreline Undesirable non-forest condition mowed grass/forbs Semi-open Woodland maintained by brush hogging Delayed or failed Regen patch Other	Choose closest match
Coarse woody debris ≥ 6"	0 - 25	Quick count of # pieces of unique origin visible, stop at 25.
LEAFLITTER	0= no, 1 = partial, 2 = thick	0= leaf litter lacking, 1 = leaf litter partially covering soil but exposed soil is more than an exception, 2 = thick (typically includes beech/oak or thick needles)
Earthworms	0,1,2, NA	0= no evidence, 1=some evidence, 2=widespread evidence
INVASIVES	0, 1,2,3,4,5	See explanation elsewhere. 0 is new category meaning none detected. 1 = one or only a few. Refer to lists for major/minor species.
INTERFERING WOODY	0= no, 1 = present 2 = abundant, 3= dominant	0 = absent or essentially absent, 1 = minor but concerning presence, 2 = interfering vegetation is significantly impacting or will significantly impact future establishment of desirable trees, 3= interfering veg has precluded or overwhelmed most other understory veg. Refer to lists for major/minor species.
REGENERATION free to grow	0, 1, 2, 3, 4	0 = none, 1=one or a few REGEN is FTG (free to grow) in single-tree gap or is well-established and very shade tolerant (e.g. red spruce, sugar maple), 2=abundant in several-tree gap or small group; 3=REGEN is overstory in large gaps in 2-age structure with scattered taller residuals, 4=REGEN forms entire overstory or nearly so (very few or no residuals). If REGEN does not appear likely to outgrow deer/moose browse then it is not considered free-to-grow. Regeneration may be considered FTG if it is sufficiently shade tolerant to survive current shade. NOTE: The species of regeneration is recorded in a separate table.
LOW PLANTS	0= no, 1 = present 2 = abundant	Characterize non-woody groundcover. 0 = none or almost none, bare leaves or soil, 1= some understory plants present, 2= thick understory plants. Refer to separate list for species.

Other mgmt	invasives Invasives pull/dig, Invasives-herbicide Cut grapes, Erosion mgmt, Ash, TSI for diversity TSI & cut grapes Grapes And invasives Control MTN Plant spruce? CNTRL HAY HAZARD MOW NA	Select one of more practices that require special attention
MAXSILV	TSI, thin, shelterwood, shelterwood release, irregular shelterwood, E-S coppice or clearcut, SLASH WALL Let grow / Monitor, See notes, NA	Pick most intense level of silviculture compatible with the majority of the <u>site</u> visible from the plot (rather than based on the current forest) for the entire area within view from plot center. This is not necessarily the recommended silviculture but merely the maximum intensity silviculture for the site and situation.

Table d: Plot-Level Data

Shrubs	NA, Alternate-leaved dogwood, Arrowwood, Beaked hazel, Blackberry/raspberry, Boxelder, Choke cherry, Hawthorn, Highbush blueberry, Hobble bush, Huckleberry, Ironwood, June pink or other azalea, Lowbush blueberry, Maleberry, Maple-leaved viburnum, Mountain maple, Muscledwood, Red elderberry, Shadbush, Speckled alder, Spice bush, Spirea, Willow, Wild raisin, Winterberry, Other, None.	This is not as quantitative as some categories due to the thickets shrubs can form; major is reserved for a pronounced presence of a shrub at least in a notable thicket or otherwise having many stems scattered around so as to be a notable ecological presence; minor indicates that it is present or sparse, as opposed to totally absent. In all check off lists, generally try to check none if there are none as a way of confirming that the category was evaluated (rather than leaving it blank).
Major Invasives	NA, bittersweet, glossy buckthorn, barberry, honeysuckle, multiflora- rose, autumn-olive, J knotweed, burning bush, Norway maple, garlic mustard, locust, privet, phragmites, cork, None,	See ranking scheme elsewhere. A major invasive is generally assigned when the rank is 3 or greater. A minor invasive is 2 or less. There can be a gray area between 2 and 3 - this is a field judgement call.
Minor Invasives	same	See note above
Other veg	NONE, NA, Wild leek, spring beauty, trout lily, maidenhair fern, other rich mesic, red trillium, white trillium, Xmas fern, cinnamon fern, sensitive fern, evergreen woodfern, bracken fern, cliffbrake, Beech fern, Royal fern, Canada mayflower, starflower, Indian cucumber, wild sarasparilla, patridgeberry, wintergreen, goldthread, prickly dewberry, Skunk cabbage, False hellebore, moss, Sphagnum, Club moss, Blue bead lilly, Star flower, Blue cohosh, Doll's eyes, Wood	Other vegetation may be indicated in notes.

	<p>sorrel, Toothwort, Blood root, Pipsissewa Other wildflower, Sedge, Trailing arbutus Poison ivy, RO SEEDLINGS, Horsetail, Hog peanut, Broadleaved Sedge , Virginia creeper, R spruce seedling, Chestnut oak seedlings , Broadleaved sedge, WO seedlings OTHER,</p>	
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Table e: Plot-Level abundance

Overstory trees (all species)	0,1,2,3	If a species could not be seen, it was marked <i>absent</i> and given a value of 0. If only a single individual was observed, it was considered <i>present</i> and a value of 1 was assigned. If 2-5 individuals were observed, the species was considered <i>common</i> and a value of 2 was assigned. A value of 3 was assigned for observations of 6 or more individuals; in this case, the species was considered <i>abundant</i> . Data for less common species is recorded in the "Notes" section with the rank indicated as "level".
Shade-tolerant midstory trees (HK & BEE)	0,1,2	0=absent, 1=present, 2=abundant enough to impact regeneration,
Interfering Native Vegetation (witch hazel, mountain laurel, grapes, striped maple, hayscented fern)	0,1,2,3	0=absent, 1=present, 2=abundant enough to impact regeneration, 3=very dominant

Plot-level data: non-native invasive plants

Non-native invasive plants are plants which, having been brought in intentionally or inadvertently from other regions of the world, pose a range of problems for owners and managers of natural areas such as the DPW watershed lands. The problem of non-native invasive plants (aka *invasives*) is their ability to interfere, on a number of levels, with the natural processes we would normally expect to see occurring within a natural area. An obvious example is the tendency of some invasives (e.g., oriental bittersweet) to completely overwhelm forested areas and hinder, sometimes entirely, the growth of native plants, including trees. This possibility poses a serious risk to a water supply that intends to rely, in perpetuity, on the water quality benefits provided by a broad-scale, forested landscape. A more subtle example is the ability of at least one invasive, garlic mustard, to alter soil chemistry in a way that disadvantages certain soil fungi that are beneficial to sugar maple. There is probably a lot more to be discovered about the impact of invasives on forests, but the knowledge already available is enough to make it clear that there is no constructive role for invasives to play within a healthy forested watershed. A wise policy for a watershed would be to strive to keep as much of the forest as invasives-free as possible. Invasives control efforts involve ongoing monitoring and generally need to be directed at specific sites, implemented with specific methods, and appropriately prioritized with respect to the sum total of all other invasives needing treatment. Recommendations to this effect are made in the Management Practices section.

Because a forested watershed such as that owned by DPW is so large, it will be a challenge to maintain an invasives-free condition over the entire area, over time. To a large extent, therefore, the inherent passive resistance of the forest to the spread of invasives, or at least the inherent tendency to *slow* the spread of invasives, is an important asset to be recognized and utilized over large areas. Exceptions to this can then be dealt with in a more direct and prioritized fashion.

Data gathered for this FSP related to invasives in a number of ways. First, there was a ranking of invasives themselves (by species and by intensity at each plot) (as discussed above under plot-level data gathering). The ranking system used is similar to a ranking system developed in 2012 for the City of Northampton watershed, which ranked invasives on a scale of 1-5. This has been a good system, but based on my experience using it since then, I have added a new category, 0, which refers to the complete absence of detection of invasives (see the invasive plant ranking system in Table f below). This allowed what used to be the lowest category, 1, to be used for even the slightest level of detection. In the original system, the two conditions of total absence and extremely minor presence were lumped together. The addition of 0 provides greater clarity at the zero- or low-infestation end of the spectrum.

Table f: Plot-Level Data – Invasives Ranking

Level of Infestation or Presence (Rank)	Interpretation of Rank
0	ABSENT / NONE DETECTED
1	EXTREMELY MINOR (< 1% cover)
2	MINOR AND READILY TREATABLE (1% - 5% cover)
3	MODERATE TO SEVERE (6%-90% cover in understory), cannot readily be controlled)
4	SEVERE (>90% invasives cover in understory, tall overstory intact)
5	NO LONGER A FOREST / IN NEED OF RESTORATION (nearly 100% invasives cover, no tall overstory)

The ranking system can be used in a number of ways, including ranking the severity at a given point, ranking (by averaging) the severity of a larger unit (e.g., a stand, zone, compartment or watershed), and as a way of comparing the relative level of infestation of different areas. The ranking number must be interpreted in light of the types of invasives present, site conditions, etc. – some invasives, such as bittersweet, glossy buckthorn and apparently cork, appear to spread much more aggressively than some others, so that a rank=2 might be more worrisome for bittersweet than for barberry, for example. It is also important to remember that the sampling system, even at the intensity used here, can overlook some portions of an invasive plant population. The as-encountered data is intended to help fill that gap in information.

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Stand Descriptions Mountain Street

Notes for Stand Descriptions

DCR Program Objectives for all stands

Enrollment in Forest Stewardship Program.

Desired future condition for all stands

See Landowner Goals section.

Impacts of feeding (browsing) by deer and moose

With evidence of heavy browsing activity ubiquitous throughout the watershed, there was no systematic effort to quantify deer or moose browse impacts at the stand level for the Forest Stewardship Plan (see discussion in **Excessive browse impacts due to deer and moose** in the Forest Overview section). For all stands, the impact of deer and/or deer and moose browse is considered to be substantial.

Delineation of Stands

In order to make large areas of land manageable, the practical application of forest management generally requires breaking larger land units into smaller units that are appropriately-sized for a given purpose. This situation here is no different.

As used here, an area defined as “a stand” captures some aspects of vegetation type as well as soil conditions, accessibility, and other factors that seem to combine to form a coherent group that can be identified on the ground, even though there is often not a perfect way to apply the sharp conceptual distinction of stand boundaries onto a forested landscape. In the bigger picture, stands are not really a property of the forest, but are purely a management construct to help organize thinking and action. In any case, stands, as delineated here, are not absolute in any ecological sense and are primarily meant to help facilitate management.

Stands were originally created in 2011 for the 2012 Forest Stewardship Plan. Since that time, DPW has acquired a number of new parcels (see TABLES A B C - Property Records). These are adjacent to pre-existing stands. The same basic system of stands created in 2011 was re-used here, but with the following adjustments as needed:

- Some portions of the original 2011 stands were merged with or reassigned to other stands
- Some of the new properties were tacked on to pre-existing stands
- Some of the new properties constitute their own stand

The stands are listed in Table 5.1 and their location within each watershed forest is shown on the Stand Locator Map. Stand-level details are shown in the **Forest Stand and**

Boundary Maps. Further discussions of individual stand delineation are provided within the Stand Descriptions.

Notable occurrences of uncommon native tree species

If there were any notable occurrences of uncommon native tree species, these are mentioned with each stand description. Some of these species are shown on maps provided in the Overview Section of this plan.

Non-native invasive plants: stand-level severity ranking

Non-native invasive plants pose a threat to the functioning of the watershed forests. This Forest Stewardship Plan places a particular focus on *woody* non-native invasive plants which, from a forest perspective, seem to pose the greatest in-forest threat at this time. All references to non-native invasive plants discussed below are to woody non-native invasive plants unless otherwise specified. Data on non-native invasive plants was gathered both systematically, at each of the 318 sample plots, as well as on an as-encountered basis. The composite results of this data gathering are shown in a number of maps included in the Overview Section. Based on the data gathered specifically for this Forest Stewardship Plan as well as on observations made over time at these sites, a perceived severity of the non-native invasive plant infestation is categorized for each stand and a general management approach is recommended. The ranking system is presented in the table below. These categories are intended to help with interpreting the relative severity of the infestation and in developing management planning at the stand level. There is admittedly a subjective-interpretive aspect to these categorizations. In many cases it is hard to draw sharp distinctions between levels of severity, especially in the vast middle ground between non- or minimally-infested states and extremely infested states. This middle ground is represented by a Rank = 3. The categories are intended to capture increasing degrees of severity, from 0 to 5, but each category necessarily grades into the next. A main distinguishing criterion between categories 2 and 3 is how discrete or separate the various occurrences are on the ground. Are they widely scattered or do they tend to merge into larger “runs”? For stands with Level = 2, the invasives tend to occur in discrete patches that can easily be circumambulated. For stands with Level = 3, there is a tendency for patches to be agglomerated in larger extents or in frequent occurrences. Another criterion is how theoretically treatable the given population of invasives is in each case. There is some consideration of this question by species; some invasives are potentially easier to treat, or are less aggressive in their spread or impact, than others. In the Northampton DPW watershed forests, at this time, it seems that bittersweet is the most problematic in terms of both the difficulty to successfully treat it and the aggressiveness of its spread and impact, and thus carries the greatest weight in ranking. In the future, other invasives may be considered even more worrisome. Amur cork, glossy buckthorn, burning bush and autumn olive may play a larger role. Amur cork is, currently, found only at the Mountain Street watershed forest.

Severity Rank at Systematic Plots	Interpretation of Rank
	Present
0	ABSENT / NONE DETECTED
1	EXTREMELY MINOR (< 1% cover)
2	MINOR AND READILY TREATABLE (1% - 5%)
3	MODERATE TO SEVERE – CANNOT READILY BE CONTROLLED (6%-90% cover in understory)
4	SEVERE (>90% invasives cover in understory, tall overstory intact)
5	NO LONGER A FOREST – IS IN NEED OF COMPLETE RESTORATION (100% invasives cover, no tall overstory)

Native interfering vegetation

Data points showing elevated occurrences of wild grape vines and hayscented fern are shown in separate maps included in the Overview Section.

Stand-level management approach

For each stand, in light of the overall landowner objectives for this plan, a management approach is presented that specifically addresses concerns and opportunities identified at the stand level. The approach for each stand represents steps toward maintaining or achieving desired future conditions. These stand-level approaches are summarized assigned a priority ranking in tabular form in the management practices section (see: Watershed Forest Management Practices for the Next 10 Years).

Table 5.1 – Key stand parameters

Stand	TYPE	Acres	Size (avg. diam. in.)	Live Basal Area (ft ² per ac)	MBF per acre	CORDS per acre	Total stem bio-mass (cords)	R *	Site Index	WSHD **
1	WH	168.8	9.9	128	10.6	10.6	31.8	3.5	65 WP	MTN
2	RO	8.2	14.0	118	11.8	6.3	29.8	0	60 RO	MTN
3	WHK	6.7	10.0	120	5.0	10.0	20.0	3	60 RO	MTN
4	WP	23.2	12.8	187	27.4	15.6	70.4	4	70 WP	MTN
6	WH	16.9	20.1	160	21.9	12.2	55.9	3	65 WP	OUT
7	WH	90.8	16.4	138	15.2	20.2	50.6	3.5	65 WP	MTN
8	BB	54.2	11.0	46	4.0	4.0	12.0	4	70 WP	MTN
9	WH	54.9	8.3	144	8.9	19.1	36.9	2	60 WP	OUT
10	WH	109	7.6	124	21.2	8.4	50.7	3.5	70 WP	OUT
11	GF	6.2	NA	0	0.0	0.0	0.0	5	65WP	MTN

12	OH	62.9	12.6	131	12.0	12.5	36.5	1	55 RO	MTN
13	WHK	45.9	9.0	110	5.5	10.8	21.8	1	60 RO	MTN
14	WP	3.2	20.1	160	21.9	12.2	55.9	4	70 WP	MTN
EX 5	GR	1.4	NA	NA	NA	NA	NA	NA	NA	OUT
EX WTP	NA	12	NA	NA	NA	NA	NA	NA	NA	OUT

664.3

Notes for Table 5.1: The OBJ for all stands is Forest Stewardship. Minimum live tree size to be included in this data: 1" diameter. Objective (OBJ), stand number (STAND), forest type (Type — see discussions for each stand below), stand acreage (Acres), size -- average tree size or stand diameter (MSD) (quadratic mean stand diameter in inches), basal area (BA) in square feet per acre (BA is a measure of site occupancy), timber volume (Timber) (in thousand board feet per acre, International ¼" rule), cords of stemwood per acre (1 cord = 128 cubic feet of wood, bark and air) including stemwood or significant branchwood above sawlogs but not including other topwood. Total stem biomass = Mbf X 2 + cords. Site index (anticipated tree height at age 50 if the tree has been free to grow). Site Index is generally based on red oak or white pine as indicated by RO or WP, but may be indicated by other species (e.g., sugar maple = sugar maple). *R = the stand-level rank (from 0 – 5) assigned based on various sources of data gathered for this Forest Stewardship Plan, with ==no-infestation and 5=complete-infestation. **Hydrologic watershed: some stands may be located in >1 watershed (RYN = Ryan, WWT, = West Whately, MTN = Mountain Street, OUT = not in NOHO DPW watershed).

MTN Stand 1

This stand was delineated to capture the large area of forest to the northeast of the Mountain Street Reservoir that had been managed by Northampton DPW in the decades prior to about 2003. This stand is accessed by Chestnut Mountain Road. This stand is bounded to the east by Chestnut Mountain Road, to the north by RWW Stand 2 and non-DPW land, to the south by non-DPW land, and to the west by Haydenville Road and the Mountain Street Reservoir. There is a large, 3-sided inholding within this stand (owned by WD Cows). No logging occurred in this stand in the past 10 years, but > 300 red pines were cut and left along the western boundary with Haydenville Road, on the east side of Borowski Brook. These trees were considered hazardous to public safety on Haydenville Road and there was no acceptable way to remove them by logging.

Forest attributes and management history

This is a mature-maturing hardwood-softwood stand with, typically, about 5 *common* overstory tree species visible nearby from any point. Note however (see below) that this stand has 6 uncommon species as well. In the overstory, black birch is the most common or abundant, with less red maple, white pine and sugar maple, and even less red oak and cherry. Hemlock is present but not abundant. A small red pine plantation is found in the SE part and traces of red pine plantations are found in the central part. The DCR type designation most-closely approximating this stand is WH (white pine and hardwoods).

This stand has a tall, mostly closed-canopy overstory with a layered midstory consisting of more hemlock (level = 1.5 out of 2) and less beech (level = 0.5 out of 2). There is a significant volume of standing wood (31.8 cords of total stem biomass) consisting of both

timber and cord products (see stand header). White pine and black birch are the primary timber species, with less red oak and other species; and, white pine, black birch and red maple are the primary cord product species. There is generally a thick covering of leaf litter and a thin layer of non-interfering, desirable low vegetation. Common understory plants include partridgeberry, Christmas fern, evergreen woodfern and club mosses, with less wintergreen and prickly dewberry. Coarse woody debris is markedly abundant on the forest floor (10.1 pieces visible on average from each plot). In part due to dense shade and interfering factors, viable regeneration is generally lacking at this time, but in places there is black birch, less sugar maple, and even less white pine, red maple and hickory.

Notable occurrences of uncommon native tree species

Remarkable, widely-scattered diversity with three uncommon oaks and three hickories observed. White oak, chestnut oak and scarlet oak plus bitternut hickory shagbark hickory and pignut hickory are present.

Habitat

This is a tall, closed-canopy, mixed species forest, with midstory layers, snags, downed logs, and thick leaf litter. There are areas of exposed ledge. Streams and associated riparian areas include Borowski Brook and numerous, unnamed minor streams. Unique features include vernal pools and a rich mesic swale (south of the old quarry shown on abutting land of W.D. Cows).

Soils

Westminster extremely rocky loam. This is considered a “droughty”, “shallow” soil formed in layers of glacial material derived from gray-mica schist containing impure limestone, with dark-gray schist bedrock at a depth of about 18”. The water table is high 7 – 9 months of the year, and this soil is subject to erosion on slopes. Overall, trees in this soil cannot develop deep root systems (due to high water tables and shallow depths to bedrock) and are often not windfirm. These soils are considered to produce “poor yields” of timber, though there is variability within this broad categorization, and trees can and do grow well in some areas. Perhaps it is the shallow depths to the water table that seem to favor the growth of grapes and invasive plants (esp. bittersweet). Site index for northern hardwoods: 46-51, site index for upland oaks: 55-64, site index for white pine: 60-69. My own measurements (on this soil, but in other locations) indicate a site index of 70-75 for black birch and poplar.

Soils as related to tree growth purposes

This is a common soil in the region and, as evidenced by the many large trees, it is well suited to growing trees for timber and for water quality purposes.

Soils as related to logging purposes

Logging is possible on these soils, but extreme care must be used to minimize rutting and erosion; very frozen or very dry conditions must prevail. Skid roads must be properly drained off (water bars, etc.) and should be closed to unofficial vehicle use.

Management history

The southern section was last logged ca. 1990. The northern section last logged ca. 1998. Both cuts were under the direction of previous DPW forester Karl Davies. In large part due to the risk of non-native invasive plants, no logging-based silviculture has occurred since then. A cut and leave treatment of dead and dying red pine occurred all along

Borowski Brook in late winter, 2020. The red pines had been planted and were infested with red pine scale, an insect. In order to avoid disturbance to the brook and the associated riparian area, the trees to cut were climbed, trimmed out, then carefully felled away from the brook, cut into shorter sections, and left on the ground to decompose. Approximately 310 trees were cut in this manner. The work was carried out by Dave Cotton of Cotton Tree Service. The reason for cutting the trees was safety concerns raised by the Town of Whately Highway Superintendent, who worried that the trees would fall into the road.

Interfering vegetation

Non-native invasive plants

Bittersweet is widespread and well-established in this stand, occurring at all severity levels (localized rankings 1-5), with numerous occurrences of the most severe level, which refers to situations in which bittersweet has actually become the overstory. Bittersweet seems especially strongly associated with Chestnut Mountain Road and with slopes, including swales and riparian areas on the slopes, draining down toward Borowski Brook and the Mountain Street reservoir. There is a notable hotspot of bittersweet directly on Chestnut Mountain Road: this hotspot stretches across the road to the abutting property (n/f Smith College). Often there are other invasives that co-occur with the bittersweet, especially barberry and multiflora rose, with localized rankings as high as level 3. If there is a bright spot, it is that the immediate area along Borowski Brook is relatively non-infested by invasives when compared to the area along Chestnut Mountain Road.

Native interfering vegetation

Grape vines are widespread and occur both together with bittersweet and separately. This area seems very favorable to grapes. Hayscented fern is widespread in the northern part of the stand though, curiously, was not noted in the southern portion of the stand. Mountain laurel was present in a few locations in the western part of the stand including in the NW part of the stand where it forms large thickets as the land begins to drop down to Borowski Brook.

Areas and aspects of concern for future monitoring of interfering vegetation

All areas of this stand need to be inspected, including all along Chestnut Mountain Road, Borowski Brook, and any riparian areas and low swales.

Management approach for the coming 10 years

Contain and control non-native invasive plants to limit their spread and limit their seed production. For the bittersweet hotspots on Chestnut Mountain Road, a special response should be developed, ideally in coordination with abutter Smith College. Cut grapes. Use silvicultural methods to support uncommon native tree species possessing special adaptive potential.

MTN Stand 2

This stand was delineated to capture the entirety of the Delano and Martiniano parcels, which were acquired in the past 10 years. These parcels were not merged into MTN

Stand 1 because they feature a much lower level of non-native invasive plant infestation. This stand is accessed from Haydenville Road. This stand is bounded to the Haydenville Road to the west, by non-DPW land to the north and east, and by MTN Stand 1 to the SE and south. No logging occurred in this stand in the past 10 years.

Forest attributes and management history

This is a mature-maturing hardwood stand with, typically, several common overstory tree species visible nearby from any point. In the overstory, RO is dominant, with much less scarlet oak, white oak, sugar maple, red maple, black birch. The DCR type designation most-closely approximating this stand is RO (red oak).

This stand has a tall, mostly closed-canopy overstory with a limited midstory consisting of minor amounts of beech, black birch and witch hazel. There is a significant volume of standing wood (29.8 cords of total stem biomass) consisting of both timber and cord products (see stand header). Red oak is the primary timber species, with less red maple and other species; and, red oak, other oaks and red maple are the primary cord product species. Because of the sampling pattern and delineation of the stands, no systematic sample point fell in this stand. The stand-level volume averages are interpreted from prior inventory work. There is generally a thick covering of leaf litter and a thin layer of non-interfering, desirable low vegetation. No new assessment of the understory was made for this stand but it will be similar to the contiguous Stand 1. Coarse woody debris is present on the forest floor (but was not counted). In part due to dense shade, viable regeneration is lacking at this time.

Notable occurrences of uncommon native tree species

Shagbark hickory and pignut hickory were noted in the eastern portion of the stand at the top of the slope. This stand directly adjoins Stand 1.

Habitat

This is a tall, closed-canopy, hardwood forest, with a strong component of oaks and acorn production, with hardwood midstory layers, snags, downed logs, and thick leaf litter. There are areas of exposed ledge. Streams and associated riparian areas include a stony, steep feeder brook flowing down to Borowski Brook.

Soils

Westminster extremely rocky loam. See discussion for Stand 1.

Soils as related to tree growth purposes

See discussion for Stand 1.

Soils as related to logging purposes

See discussion for Stand 1.

Management history

No recent management has occurred in this stand. It is possible that this stand has never been thinned. There are traces of perc tests that were done prior to the transfer of this land to the City of Northampton.

Interfering vegetation

Non-native invasive plants

No non-native invasive plants were observed in this stand, with one exception. A minor amount of rose was observed at the old backhoe entrance to this property off Haydenville Rd.

Native interfering vegetation

No grapes were observed in this stand. No hayscented fern glades were observed in this stand. There is thick mountain laurel on the eastern boundary.

Areas and aspects of concern for future monitoring of interfering vegetation

Inspect the road frontage along Haydenville Road and the riparian area in common with Stand 1. Inspect the mountain bike trail that crosses through the upper part.

Management approach for the coming 10 years

Maintain non-native invasive plants at or below their current low level. Pull the rose and any others from the side of Haydenville Rd. Use silvicultural methods to support uncommon native tree species possessing special adaptive potential.

MTN Stand 3

This stand was delineated to capture the footprint of a number of former red pine plantations. Previously, this stand included more land to the north which did not have red pine plantations, but this other land has been added to MTN Stand 13. This stand is accessed from Rocks Road and from a gated service road. This stand is bounded to the east by Rocks Road and by parts of MTN Stand 13, to the north by MT Stand 13, to the west by the Mountain Street Reservoir. Some logging occurred in this stand in the past 10 years as part of addressing the decline in red pine health. Additionally, a number of trees were cut and left by DPW staff.

Forest attributes and management history

This is a partially transitioning former red pine plantation with included natural forest components in steep embankments, wetter swales, etc. This stand is extremely variable. The overstory included red pine that is mostly dying or dead, white pine, hemlock black birch, red maple and black birch, with less ash, cherry and yellow birch. The DCR type designation most-closely approximating this stand is WHK (white pine hemlock hardwoods).

This stand has a tall, but very irregular overstory with large openings that have partially filled with young trees and other vegetation. There is a variable volume of standing wood (with an estimate of 20 cords of total stem biomass) consisting of both timber and cord products (see stand header). White pine is the primary timber species, with less red pine, red maple and hemlock; and, white pine, red maple, hemlock and red maple are the primary cord product species. Because of the sampling pattern and re-delineation of the stands, only one systematic sample point fell in this stand. The stand-level volume averages are interpreted from field experience at the site and from the single point. There

is generally a thick covering of leaf litter and a moderate to thick layer of non-interfering, desirable low vegetation. Understory vegetation is often thick, often with prickly dewberry, evergreen woodfern, and chestnut oak seedlings. Coarse woody debris is common on the forest floor (25 pieces visible on average from each plot). Regeneration is variable. While in the southern part, on the gravel shelf, there are actually stout saplings of red oak and chestnut oak, along with black birch and sassafras, in the northern part, where moisture is better, red oak is present but heavily browsed, occurring with red maple, sugar maple, white pine, black birch and hemlock.

Notable occurrences of uncommon native tree species

A numbers of stout chestnut oak saplings were noted amongst the regeneration in the red pine logging footprint. This is the only site of established chestnut oak regeneration noted across the entire Northampton DPW combined watershed forests. There are also sassafras saplings and actual chestnut sprouts, quaking aspen seedlings, gray birch saplings, and stout pin cherry saplings.

Habitat

This is a tall, irregular, semi-open canopy, mixed species forest, with midstory layers, snags, a large volume of downed logs, and thick leaf litter. There are areas of exposed ledge. In the southern portion of the stand the soil is deep and gravelly. There is a central wetland swale featuring a seasonal stream that draws water from two distinct areas, one of which is a manmade canal.

Soils

The primary soil type is Sudbury fine-sandy loam. The Sudbury is a deep, somewhat excessively drained soil formed in glacial outwash deposits. With few stones, gentle slopes, and good drainage, this soil is well suited to management, though overall fertility is said to be compromised by limitations on moisture availability. The central swale is classified as Ridgebury fine sandy loam, a hydric soil.

Soils as related to tree growth purposes

Site indices for Sudbury are listed as 60 for white pine but only 45 for red oak. In actuality, the oaks on this site look better than a “45” would indicate. Overall, a site index of 60 for red oak will be used. In any case, this soil is well suited to growing trees for timber and for water quality purposes.

Soils as related to logging purposes

This well-drained and stable soil is very well suited for logging purposes. Nonetheless, the normal precautions of operating during adequately dry or frozen conditions need to be observed to avoid rutting and compaction.

Management history

In response to large-scale dieback and death of the red pine component of this stand, caused by the red pine scale, a significant proportion of the red pine was removed in 2014-2015. The loggers were Joe Adams and Chad Blackbird, using a variety of methods that processed trees at the stump, leaving the tops in the woods. By request, to reduce clutter near Rocks Road, some of the tops were bunched and moved into the northern part of the stand. In the logging operation, the steep banks down to the reservoir were left unharvested. This was done in order to avoid any alteration to the soils on the steep

banks, so that overland and subterranean water flows would not be altered. Subsequently, for reasons that were not given, additional red pines were cut and left by DPW staff.

Interfering vegetation

Non-native invasive plants

Bittersweet is present throughout this stand, especially in the southern and northern thirds, and less so in the central portion. In the southern part, bittersweet is strongly associated with the edge of Rocks Road, where it flourishes, with localized rankings of 2-5. In the northern section it is found within the footprint of the red pine stand that had experienced a significant wave of mortality prior to 2012 and which was then logged in 2015. Here it was observed at localized rankings of 2-3. In the middle section, it was also associated with Rocks Road, but was less frequent and occurred at lower levels of infestation. Multiflora rose occurred to a minor extent. Unfortunately, glossy buckthorn has established a widespread presence here as scattered but tall, stout plants in all sections of this stand. Glossy buckthorn seems to thrive on gravelly sites such as this. It is not clear where the seed source is for the glossy buckthorn here. But the established individuals will increasingly become a seed source if not kept in check within the stand.

Native interfering vegetation

Grape vines are present on a scattered basis. Hayscented fern occurs in larger glades in the northern section; presumably, the lower moisture in the middle and southern sections will help keep hayscented fern at bay there. Mountain laurel was not observed.

Areas and aspects of concern for future monitoring of interfering vegetation

Inspect the road frontage and interior of the logging footprint in this stand.

Management approach for the coming 10 years

Contain and control non-native invasive plants to limit their spread and limit their seed production. Focus especially on controlling glossy buckthorn by pulling, digging or other methods. Note that if glossy buckthorn is cut and then left alone, it will soon resprout and become an ever larger, multi-stemmed shrub vigorously producing seeds, so, unlike significant albeit temporary setback to bittersweet brought by cutting large vines, there is little benefit in simply cutting glossy buckthorn. Glossy buckthorn is avoided by deer and can sprout from the root collar and from the stem! Cut grapes. Use silvicultural methods to support uncommon native tree species possessing special adaptive potential – in this case oak and sassafras saplings.

MTN Stand 4

This stand was delineated primarily to capture an area of large white pine trees west of the Mountain Street Reservoir dam. This stand is crossed by a snowmobile trail and by a water main. This stand is accessed by Reservoir Road, which is a public road. This stand is bounded to the south by Rocks Road, to the west by Mountain Street, to the north by MTN Stand 11, and to the east by the Mountain Street Reservoir and associated land below the dam. Logging occurred in the southern part of this stand in the past 10 years. This included thinning to help improve the health of white pine, as well as the complete

removal of a small red pine plantation in the SE part of the stand. The latter area was transformed into an area to be managed foreseeably by brush hogging.

Forest attributes and management history

This is a mature-maturing softwood plantation with, typically, about 4 common overstory tree species visible nearby from any point. The southern part of this stand was recently thinned. In the overstory, white pine is dominant, with less black birch, red maple and sugar maple. The DCR type designation most-closely approximating this stand is WP (white pine). There is a small pocket of sugar maple in the northernmost part of this stand.

This stand has a tall, mostly closed-canopy overstory with a layered midstory in the northern part but not in the southern part within the recent logging footprint. Unlike many of the stands, this stand does not have a hemlock and beech midstory. In the northern part, there is tall regeneration that serves as a midstory, primarily sugar maple, red maple and black birch. The stand was established in prior cutting about 20+ years ago. There is a very significant volume of standing wood (70.4 cords of total stem biomass) consisting of both timber and cord products (see stand header). White pine is the dominant and effectively the sole timber species; white pine is also the primary cord product species, with less red maple, sugar maple and black birch. There is generally a thick covering of leaf litter and a thin to moderate layer of non-interfering, desirable low vegetation. Common understory plants include evergreen woodfern, poison ivy and Virginia creeper. Coarse woody debris is common on the forest floor (6.3 pieces visible on average from each plot). In part due to shade, in the northern part, and due to setbacks driven by interfering factors in the southern part, viable regeneration is lacking at this time.

Notable occurrences of uncommon native tree species

None noted.

Habitat

This is a tall, variable, closed or semi-open canopy, dominated by large white pines, with midstory layers, snags, a large volume of downed logs, and thick leaf litter. The northern portion of the stand has a closed canopy. The understory is very thick in the southern portion of the stand, where logging occurred in 2018, and is an open grass-forb habitat in the southeast corner, where the red pine was cut in 2015. There is a section of section of tall hardwood poles near Mountain Street.

Soils

There are three similar fine sandy-loam soil types here. The bulk of the soil (the entire northern knoll) is Paxton fine sandy loam. The frontage along Rocks Road is Merrimac fine sandy loam. The stripped area (pole hardwoods) is Sudbury fine sandy loam. The first two soils are well-suited for both tree growth and tree harvesting, whereas the stripped soil is somewhat reduced in suitability in both categories. The Paxton series consists of deep, well-drained soils on glaciated uplands. The soils formed in glacial till, with a drainage- and root-restricting fragipan typically ranging from 20" to 38" in depth. The Merrimac series consists of deep, somewhat excessively drained soils formed in glacial outwash deposits. Lacking a fragipan, rooting depth can be as deep as 60". The pines growing on this soil in this stand are especially tall. The Sudbury series consists of

deep, moderately well-drained soils on glacial outwash plains and terraces, and are formed in glacial outwash deposits, with rooting depths of 18”-30”.

Soils as related to tree growth purposes

This is a productive soil, with site indices of 66, 64 (and 60) for white pine; 65, 51 (and 45) for red oak; and 75, 58 (and none given) for sugar maple. Both pine and hardwoods grow well here.

Soils as related to logging purposes

This well-drained and stable soil is very well suited for logging purposes. Nonetheless, the normal precautions of operating during adequately dry or frozen conditions need to be observed to avoid rutting and compaction.

Management history

The white pine (and former red pine) were probably planted (circa 1920), though the white pine may be of old-field origin, and these areas were thinned over the years (probably two times, if not three), with the last of these thinnings occurring in 1999 (John Conkey & Sons). This has helped allow large, well-formed white pines to develop. The section of hardwood poles near Mountain Street and the hardwood saplings sections were created where patches were clearcut (in one case, the soil was stripped as well); these clearcut areas regenerated naturally to a mix of hardwoods from sprouts and seed. In 2015, in response to decline and mortality caused by the red pine scale, the red pine portion of this stand (a triangular area in the SE part of the stand) was clearcut, with all tops removed and chipped. The logger was Cotton Tree Service. Subsequently, the former red pine footprint was much-mowed (with stumps ground down) so that this area could be maintained by brush hogging. The operator was Ted D’Onofrio. In response to the poor health in the white pine overstory, attributable to the fungal pathogens white pine needle disease and caliciopsis canker, the southern portion of this stand was thinned in 2018. The logging was done using a whole-tree biomass system (with removal and chipping of tops). The logger was Chris Goodnow.

Interfering vegetation

Non-native invasive plants

This stand is uniquely problematic due to the variety and intensity of infestation. Bittersweet is widely established, especially in the portion of this stand south of the water main strip. Bittersweet increases as you move south down the south-facing slope and onto the broad flat area next to Reservoir Road. Bittersweet was already well-established prior to the 2018 logging (which was done as a necessary response to white pine needle disease), and it only—and predictably—benefitted from the logging and now occurs even more so in large thick glades with localized rankings of 3-5. By comparison, in the northern portion of this stand, especially in the part that was north of the recent logging (north of the water main), bittersweet is present but is held largely in check by overstory and midstory shade. Here it does not occur in open, unshaded glades. Barberry, honeysuckle and multiflora rose are present to an extent, though are not as widespread or aggressive as the bittersweet. Occurrences of glossy buckthorn were noted. Glossy buckthorn was somewhat abundant in the red pine stand below the dam that was cut in 2015 and which, since, has been mulch-mowed once but has not apparently been mowed

since. Now, glossy buckthorn forms a tall thicket at the northern end of this area, along with bittersweet and cork (see below) just below the dam. A unique and further troubling feature of this stand is the rapid spread and establishment of a new non-native invasive plant, the Amur cork tree, (*Phellodendron amurense*), which is native to Asia. Though it has been in North America since the 19th century, it had yet to be found on Northampton DPW watershed land. It has spread very aggressively, apparently by seed, since the 2018 logging, quickly growing to the size of large sumacs and ultimately able to reach heights of about 50' with stout trunks. It also provides good climbing structure for bittersweet. It now is found within the entire footprint of the logging, though at decreasing levels as you move to the northern extent of it. It also jumped to Stand 13 (so far only 1 individual detected).

Native interfering vegetation

Grape vines are present but not widespread. Hayscented fern occurs in some larger glades within the footprint of the 2018 cutting. Mountain laurel was not observed.

Areas and aspects of concern for future monitoring of interfering vegetation

Inspect the entire stand, including along the snowmobile trail, along road edges, along the edge of the maintained pipeline strip, in the former red pine area next to the dam, on embankments down to the reservoir.

Management approach for the coming 10 years

Limit seed production of non-native invasive plants. This stand has a very tall overstory of large white pine which, we hope, will survive the undermining effects of white pine needle disease. But if it does not, or if there is a large storm or multiple storms, or simply a continuation of the little-by-little blowdown that has been occurring here in summer storms from the west as well as heavy winter snows, this stand will continue to become dominated by non-native invasive plants, especially bittersweet and Amur cork tree (*Phellodendron amurense*), with glossy buckthorn. As an immediate stop-gap measure, because Amur cork appears to be so extremely invasive at this site, a dedicated effort should be made to pull or dig all individuals that can be found, and a special effort should be made to track down any seed bearing trees and control those.

For the portions of this stand that are below the dam, control of non-native invasive plants by animal grazing might seem to be an option, however no animal grazing is allowed in Zone A, even though this is downgradient from the reservoir. A second approach is to manage this stand as with Stand 8, by mulch-mowing the understory and then maintaining it in a mowed condition, as is done around the Water Treatment Plant. In order to prevent seed production, the former red pine area should in any case be included in the regular mowing for Stands 8 & 11. This should happen early in the 2023 growing season before the glossy buckthorn and Amur cork become too stout for brush hogging.

MTN Stand 6

This stand was delineated to capture an area of mature white pine near the Water Treatment Plant. Formerly, this stand was included with MTN Stand 10 due to its

similarity in timber type. This stand is accessed by a trail heading north from a gated service road. This stand is bounded by MTN Stand 9 to the north, Potash Brook and MTN Stand 10 to the west, and MTN Stand 8 and the Water Treatment Plant to the east and south. Logging occurred in this stand in the past 10 years both with the intention of removing red pine in poor health and the intention of thinning to promote white pine health.

Forest attributes and management history

This is a mature-maturing softwood and softwood-hardwood stand with, typically, 5 common overstory tree species visible nearby from any point. This stand is a white pine plantation that is transitioning to a native forest stand. In the overstory, white pine is dominant, and red maple and black birch are common or abundant, with less paper birch and cherry. This stand also included a component of red pine, most of which was cut in recent logging. The DCR type designation most-closely approximating this stand is WH (white pine and hardwoods).

This stand has a tall, mostly closed-canopy overstory with a layered midstory consisting of a low level of hemlock (level = 0.5 out of 2) and a moderate level of beech (level = 1.0 out of 2). There is a significant volume of standing wood (55.9 cords of total stem biomass) consisting of both timber and cord products (see stand header). White pine is the primary timber species, with less mixed hardwood and a smattering of red pine; and, white pine is also the primary cord product species, with less birch, oak and maple. There is generally a thick covering of leaf litter and a somewhat abundant layer of non-interfering, desirable low vegetation. Coarse woody debris is common on the forest floor (6.5 pieces visible on average from each plot). Common understory plants include evergreen woodfern, poison ivy, partridgeberry and prickly dewberry. In part due to dense shade and interfering factors, viable regeneration is not abundant at this time, but includes black birch and hickory. The presence of hickory here, adjacent to a concentration of hickory (Stand 9), suggests that hickory has the ability to spread.

Notable occurrences of uncommon native tree species

This stand was delineated to capture part of a white pine plantation but it turns out it includes a few scarlet oaks and a white oak spilling over from Stand 9 to the north.

Habitat

This is a tall, loosely-closed canopy (after recent thinning), mixed species forest, with midstory layers, snags, downed logs, and thick leaf litter. Potash Brook is a major brook and features associated riparian areas.

Soils

Soils are variably, with Paxton stony or very stony fine sandy loam in the east, Woodbridge fine sandy loam in the west, and Charlton-Hollis Rock outcrop in the central part of this stand. These generally well-drained glacial till soils are quite variable in their depth to a root-restricting feature, ranging from quite shallow, with ledge near the surface, to 38" deep.

Soils as related to tree growth purposes

Good, as evidenced by the tall pine trees in this stand. Drainage and depth are mostly good and moisture is adequate for average or better growth. Site indices range from 65 or more for white pine, and 55 or more for red oak.

Soils as related to logging purposes

Good, but normal precautions must be taken to minimize rutting and erosion; frozen or dry conditions must prevail. Slopes are mild and the risk of erosion is minimal, but root and soil can be damaged if the ground is not stable.

Management history

This is likely a planted stand of white pine (and red pine), dating probably to around 1920. Records viewed in 2012 show various silvicultural cuttings dating to the early 1980's. Recently, most of the red pine was removed in 2015-2016 due to decline and mortality driven by the red pine scale. This logging was done by Russ Mader, using a rubber-tired cut-to-length system that left all the tops at the stump. Then, in response to poor health observed in white pine, driven by white pine needle disease and caliciopsis canker, white pine was thinned to improve spacing in 2017-2018. The logger was Joe Adams using a tracked hotsaw and rubber-tired grapple skidder. The tops were left in the woods.

Interfering vegetation

Non-native invasive plants

Bittersweet occurs in multiple locations within the central part of this stand, with a localized ranking of 1, 2 and, in a number of cases, 3. Bittersweet is likely to be able to continue to expand in this stand. There is a minor amount of rose.

Native interfering vegetation

Grape vines are not established in this stand. Hayscented fern is present to a minor extent. Mountain laurel was not observed in this stand.

Areas and aspects of concern for future monitoring of interfering vegetation

Inspect the entire stand especially on and along skid trails used in recent logging on the east side of the old N-S trail. Inspect the riparian area of Potash Brook on the west side of the stand.

Management approach for the coming 10 years

Contain and control non-native invasive plants to limit their spread and limit their seed production. The bittersweet is still discrete enough in its distribution that one could attempt to eradicate it if one had effective tools. In lieu of that, preventing it from thriving by pulling and cutting as much as one can is the recommendation.

MTN Stand 7

This stand was delineated to capture a large stand of large old-field white pine on the east side of Laurel Mountain. This old road is a discontinued, two-rod-wide county highway whose history was studied and documented in conjunction with the construction of the Water Treatment Plant. This stand is accessed by and crossed by Laurel Mountain Road. This stand is bounded to the west by MTN Stand 9 and also by Grass Hill Road, to the

north by non-DPW land, to the east by Haydenville Road, and to the south by MTN Stand 8. No logging occurred in this stand in the past 10 years. Grape vines were extensively cut in this stand within the past 10 years.

Forest attributes and management history

This is a mature-maturing softwood-hardwood stand with, typically, 4-5 common overstory tree species visible nearby from any point. In the overstory, white pine is generally dominant, black birch and red maple are common or abundant, with less red oak, and hemlock, and even less sugar maple, paper birch, ash and cherry. The DCR type designation most-closely approximating this stand is WH (white pine and hardwoods).

This stand has a tall, mostly closed-canopy overstory with a layered midstory consisting of more hemlock (level = 1.0 out of 2) and less beech (level = 0.3 out of 2). There is quite a significant volume of standing wood (50.6 cords of total stem biomass) consisting of both timber and cord products (see stand header). White pine is the primary timber species, with less red oak, other hardwoods, and white pine is the primary cord product species, with less hemlock, black birch, red maple and other hardwoods. There is generally a thick covering of leaf litter and a thin to moderate layer of non-interfering, desirable low vegetation. Common understory plants include evergreen woodfern, prickly dewberry and poison ivy. Coarse woody debris is abundant on the forest floor (9.6 pieces visible on average from each plot). In part due to dense shade, viable regeneration is lacking at this time, though there are occurrences of red maple, sugar maple black birch and beech.

Notable occurrences of uncommon native tree species

Though much of this stand lacks uncommon native tree species, there are two fringe areas on the upper part of drier knolls with elevated diversity including scarlet oak, chestnut oak and less white oak as well as a small amount of pignut hickory. Scarlet oak is scattered around here and there as well.

Habitat

This is a tall, closed-canopy, mixed species forest, with midstory layers, snags, downed logs, and thick leaf litter. There are areas of exposed ledge – see the Forest Stand & Boundary Map. Streams and associated riparian areas include a swampy section of Borowski Brook – next to Haydenville Road there is a gurgling outflow pipe, the outflow of which is water from the West Whately Reservoir; this water flows next to Haydenville Road for a short stretch before passing under the road and becoming “Borowski Brook”. There are a number of unnamed minor streams that flow toward Borowski Brook or Haydenville Road. There are two vernal pools and a number of seepy, wetland “holes” that were apparently dug out and used as watering holes for cattle wetland areas on the east side of Laurel Mountain Road.

Soils

Soils are a mixture of Shelburne extremely stony sandy loam (on the east side of Laurel Mountain Road and Westminster extremely rocky loam, on the west side of Laurel Mountain Road. The Westminster is a “droughty”, “shallow” soil formed in layers of glacial material derived from gray-mica schist containing impure limestone, with dark-gray schist bedrock at a depth of about 18”; the steep slope from the top of the land seems

to create greater moisture deficiency, as evidenced by the noticeably shorter hardwoods, and as suggested by the presence of chestnut oak. As the slope drops toward Laurel Mountain Road, moisture increases. The Shelburne is a well-drained, deep loam with partly decomposed limestone in a substratum layer. Soil depth is good – typically 24” or more – before a hard, water-restricting layer is reached.

Soils as related to tree growth purposes

Productivity varies with soil depth and moisture, with diminished productivity at the western, ridgetop area, and markedly elevated fertility in much of the eastern-most part of the stand. White pine site indices will range, accordingly, from 50 to 70.

Soils as related to logging purposes

This is a fragile soil; extreme care must be used to minimize rutting and erosion; very frozen or very dry conditions must prevail. Skid roads must be properly drained off (water bars, etc.) and should be closed to unofficial vehicle use.

Management history

This is an old-field pine stand. Small patches of old-field pine were cut 50 years ago or more. No logging has occurred in recent times. Around 2013, the DPW crew carried out considerable cutting of grape vines. In a small section east of Laurel Mountain Road, in the southwest corner, in 2016, mulch-mowing carried out in adjacent Stand 8 was extended into this area (which was, and still is, overrun with non-native invasive plants). The operator was Ted D’Onofrio.

Interfering vegetation

Non-native invasive plants

Bittersweet is widespread and well-established in this stand, occurring in extended runs with severity levels ranging from 1-5 within these runs, including multiple occurrences of localized ranking = 5. The bittersweet seems to be strongly associated with the old road (Laurel Mountain Road) and the perimeter of the old orchard in Stand 8; there is less bittersweet at the western and eastern edges of the stand. Barberry and multiflora rose are also present. While the rose seems most strongly associated with Laurel Mountain Road, the barberry is spreading all through the eastern part of the stand, down the slope, sometimes occurring in large concentrations with localized ranking = 3-4. There are also a few occurrences of privet and burning bush. The privet occurs just north of the old orchard in Stand 8, on either side of Laurel Mountain Road, with a localized ranking = 2-3. The burning bush occurs just north of the old orchard and at the northernmost NW corner of the lot next to grass Hill Road.

Native interfering vegetation

This stand has a significant quantity of established large grape vines but most of these were cut in 2013 by a DPW crew. Current grapes remain mainly along the northern fringes of this stand. Hayscented fern occurs in large runs in the central part of this stand. Mountain laurel was noted only in a few locations.

Areas and aspects of concern for future monitoring of interfering vegetation

Inspect the roadsides, any riparian or wetland swales, and the perimeter of the old orchard.

Management approach for the coming 10 years

Limit seed production of non-native invasive plants. Cut all large bittersweet vines to temporarily reduce seed production in the hopes that some will not resprout due to shade. Cut grapes. Use silvicultural methods to support uncommon native tree species possessing special adaptive potential.

MTN Stand 8

This stand was delineated to capture all of the area around the Water Treatment Plant that was formerly occupied by red pine plantations and is now maintained by mowing. This stand also includes an associated wetland in the southern part that is neither a former red pine plantation nor is it managed by mowing. This stand is accessed by a gated service road and by the Water Treatment Plant driveway. It is crossed by Laurel Mountain Road. This stand is bounded to the east by Mountain Street, to the north by MTN Stand 7, to the west by MTN Stands 6 & 10, and to the south by non-DPW land. This stand wraps around the Water Treatment Plant on three sides. Extensive logging occurred in this stand in the past 10 years to remove most of the declining and dead red pine. Additionally, mulch-mowing was used to transform this stand into an area that can be maintained by brush hogging until such time as factors that prevent the growth and establishment of trees are brought under control.

Forest attributes and management history

This is a mature-maturing hardwood stand with, typically, 4 common overstory tree species visible nearby from any point. In the overstory, black birch and red maple are common or abundant, with much less sugar maple, cherry, ash, and yellow birch. The DCR type designation most-closely approximating this stand is BB (beech birch maple).

This stand has a tall, partly open, woodland-like overstory, as well as a very wide-open field-like overstory, and completely lacks a layered midstory (due to the management methods required to keep invasives in check – see below). There is a low volume of standing wood (12 cords of total stem biomass) consisting mainly of cord products (see stand header). For perspective, however, though this is low, it could have been much lower if it were not for efforts to save as many trees as possible when removing the dying red pine in recent years. White pine and black birch are the primary timber species; black birch is the primary cord product species, with less white pine and red maple. There is generally a thick covering of leaf litter and a thin to moderate layer of non-interfering, desirable low vegetation. Common understory plants include evergreen woodfern, cinnamon fern in wetter areas, and prickly dewberry. Coarse woody debris is not common on the forest floor (most of it has been mulched or otherwise removed). Due to dense shade, a number of factors, viable regeneration is lacking at this time.

Notable occurrences of uncommon native tree species

One shagbark hickory was noted. There is a cluster of sassafras along the western edge of the old orchard. Several of the oaks in the old orchard may be scarlet oaks (not shown on map).

Habitat

This is one of the stands with habitat that contrasts starkly with the typical tall, closed-canopy forest that covers much of the watershed, offering a combination of woodland (widely scattered trees and a low understory), open grass and forbs and a scrubby, shrubby slope (in the northeast quadrant). Curiously, woodland habitat in the Northeast, to the extent it exists, is generally thought to be feature oaks and is thought to be maintained by frequent, low-intensity fire. In this case, the woodland features black birch and red maple (with sugar maple, white pine and black cherry), none of which thrive with frequent fire, and it is maintained by mowing.

Soils

Soils are a mixture of Paxton stony or very stony fine sandy and Shelburne extremely stony sandy loam (on the Whately side). Paxton is a deep, well-drained soil formed in glacial till, having a drainage- and root-restricting fragipan typically ranging from 20” to 38” in depth, and also occurs in Stands 4, 8 and 10. These are good all-around soils for timber management. Shelburne is a well-drained, deep loam with partly decomposed limestone in a substratum layer. Soil depth is good – typically 24” or more – before a hard, water-restricting layer is reached.

For tree growth purposes: good. Drainage and depth are good and moisture is adequate for average or better growth. Site indices range from 65 or more for white pine, and 55 or more for red oak.

For logging purposes:

Soils as related to tree growth purposes

Good. Drainage and depth are good and moisture is adequate for average or better growth. Site indices range from 65 or more for white pine, and 55 or more for red oak. However, based on tall red pine growth that once occurred here, a site index of 70 for white pine will be used.

Soils as related to logging purposes

Logging is possible on these soils, but extra precautions must be taken to minimize rutting and erosion; frozen or dry conditions must prevail. Slopes are mild and the risk of erosion is minimal, but root and soil can be damaged if the ground is not stable.

Management history

This stand began as a red pine plantation (with an old orchard in the northernmost section). It appears the red pine was thinned in the 1950’s or early 1960’s, with one or more additional thinnings dating back to the 1980’s. During this time, the hardwood component grew in amongst the red pines. In 2015-2016, in response to decline and mortality caused by the red pine scale, the substantial red pine component of this stand was thinned out, leaving as many viable hardwoods and white pines as possible, and with all tops left on site. The logger was Russ Mader, using a rubber-tired, dangle-head cut-to-length system. Some of the felling was made much more difficult by the large grape vines festooning some of the trees; the vines ended up damaging many of the hardwoods, which had to be cut as well. Some of the felling along Mountain Street was done by Joe Adams using a tracked, fixed-head hot-saw, to have better control over trees near the road. Subsequently, the entire area was mulch-mowed, including grinding of the stumps,

in 2016, by Ted D’Onofrio. The area was re-mulch-mowed in 2018; the operator was Bob Glidden initially, but then after frustration and breakdowns, the job was completed by Ted D’Onofrio. The intention was to set this area up for to be able to control bittersweet by brush hogging. In 2019, additional red pine was cut using small-tractor logging; the logger was Tyler Sage. In the interim, some brush-hogging was carried out by DPW staff. Because the vegetation was outgrowing the pace of the DPW in-house mowing, a combination of mulching and brush-hogging was carried out over the entire area again, in 2022. The operator was John Cain of Cains Mechanical. In 2023, much of the area was brush-hogged by DPW staff. This is a high-maintenance stand; if the maintenance were to stop, however, it is anticipated that the bittersweet would soon overwhelm much of the site.

Interfering vegetation

Non-native invasive plants

This stand is a special case. Bittersweet is dominant in the understory but due to ongoing mowing has been kept in check and has largely prevented from climbing trees or producing seeds. If mowing were to cease, then the bittersweet would soon climb the trees and would eventually entirely dominate the site. A challenge is that mowing equipment cannot quite reach all the bittersweet around the edges of the stand, along internal stone walls, and around the bases of trees. Furthermore, especially around the old orchard, bittersweet is growing into the stand from the edges. And there is a section of this stand along Haydenville Road that has proven too steep and too fragile for mowing equipment. Thus, there is some escape of bittersweet and some seed production. Common invasives such as barberry, honeysuckle and multiflora rose are present only to a very minor extent. An exception is rose in the large wetland in along the southern property boundary, where it has not been subjected to any treatment and is able to thrive. Other invasives, also present to a minor extent, include thistle (which was observed in the orchard), Norway maple (which is a large tree in the main canopy that was not previously noticed), and glossy buckthorn (near and in the wetland along the southern property boundary). There is also a discrete and relatively small patch of Japanese knotweed at a location north of the Water Treatment Plant where it appears debris or soil was dumped at some point and which contained propagules—perhaps roots—of Japanese knotweed. A project to control this by smothering is already underway.

Native interfering vegetation

Grape vines that were here have mostly been cut and now are generally absent. Hayscented fern has formed large glades in some places. Mountain laurel was not noted, though there may be some in the southern wetland.

Areas and aspects of concern for future monitoring of interfering vegetation

Inspect all parts of this stand including along internal stone walls, and around the bases of trees, in the wetland along the southern property boundary, the perimeter around the old orchard. Inspect the knotweed patch site.

Management approach for the coming 10 years

Continue to transform and maintain. Continue to routinely mow the bittersweet understory to keep it substantially in check. Strive to do this at least twice per growing

season, once early after bittersweet expends energy to emerge, and once late in the growing season before bittersweet fruits ripen (if any) and to cut off photosynthate transfer to overwintering root systems. Consider continuing to seed in alternative mixtures such as deer tongue which are compatible with the site and the mowing regime. Expand treatment of bittersweet by hand methods (e.g., people on the ground with hand saws or brush saws) that cover areas and spots that mowing equipment cannot reach, such as around the edges of the stand, along internal stone walls, around the bases of trees, and section of this stand along Haydenville Road that has proven too steep and too fragile for mowing equipment. Possibly a very small and light machine such as a remotely-controlled tracked “green climber” could be used to accomplish some of this. Expand this treatment by pursuing bittersweet into the edge areas, especially around the orchard, to keep bittersweet from growing in. Consider cutting down all the dead orchard trees and removing them to facilitate faster mowing. If late season mowing occurs in mid-late August, before hayscented fern turns brown for the winter (usually by the first frost at the latest), the mowing will help reduce the fern. If mowing only occurs after hayscented fern has browned for the winter, it will inadvertently help promote the fern. Controlling the bittersweet is the top priority, but if this can be arranged to control hayscented fern as well, it will be an added benefit. Ideally, the glossy buckthorn in the southern part of the stand will be controlled (by hand methods, for example) before it becomes a major seed source in this area. This entails entering the wetland area on foot with tools. Large rose bushes can be chopped back at the same time. Continue to attempt to eradicate the knotweed by smothering with impermeable plastic weighted down by wood chips, and other methods. Cut any remaining grape vines.

MTN Stand 9

This stand was delineated to capture the area on the west side of Laurel Mountain. Access is from Laurel Mountain Road (via MTN Stand 7) and from the snowmobile trail from MTN Stand 6 to the south. This stand is bounded by non-DPW land to the west and north, by MTN Stand 7 to the east and by MTN Stand 6 to the south. No logging occurred in this stand in the past 10 years.

Forest attributes and management history

This is a mature-maturing softwood-hardwood stand with, typically, 6 common overstory tree species visible nearby from any point. In the overstory, white pine, black birch, red maple, and red oak are common or abundant, with less hemlock, paper birch, and yellow birch, and even less sugar maple. Chestnut oak, scarlet oak and pignut hickory are also a part of the overstory (see below). The DCR type designation most-closely approximating this stand is WH (white pine and hardwoods).

This stand has a tall, mostly closed-canopy overstory with a layered midstory consisting of a lot of hemlock (level = 1.8 out of 2) but a lot less beech (level = 0.5 out of 2). There is a significant volume of standing wood (36.9 cords of total stem biomass) consisting of both timber and cord products (see stand header). White pine is the primary timber species, with much less hemlock and mixed hardwoods; cord products are spread over a number of species including white pine, birches including paper birch, oaks (red, scarlet

and chestnut oak) and hemlock. There is generally a thick but sometimes less thick covering of leaf litter and a thin to moderate layer of non-interfering, desirable low vegetation. Common understory plants include Christmas fern, cinnamon fern, pipsissewa, partridgeberry and chestnut oak seedlings. Coarse woody debris is common on the forest floor (8.0 pieces visible on average from each plot). In part due to dense shade, viable regeneration is utterly lacking at this time.

Notable occurrences of uncommon native tree species

This is a high-diversity stand with numerous pignut hickories and three uncommon species of oak: white oak, chestnut oak and scarlet oak. Most of these trees are found on the western face and top of Laurel Mountain. Together with MTN Stand 1, this is probably the largest concentration of white oak on the Northampton DPW watershed forests.

Habitat

This is a tall, closed-canopy, mixed species forest, with midstory layers, snags, downed logs, and thick leaf litter. There are areas of exposed ledge at the top of steep, west-facing slopes. Potash Brook and associated riparian areas delineate or are near the western boundary.

Soils

Primarily Westminster extremely rocky loam, except on the flatter land in the southwest corner, which is Buckland extremely stony fine sandy loam. The Westminster is a “droughty”, “shallow” soil formed in layers of glacial material derived from gray-mica schist containing impure limestone, with dark-gray schist bedrock at a depth of about 18”; the steep slope from the top of the land seems to create greater moisture deficiency, as evidenced by the noticeably shorter hardwoods, and as suggested by the presence of chestnut oak. Lower down on the slope, however, moisture availability appears to be more typical. Overall, trees in this soil cannot develop deep root systems (due to high water tables and shallow depths to bedrock) and are often not windfirm. These soils are considered to produce “poor yields” of timber. The Buckland soil is formed from the same parent material as the Westminster, but is slightly deeper, with a hard layer typically at around 20” depth. Fertility in this moderately well-drained soil is better than in the adjacent Westminster (as seems to be evidenced by the tall pines).

Soils as related to tree growth purposes

Productivity is below average on the dry, shallow face of the long slope (however, this condition favors the growth of Chestnut Oak, which is not common across the watersheds). On the flatter riparian area, moisture, and fertility are good or above average. Overall site index for upland oaks: 50-55, site index for white pine: 55-69.

Soils as related to logging purposes

Logging is possible on these soils, but normal care must be used to minimize rutting and erosion; frozen or dry conditions should prevail. The steep slope poses a considerable erosion risk (though this will not effect the reservoir because this area is not within the watershed). Skid roads must be properly drained off (by water bars, etc.).

Management history

As evidenced by stumps, there was some logging of old-field white pine a long time ago (50+ years) and apparently some firewood cutting of defoliated trees around 1980.

Interfering vegetation

Non-native invasive plants

Bittersweet is present in a number of discrete locations within this stand, with a localized ranking of 1-3. While bittersweet was mostly at the lowest levels (localized ranking 1-2) in the eastern half of the stand, a couple clusters of bittersweet with a localized ranking = 3 were observed in the western part of the stand, in the vicinity of the old road and current snowmobile trail, and in the riparian area of a stream. Barberry and multiflora rose occurred at a very minor level in association with the bittersweet.

Native interfering vegetation

Grape vines were observed only in one location, along the old road. Hayscented fern was observed in the NE part of this stand forming part of a much larger glade that extends out from the adjacent stand. Mountain laurel is found on the mid-upper slope of Laurel Mountain, which faces west.

Areas and aspects of concern for future monitoring of interfering vegetation

Inspect the old road and snowmobile trail, including the new re-routing of the northern part of the snowmobile trail, and old trails that have been or may still be used by ATVs. Inspect the riparian area in the NW part of the stand.

Management approach for the coming 10 years

Contain and control non-native invasive plants to limit their spread and limit their seed production. Use silvicultural methods to support uncommon native tree species possessing special adaptive potential.

MTN Stand 10

This stand was delineated to capture all of the Northampton DPW west of Potash Brook. This stand is accessed from the western end of a gated service road off Mountain Street; however, there is no bridge in place to cross Potash Brook at this time. This stand is bounded by non-DPW land to the north, west and south, and by Potash Brook and MTN ST Stands 6 & 8 to the east. No logging occurred in this stand in the past 10 years.

Forest attributes and management history

This is a mature-maturing softwood-hardwood stand with, typically, 5 common overstory tree species visible nearby from any point. In the overstory, white pine and BB are common or abundant, with less red maple and sugar maple, and even less red oak, ash and cherry. There are remnants of red pine plantations. The DCR type designation most closely approximating this stand is WH (white pine and hardwoods).

This stand has a tall, mostly closed-canopy overstory with a somewhat poorly-established layered midstory consisting of a modest amount of hemlock (level = 0.4 out of 2) and a modest amount of beech (level = 0.6 out of 2). There is quite a significant volume of standing wood (50.7 cords of total stem biomass) consisting of both timber and cord products (see stand header). White pine is overwhelmingly the primary timber species,

with minor amounts of black cherry, sugar maple and other hardwoods; white pine is the primary cord product species, with less black birch and other hardwoods. There is generally a thick covering of leaf litter and a thin to moderate layer of non-interfering, desirable low vegetation. Common understory plants include evergreen woodfern, cinnamon fern, partridgeberry, Virginia creeper, poison ivy and prickly dewberry. Coarse woody debris is abundant on the forest floor (10.3 pieces visible on average from each plot). Due to a combination of shade and interfering factors, viable regeneration is generally lacking at this time, though there are occurrences of black birch, red maple, sugar maple, and hickory, and trace amounts of red oak and paper birch. This mix of species reflects some of the potential that was undoubtedly the intention of the cutting done here 20+ years ago.

Notable occurrences of uncommon native tree species

This stand has a smattering of uncommon species including white oak and scarlet oak, as well as bitternut hickory scattered about. There is also sassafras, basswood and bigtooth poplar.

Habitat

This is a tall, closed-canopy, mixed species forest, usually with midstory layers, but sometimes with an open midstory, snags, downed logs, and thick leaf litter. There are areas of exposed ledge. Streams and associated riparian areas include a large brook along the western boundary, which drains from Grass Hill, and a central, unnamed stream complex. Potash Brook forms the eastern boundary. A notable white ash tree (32" diameter) is noted on the Forest Stand & Boundary Map.

Soils

Primarily Paxton fine sandy loam. Paxton is a deep, well-drained soil formed in glacial till, having a drainage- and root-restricting fragipan typically ranging from 20" to 38" in depth.

Soils as related to tree growth purposes

Productivity is generally good or excellent, with elevated fertility along Potash Brook. On the wetter soils there is a somewhat increased risk of windthrow. Overall site index is 66 or more for white pine, 65 for red oak, and 75 for sugar maple.

Soils as related to logging purposes

On upper and top-slope positions, Paxton is suited for logging at most times of year, but on mid- and lower slopes, logging should be seasonally restricted. West of Potash Brook, on a long, gradual slope, large areas have wet, fragile soil, and extreme care must be used to minimize rutting and erosion; very frozen or very dry conditions must prevail. Skid roads must be properly drained off (water bars, etc.). Both approaches to the Potash Brook crossing are seepy and unstable, and, if logging were to take place, it would be wise to either build these up with stone or choose an alternate crossing (if one can be found) with more stable ground. On the east side of Potash Brook, the soil is generally more well-drained and stable, with the exception being the area directly west of the treatment plant.

Management history

This stand includes planted white pine and remnants of red pine (though most of the red pine has been logged). There were various silvicultural cuttings in the 1980's and presumably the 1990's, though no cutting has occurred since then.

Interfering vegetation

Non-native invasive plants

Bittersweet is widely distributed and occurs in a number of larger runs and open patches, with localized rankings often in the 3-5 range. The bittersweet seems especially prevalent along the top of a low, N-S hilltop that features current and former white pine and red pine plantations, but it is also prevalent more broadly. This is a very significant infestation and was already recognized as such in 2012. Barberry and multiflora rose are also present, often in conjunction with the bittersweet. Frustratingly, perhaps, there are also large sections of this stand that are relatively free of invasives, which serves as a reminder of what a forest "should" be like.

Native interfering vegetation

Grape vines are well established but primarily along the same N-S hilltop that has the highest concentrations of bittersweet. Together with bittersweet, a number of examples of gap process failure were noted on this hilltop. Hayscented fern occurred on a scattered basis, especially in the eastern half of the stand, but rarely at a problematic level. Likewise, mountain laurel was noted at a minor level primarily in the eastern part of the stand, in the general vicinity of Potash Brook.

Areas and aspects of concern for future monitoring of interfering vegetation

Inspect the riparian area of Potash Brook. Inspect all swales and minor riparian areas. Inspect the entire N-S hilltop.

Management approach for the coming 10 years

Contain and control non-native invasive plants to limit their spread and limit their seed production.

MTN Stand 11

This stand was delineated to capture the entirety of a former red pine stand on the east side of Mountain Street that is now maintained as a mowed field. This stand is accessed from Mountain Street. This stand is bounded to the east by the Mountain Street Reservoir, to the north by MTN Stand 14, to the west by Mountain Street, and to the south by MTN Stand 4. As with Stand 8, extensive logging occurred in this stand in the past 10 years to remove most of the declining and dead red pine. Additionally, mulch-mowing was used to transform this stand into an area that can be maintained by brush hogging until such time as factors that prevent the growth and establishment of trees are brought under control.

Forest attributes and management history

This is a former red pine stand. Currently, this stand appears to be a meadow, but in reality this stand is in the process of a protracted transition back to native forest conditions. Currently brush hogging is needed to keep non-native invasive plants in check, and thus, trees cannot grow at this time in most of this stand. The DCR type designation most-closely approximating this stand is GF (grass and forbs). Along the edge of the reservoir there is a tall, narrow band of sprout hardwoods, mostly red maple, that have been maintained over the years by infrequent flush cutting, which triggers resprouting. This practice is referred to as coppicing. This has not been done since sometime prior the removal of the former red pine stand in 2015.

Notable occurrences of uncommon native tree species

None noted in this former red pine plantation that is now maintained as a mowed meadow.

Habitat

This is a wide-open grass & forb meadow, with a tall, thick area of hardwood sprouts on the reservoir edge. A rocky slope area near the northern gate is difficult to mow and often features taller vegetation, which has been attractive to white-throated sparrows.

Soils

Paxton stony or very stony fine sandy loam. This is generally a deep, well-drained soil formed in glacial till, having a drainage- and root-restricting fragipan typically ranging from 20” to 38” in depth, and also occurs in Stands 4, 6 and 10. Where this soil flattens out at the toe of the slope that descends from Laurel Mountain, however, this soil is often wet, sometimes with ponding on the surface. This may be partly a legacy of the construction of the reservoir and associated alterations to drainage, and perhaps partly due to altered drainage from Haydenville Road.

Soils as related to tree growth purposes

This soil is good for tree growth though the poor drainage may limit rooting depth in some places.

Soils as related to logging purposes

The shoreline area of the reservoir has both flatter ground with less fragile soil, where erosion risk is minimal, but the risk of rutting and compaction is high. Normal precautions (dry or frozen ground) should be followed when any equipment is operated here.

Management history

This was a nearly pure red pine plantation that had been thinned at least once prior to 2003. Due to the decline in red pine health driven by red pine scale, and due to the thick understory of bittersweet, the decision was made in 2014 to clearcut the red pine and attempt to control the bittersweet by mowing. The clearcut was done using a whole-tree biomass system that removed the tops. The operator was Dave Cotton of Cotton Tree service. Due to a complex contracting process, the opportunity to log in the winter of 2014-2015 was lost. In March, 2015, Cotton entered into a contract with the City and logged during the night on consecutive nights, starting around 10:00 p.m., so that the ground would be as frozen as possible (daytime temperatures were in the 40’s). The City provided a large bank of lights for the landing. This was a remarkable and extraordinary

effort to protect the soil and it deserves to be recorded here. In the summer of 2015, Cotton, at no charge, used a hydro-ax to do an initial mowing of this stand to control bittersweet. This rotary flail mower struggled with the very strong red pine stumps. Subsequently, the entire area was mulch-mowed with a drum mulcher, including grinding of the stumps, in 2016, by Ted D’Onofrio. The high horsepower drum mulcher, mounted on a tracked, dozer-like machine, was well-suited to the project. In the interim, brush-hogging was carried out by DPW staff. In conjunction with work in Stand 8, this stand was brush-hogged by John Cain of Cains Mechanical, in 2022. In 2023, much of the area was brush-hogged by DPW staff.

Interfering vegetation

Non-native invasive plants

This stand is also an exception. Bittersweet is widely established but, as in Stand 8, is held in check by mowing. As with Stand 8, it continues to thrive in perimeter areas that are beyond the reach of mowing equipment on the fringes of the stand and around internal features that are difficult to mow such as a large rock pile and some of the steep area below the guardrail. The edge of the Mountain Street reservoir is a tall sprout-based strip of hardwoods that also harbors bittersweet, as does a small grove of sugar maples at the southern end of the stand. Other invasives are present and fit in to the same distribution pattern, including honeysuckle and multiflora rose, thistle, privet, and glossy buckthorn. Also, in a parallel to Stand 8, there is a problematic patch of Japanese knotweed—in this case, it runs along the NW edge of the stand at the top of a steep bank which features a guardrail. This population straddles jurisdictions. It is spreading down the hill, and is linked to the northward into adjacent Stand 14. It is very difficult access this patch of knotweed to control it by cutting or mowing.

Native interfering vegetation

Grape vines are present to a minor extent in the reservoir edge hardwood copse. This area seems very favorable to grapes. Hayscented fern is part of the meadow-like vegetation that occupies most of this site, though in the wetter areas, other ferns dominate. Mountain laurel is absent from this stand.

Areas and aspects of concern for future monitoring of interfering vegetation

Inspect all areas of this stand, with special attention to all perimeter areas. To understand whether Japanese knotweed is expanding, and if so, at what rate, consider measuring its annual lateral extent from the guardrail toward the reservoir.

Management approach for the coming 10 years

Continue to transform and maintain. Adopt a similar approach as for Stand 8, with multiple annual mowings for areas that can be reached (with, for example, a brush hog), and with innovative treatments for all of the perimeter and internal fringe areas that cannot be reached with the mower. Adopt special measures to smother or otherwise contain the knotweed. Over time, if invasives—especially bittersweet—can be controlled, a process of re-establishing woody vegetation could begin with planting species that deer tend to avoid, such as witch hazel. At some point, the sprout hardwoods along the edge of the reservoir may become too tall and may need to be cut and allowed to resprout. Any

grape vines, bittersweet or other invasives occurring within the band of sprout hardwoods should be kept in check at that time so they do not interfere with regrowth.

MTN Stand 12

This stand was delineated to capture all of the Northampton DPW land that is located east and south of Rocks Road. Most of this land was acquired within the past 10 years (the former Steidler parcel). This land occupies the northern toe of Horse Mountain and is accessed by Rocks Road. This stand is crossed by utility ROWs, with about 3,000 linear feet of ROWs and associated roads. Near the bottom of the “driveway” there is a flat memorial stone that looks like a gravestone. It commemorates the Steidlers. This stand is bounded to the north and west by Rocks Road, and to the west, south and east by non-DPW land. This stand includes a small 3-sided inholding on Rocks Road. No logging occurred in this stand in the past 10 years.

Forest attributes and management history

This is a mature-maturing hardwood-softwood stand with, typically, 5 common overstory tree species visible nearby from any point. In the overstory, red oak and black birch are common or abundant, with less red maple, hemlock, white pine, paper birch and beech, and even less sugar maple. Chestnut oak is also abundant, and pignut hickory and bigtooth poplar are also present (see below). There is a significant concentration of mature hemlock in the northwest corner of this stand. The DCR type designation most closely approximating this stand is OH (oaks and other hardwoods).

This stand has a tall, mostly closed-canopy overstory with a layered midstory consisting of a lot of hemlock (level = 1.7 out of 2) and much less beech (level = 0.5 out of 2). There is a significant volume of standing wood (36.5 cords of total stem biomass) consisting of both timber and cord products (see stand header). White pine and red oak are the primary timber species, with less white and chestnut oak, pignut hickory, red maple and black birch; chestnut oak has the largest volume of cord products, with slightly lower amounts of red oak and red maple, and less pignut hickory, black birch and white pine. There is generally a thick covering of leaf litter and a thin layer of non-interfering, desirable low vegetation. Common understory plants include an abundance of chestnut oak seedlings, with wintergreen, prickly dewberry, wild sarsaparilla, and some broad-leaved sedge, which indicates rich mesic conditions. Coarse woody debris is common on the forest floor (6.9 pieces visible on average from each plot). In part due to dense shade, viable regeneration is lacking at this time, though there is a presence of black birch, sugar maple red maple, hemlock, hickory and chestnut oak.

Notable occurrences of uncommon native tree species

There is a significant amount of chestnut oak with less scarlet oak and white oak. There is a small amount of pignut hickory and less shagbark hickory. While the pignut hickory tends to occur on the upper slopes, the shagbark hickory was found on lower slopes.

Habitat

This is a tall, closed-canopy, mixed species forest, with midstory layers, snags, downed logs, and thick leaf litter. The significant component of red, white and chestnut oak along

with pignut hickory has the potential to provide important mast. There are many areas of exposed ledge and steep ground; indeed, the terrain is quite rugged. There is an ephemeral, vernal-pool-like body of water set amidst ledge outcrops that is drained by a minor stream (see Forest Stand & Boundary Map).

Soils

The soils in this stand are classified as Charlton-Rock-outcrop-Hollis complex, and are further classified as “steep” and well-drained. The Charlton component is on hills on uplands. The parent material consists of friable loamy eolian deposits over friable loamy basal till derived from granite and gneiss. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is moderate. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. This component does not meet hydric criteria. The “rock outcrop” component is bare ledge. The Hollis component is also on hills on uplands. The parent material consists of friable loamy basal till over granite and gneiss. Depth to a root restrictive layer, bedrock, lithic, is 10 to 20 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is very low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. This component does not meet hydric criteria.

Soils as related to tree growth purposes

The site and its soils are extremely variable in fertility, depending largely on slope position, with soils on upper knobs tending to be less fertile, but is, in all cases, well-suited to growing a mix of native trees that can protect water quality.

Soils as related to logging purposes

Most areas are well-suited to logging—other than steep, ledgy areas that cannot be accessed—but it is important to restrict operations to periods of dry or frozen ground, and to design logging access to avoid creating pathways for run off.

Management history

This stand may have originated following a clearcut long ago. No recent management. Some more recent stumps are visible, potentially dating back to the last major spongy moth infestation around 1979-1981. No management appears to have occurred since that time.

Interfering vegetation

Non-native invasive plants

This stand is one of the notable exceptions for which almost no bittersweet was detected. In fact, no bittersweet was detected internally within the stand, but bittersweet was found at the fringe (near Rocks Road near the reservoir spillway), along the internal Aquadro power line ROW, near the small utility building that is located on an out lot surrounded on three sides by Northampton DPW, and off-property but near the boundary in the NW part of the lot, where a driveway easement comes through the parcel and then continues south. In short, bittersweet is all around but has not yet been detected in the core of this

stand. The same is true for other invasives; barberry, rose and glossy buckthorn were found to a limited extent in associated with the bittersweet.

Native interfering vegetation

Grape vines were not observed in this stand. Hayscented fern was not observed at a problematic level. Mountain laurel tends to occur in large but widely scattered, discrete thickets.

Areas and aspects of concern for future monitoring of interfering vegetation

Inspect the perimeter of this stand including along Rocks Road, and inspect all internal roads, all utility-related infrastructure or debris piles, all rights-of-way crossing this property, and the boundaries.

Management approach for the coming 10 years

Maintain non-native invasive plants at or below their current low level. Cut grapes. Use silvicultural methods to support uncommon native tree species possessing special adaptive potential.

MTN Stand 13

This stand was delineated mostly to capture land on the north side of Rocks Road that was acquired in recent years. It also includes an area formerly of MTN Stand 3 that does not contain red pine. This stand includes a large area of forested and shrub swamp wetland in the central part. This stand is accessed both by Rocks Road and by Chestnut Mountain Road. This stand is bounded to the west by the Mountain Street Reservoir, to the north by non-DPW land, to the east by Chestnut Mountain Road and to the south by Rocks Road and MTN Stand 3. This parcel includes a 3-sided inholding not owned by Northampton DPW. Some logging occurred in this stand in the past 10 years, both in the westernmost and the easternmost parts. The intention was to begin a process of establishing young trees of diverse species.

Forest attributes and management history

This is a highly variable mature-maturing hardwood-softwood stand with, typically, 6 common overstory tree species visible nearby from any point. In the overstory, red oak, red maple, white pine and yellow birch are common or abundant, with less black birch, hemlock, ash and sugar maple, and even less paper birch. On more than one occasion, black ash has been confirmed in the central wetland. Hemlock is more prominent in the western part, near the reservoir. The DCR type designation most-closely approximating this stand is WHK (white pine hemlock and hardwoods). An old AT&T ROW crosses this stand.

This stand has a tall, mostly closed-canopy overstory with a layered midstory consisting entirely of hemlock (level = 2.0 out of 2) with no beech (level = 0 out of 2). There is a significant volume of standing wood (21.8 cords of total stem biomass) consisting of both timber and cord products (see stand header) – this number would be higher if the large wetland acreage were excluded from the calculation. Red oak, sugar maple and hemlock are the primary timber species captured by the 3 inventory plots that fell within this

stand; red maple is the primary cord product species, with an appreciable component of sugar maple, and less yellow birch, red oak and hemlock. There is a typical covering of leaf litter in the upland forest but a thin layer in the wetland; there is a relatively abundant layer of non-interfering, desirable low vegetation, in part because of the included wetland. Common understory plants include sensitive fern, cinnamon fern, Christmas fern, poison ivy and goldthread; in the wettest areas, sphagnum moss, goldthread, sensitive fern and cinnamon fern are abundant, as are poison ivy and foamflower, with tall winterberry and spicebush. Swamp saxifrage was abundant on the periphery of the wettest areas. Coarse woody debris is common on the forest floor (>5 pieces visible on average from each plot). In part due to dense shade, viable regeneration is generally lacking at this time, though in the footprint of the recent cutting, there are pockets of black birch or white pine that regenerated from seed as well as pre-existing hemlock that was released.

Notable occurrences of uncommon native tree species

Pignut hickory and less shagbark hickory on the south- and west-facing slopes in the eastern part of the stand. There are also a number of chestnut oaks in this same area, and less scarlet oak. There are also sassafras and chestnut sprouts in this same area. A single white oak was noted on the top of the slope down to the reservoir in the western part of the stand. The central wetland has black ash—which is the only known occurrence across the entire Northampton DPW active watershed forest.

Habitat

This is a tall, closed-canopy, mixed species forest, with midstory layers, snags, downed logs, and thick leaf litter. Though most of this stand is upland, there is a large, hummocky wetland swale with somewhat stunted and sparse red maple, yellow birch and hemlock, that drains slowly to the southwest.

Soils

The soils are a mix of Paxton stony or very stony fine sandy loam, Ridgebury fine sandy loam, and Charlton-Rock-outcrop-Hollis complex. The Paxton is a deep, well-drained soil formed in glacial till, having a drainage- and root-restricting fragipan typically ranging from 20” to 38” in depth. It occurs in the eastern and western parts of this stand. The Ridgebury fine sandy loam occupies the central, wet swale. It is a hydric soil. The parent material consists of friable loamy eolian deposits over dense loamy lodgment till derived from granite and gneiss. Depth to a root restrictive layer, densic material, is 10 to 25 inches. The natural drainage class is poorly drained. Water movement in the most restrictive layer is very low. A seasonal zone of water saturation is at 3 inches during January, February, March, April, May, November, December. The Charlton-Rock-outcrop-Hollis complex is described for Stand 12. It occurs alongside the Paxton in both the eastern and western parts of this stand.

Soils as related to tree growth purposes

The peripheral area of the stand is very productive for timber growth but the core area of this site is not well-suited for timber growth. However, this site is well-suited to forested growth that can provide watershed protection.

Soils as related to logging purposes

Most of this stand is well-suited to logging operations provided adequate precautions are taken to avoid rutting and compaction; however, the core area of this site, and various swales that drain to it, are not suited for logging operations.

Management history

There is no good record of management prior to 2015, but it appears some trees were cut on the west side of the central wetland. In 2015, in conjunction with logging of red pine in Stand 3, logging occurred in a number of areas within this stand (see Forest Stand & Boundary Map). Unlike much of the logging that has been described for the Mountain Street Reservoir watershed, this logging was proactive and was designed to create openings to establish regeneration and to thin around selected trees. The logger was Joe Adams (with Chad Blackbird), using a variety of equipment that left the tops in the woods.

Interfering vegetation

Non-native invasive plants

Bittersweet is largely absent from this stand, with a few, scattered incipient occurrences (localized ranking = 1) and a higher level of occurrence along and within the old utility right of way. Some bittersweet was also observed near the NE corner, near Chestnut Mountain Road. A minor amount of multiflora rose was observed in the central wetland and a minor amount of honeysuckle was observed on the main woods road in the western part of the stand. Glossy buckthorn has a scattered presence in this stand, occurring at a very low level in a variety of settings, including dry upland, wetland, and on the utility ROW. Also, one cork tree was discovered in an opening created by logging in 2015. This tree will be studied then cut or dug out.

Native interfering vegetation

Grape vines were observed only to a minor extent, in the vicinity of the utility ROW. Hayscented fern was not observed at a problematic level. Mountain laurel is found in the southern part of the stand, where it is thick in some places and has contributed to a gap process failure.

Areas and aspects of concern for future monitoring of interfering vegetation

Inspect roadsides along and within the stand, the utility ROW, the logging footprint, and internal wetlands.

Management approach for the coming 10 years

Contain and control non-native invasive plants to limit their spread and limit their seed production. Re-inspect the entire logging footprint and pull any cork trees, in case there are any. Make a dedicated effort to find and control bittersweet and glossy buckthorn. Cut grapes. Use silvicultural methods to support uncommon native tree species possessing special adaptive potential.

MTN Stand 14

This stand was delineated to capture an area of large white pines occupying a thin strip of land on the west side of the Mountain Street Reservoir. This stand can be approached

from the west on Mountain Street and Haydenville Road, but the guardrail and busy traffic make this difficult. This stand is perhaps best accessed from the south, through MTN Stand 11. This stand is bounded to the north by MTN Stand 1, to the east by the Mountain Street Reservoir, to the south by MTN Stand 11, and to the west by the aforementioned roads. This stand is in a very difficult location. No logging occurred in this stand in the past 10 years.

Forest attributes and management history

This is a mature-maturing softwood stand dominated by white pine. The DCR type designation most-closely approximating this stand is WP (white pine). This stand has a tall, mostly closed-canopy overstory with a layered midstory consisting of vines and invasive shrubs. No sample point fell within this stand, so the numbers presented here are the same as for Stand 6, which is a reasonable approximation, though the volumes in Stand 14 may actually be higher due to a lack of recent thinning. There is a significant volume of standing wood (55.9 cords of total stem biomass) consisting of both timber and cord products (see stand header). White pine is the primary timber species; and white pine is also the primary cord product species. There is generally a thick covering of leaf litter and a thin layer of non-interfering, desirable low vegetation. It is difficult for native understory plants in this stand due to the abundance of non-native invasive plants; there is a small amount of musclewood, a woody tree or shrub, in the northern part. Coarse woody debris is common on the forest floor as are entire uprooted trees. Due to multiple factors, viable regeneration is lacking at this time.

Notable occurrences of uncommon native tree species

None noted.

Habitat

This is a tall, closed-canopy, white-pine-dominated forest, with midstory layers (of non-native invasive plants), and large snag and downed logs, and variable leaf litter.

Soils

Paxton stony or very stony fine sandy loam. This is generally a deep, well-drained soil formed in glacial till, having a drainage- and root-restricting fragipan typically ranging from 20" to 38" in depth.

Soils as related to tree growth purposes

This soil is good for tree growth.

Soils as related to logging purposes

The soil in this somewhat steep shoreline area of the reservoir is fragile, with a high erosion and compaction risk. Extreme precautions should be followed if any trees are to be removed. Ideally, they would be removed without driving on the site (e.g., by crane from the adjacent blacktopped road).

Management history

There is no evidence of past logging. Around 2015, DPW staff spent some effort cutting grape vines and dead trees in the southern part.

Interfering vegetation

Non-native invasive plants

This stand offers one example of a worst-case scenario. Bittersweet is widespread and climbing, where it produces abundant fruit. Occurrences were typically had a localized ranking of 3-4, reflecting the apparent fact that overstory shade is keeping it somewhat in check, but which would quickly develop into a localized ranking = 5 in the wake of any appreciable blowdown of the overstory pines. The site seems especially conducive to bittersweet. Barberry, honeysuckle and multiflora rose are present, sometimes with localized rankings as high as 3. There is also privet, glossy buckthorn and burning bush. And there is also a component of Japanese knotweed spreading along the sideline of Mountain Street & Haydenville Road.

Native interfering vegetation

Grape vines were observed to a limited extent, though this site seems very favorable to grapes. Hayscented fern was not noted. Mountain laurel was also not noted.

Areas and aspects of concern for future monitoring of interfering vegetation

Inspect the entire stand, including along the guardrail.

Management approach for the coming 10 years

Limit seed production of non-native invasive plants as a temporary measure. The challenges in this stand go beyond the question of interfering vegetation. Though tantalizingly close to a paved road, this stand is extremely difficult to access and to operate within. Yet, given its location, this stand cannot be ignored. Ultimately, the pine overstory will eventually fail, either by dying or blowing over, and, as it stands, invasives would quickly form the new overstory. Contingency plans should be made. A first step would be to cut an access footpath through up through the stand so that it can further studied and so that options can be developed.

Watershed Forest Management for the Next 10 years

Forest management concepts

This plan is based on the premise that the water quality functions of the forest are best provided by tall, complex, vigorous, species-diverse forests which, in turn, provide the best protection for the soil which, ultimately, is the pass-through source of the water entering the reservoirs. The challenge at hand, and the goal, is to ensure that this type of complex forest is perpetuated going forward. The management practices listed here are intended to contribute to that goal.

The primary focus of forest management for the coming ten years will be to prepare the forest to maintain as much of its *current* level of water quality function as possible in the face of increasing and compounding harmful influences that are entirely beyond the control of Northampton DPW (such as the ongoing impacts of introduced pests, pathogens, diseases, storms and droughts as well as any additional consequences of climate change (see Landowner Goals section)). The focus of management will be on reducing the harmful impacts to the forest caused by those influences that, to a greater or lesser partial extent, are under Northampton DPW control. There are two aspects to this management approach.

The first aspect is to protect and support the current forest structure and species-diversity as much as possible. In the previous plan, prepared in 2012, one important aspect of this was to infuse the mature forest with components of younger forest. This was accomplished to a modest extent in the early part of the previous management period until, ultimately, most of the remainder of the forest management period ended up being devoted to cutting in direct response to forest health issues affecting single-species plantations of conifers or the decline of hemlock due to hemlock wooly adelgid. However, the intention of further infusing the maturing forest with components of young forest is not a key part of the recommendations at this point for the coming 10 years. This is not because young trees are not desirable, but rather, because conditions for establishing young trees – and, especially, conditions for establishing a diversity of young trees – are currently unfavorable. Instead, the key focus will be on preserving, to the extent possible, the dense shade of tight canopy conditions overall, and on promoting the health of existing overstory trees in particular cases, especially those which are both uncommon and have notable adaptive potential in the face of anticipated climate change.

The second aspect is to directly counteract a number of factors that greatly constrain the forest's own ability to self-perpetuate. A number of factors are contributing to this and have been identified in this plan. The main factors identified at this time are:

- The ubiquitous impacts of excessive feeding by deer (and in some cases, moose) (see **Excessive browse impacts due to deer and moose** in the Overview section of this plan), which prevent an adequate diversity and abundance of tree seedlings from becoming established and thriving.
- The widespread and increasingly excessive growth of and competition from non-native invasive trees shrubs, vines and trees—most notably oriental bittersweet

vines at this time—which prevents young native trees from becoming established and thriving. A number of other non-native invasive plants are present as well and could become increasingly problematic in the future, including glossy buckthorn, autumn olive, and Amur cork tree. Further, because deer tend to avoid feeding on these non-native invasive plants, they are often able to grow unchecked.

- The excessive growth and competition from certain *native* plants which smother, tangle or outgrow native tree seedlings; these plants are not inherently problematic but become problematic when they grow into a low-competition vacuum created by excessive browse impacts.
- Additional factors may become more important in the future, such as invasive earthworms that consume the protective leaf litter and alter the soil.

These factors present significant challenges to the forest’s ability to establish a necessary and sufficient abundance and diversity of young trees to replace mature trees as they succumb to health, weather or climate impacts. This is a fundamental problem for a watershed forest over time. Further, the difficulty in establishing new trees is also a fundamental problem for any forest in terms of *adapting to climate change*, because the core process of establishing a diversity of young trees is the key adaptation capacity that forests possess and need to rely on. And it is an insidious problem, because it is not readily apparent at a quick glance – people in the public may see the many large trees and conclude that the forest is “just fine as it is.”

Management practices listed below are intended to protect, strengthen or otherwise restore the forest’s ability to draw upon its own inherent species diversity and regenerative capacity to perpetually maintain or re-establish itself going forward. That said, given the current high levels of these interfering factors documented in the fieldwork for this Forest Stewardship Plan, this is a huge and unprecedented task at this time. And it is coming at a difficult juncture in our capacity to address these problems. This is in part due to the vast scale of treatment needed, in part because even the best tools may not be 100% effective, and in part because some of the tools that are available to help directly reduce interference may, themselves, be unpopular or technically problematic.

For example, regarding excessive feeding by deer, which is a result of very high populations of deer relative to available food, fencing is technically an option. Small-scale fencing or other exclosures show promising results, including fencing experiments installed by Harvard Forest on Northampton watershed land. However, fencing will not be practical at a large-enough scale to make a significant difference. And though hunting of deer is a direct way to reduce their populations, it is hard to envision that hunting would happen at a large enough scale and at a significant-enough intensity to literally solve the problem. Even the Quabbin hunt, in which more than 5,000 deer have been taken, has not fully resolved issues with deer, though it has brought substantial improvement. And hunting would not help with moose, which, currently, are illegal to hunt in Massachusetts. Thus, while allowing the hunting of deer will not fully resolve the current problem, it would certainly reduce pressure on the desired young trees, and thus it is

likely to bring some level of benefit relative to the status quo, or perhaps at least prevent the situation from worsening further.

The situation is similar with non-native invasive plants. Though such plants can be controlled at very small scales by simple mechanical means, such as carefully pulling them out of the ground, this becomes much harder to do even at slightly larger scales, at higher population densities, and as plants become larger and more established, including in difficult or remote locations. This is especially true at this time for bittersweet, a vine, which develops a wide-reaching shallow root system that can resprout when the main stem is damaged. But, due to their rapid growth, the ability to control such plants by hand-pulling is only effective and realistic for a very brief window; non-native invasive plants become much more problematic within the space of a year or a few years, quickly becoming too stout to pull by hand, or, with bittersweet, having too far-ranging a root system to be entirely pulled out of the ground. This is also very true for Japanese knotweed, which, to date, is found mainly along roadsides and in an isolated soil and debris dump. Furthermore, in pulling large non-native invasive plants out of the ground, there can be appreciable soil disturbance which can then serve as a seed bed for non-native invasive plants to re-establish. A common suggestion heard is that goats or other livestock be used. And while this may be partially effective in certain, special circumstances, there are major challenges in to using goats or other animals at a large scale. There are fencing and supervision challenges, there are water quality risks and regulatory restrictions (near tributaries and reservoirs), and there is the likelihood that the goats or other animals will also consume desirable native plants.

It is not surprising that chemical herbicides can be effective, or at least partially effective, as a component of an overall treatment of invasives. In 2012, Northampton DPW developed, on paper, an approach to controlling non-native invasive plants in an integrated approach that involved the use of chemical herbicides (see Forest Stewardship Plans from 2012). But it was never implemented. One cannot deny that chemical herbicides, which can be effective or partly effective in controlling non-native invasive plants when used within a multi-faceted and multi-year approach, can never be 100% free of health or ecological concerns that may be raised.

In some cases, there is the option in some cases to transform an infested area of forest or brushy non-forest into an alternate state such as a mowed woodland savannah or even a mowed meadow. Such areas would then be maintained over time by periodic re-mowing until such time as native trees can be successfully reestablished. In fact, Northampton DPW has done exactly this on roughly 50 acres around the Water Treatment Plant. This very heavy-handed and costly approach is intended to serve as a stop-gap measure against bittersweet until such time as these areas can be reforested. This approach has proven very effective within the existing footprint in preventing a lion's share of seed production, and this type of approach could be expanded, but this type of approach is only suitable for areas with relatively easy terrain, relatively well-drained soils, and few stones, and with adequate personnel, equipment, and budgetary backing. It will always remain an exception.

Finally, there is the option of using volunteers to help pull non-native invasive plants. This has been tried as well and though it can be successful within a small area, it seems unlikely to be able to be ramped up to a level that can cover the significant acreage and have the significant control needed to sustain the watershed forest. One option that has not been tried is to bring in large work crews that are skilled in manual labor and working outdoors, akin to crews seen working in agricultural fields in the Valley. Perhaps there are agricultural down times when the non-native invasive plants in the woods could be worked and such workers would be available. Crews of such workers could potentially cover significant ground. This may be one of the best options that has yet to be tried.

In light of the above discussion, what sorts of options does the Northampton DPW have going forward to counteract factors that interfere with perpetually maintain or re-establish itself going forward? In summary, in embarking on an answer to this question, one must confront the fact that the options are not as good as we might wish. There is unlikely to be a set of options that could fully resolve the interfering impediments described in this plan to the extent we would like. That is frustrating to consider. One can only resolve the problems described here to a greater or lesser degree. One must accept that the realistic hope at this point is more to *slow* the overall rate of deterioration in forest function than to completely eliminate the impediments to proper forest function. And so one is forced to think in terms of what, if anything, would offer an acceptable amount of benefit relative to the cost, effort, risk and trade-offs. With all of the above in mind, here is a set of recommendations for managing the watershed forest over the coming 10 years.

Maintain an urgent awareness of the problems and limitations

The first step is to retain an urgent awareness of the challenging situation facing the forest, as described above, and maintain a modicum of optimism in the face of limited effectiveness of options that exist in the knowledge that even if the major challenges cannot be fully resolved at this time, they will only get worse faster if we do nothing.

Maintain maximum shade in the forest

Shade provided by the overstory and midstory, along with the protective covering of fallen leaf litter lying on the soil, is the primary, broad, passive defense against the spread of non-native invasive plants. Shade is far from 100% effective, but it is much more effective than bare or exposed soil. Avoid, to the extent possible, reducing shade or disturbing the leaf litter in the forest.

Reduce harmful deer impacts on young trees

Given the substantial negative impact of high deer browse on forest vegetation across the watershed, there is a need to address this issue to make sure that watershed forests can regenerate in the future. Potential methods exist at a number of scales and include both hunting and exclusion.

- Currently, by policy and tradition, deer hunting is not allowed on Northampton DPW watershed land; however, hunting is one way to reduce the deer population and potentially increase the success of tree regeneration in terms of the total numbers of young trees, the size of young trees, and the diversity of young

trees. Other water suppliers have decided to allow hunting on their property. Most notable is perhaps the MA Division of Water Supply Quabbin Reservoir, which takes a controlled-hunt approach. The Quabbin has seen improved regeneration success as a result since introducing hunting in 1990, with three types of improvement: a greater number of young trees per acre, a greater number of tall seedlings (indicating that they are surviving the browse pressure), and a greater proportion of oaks among the young trees (despite oaks being preferred browse for deer).¹⁵ By contrast, the Town of Southbridge, MA, at the recommendation of the Water Department, decided in 2022 to allow hunting on its approximately 3,000-acre watershed, after roughly 100 years of not allowing hunting. In this case, the Town Council voted to open watershed lands to normal, legal hunting, with no special effort to control the hunt.¹⁶ Drawing from these and other practices in other water supply forests, the City could explore what type of hunting program might best fit the City's objectives and public access policies. Such a program could begin on a trial basis and be limited to certain targeted areas of the watershed, or only allow a small number of hunters access to the watershed for a managed hunt (similar to the Quabbin deer management program). Such a program should include evaluation every few years of whether hunting results in reduced browse impacts on desirable regeneration.

- Coordinated hunting of deer at neighborhood level: Deer naturally move across property boundaries. The area around the Northampton DPW watersheds contains a number of large abutters, including DCR, DFW and Smith College. As a group, abutters may share similar concerns about the difficulty of establishing young trees. And there are numerous smaller landowners who may experience high impacts from deer—in their gardens, for example. This may provide an opportunity for cooperation or coordination amongst neighboring landowners. A first step would be to reach out to abutters to see if there is interest in forming a contact group to discuss this topic (and the topic of non-native invasive plants—see below).
- Exclusion of deer at small scales: At smaller scales, consider using exclusion fencing of some kind to keep deer out during an establishment phase of young trees. This will only be successful if non-native invasive plants and other plants are also under control. This would not be practical at any larger scale but might serve as a last resort in situations with high erosion potential that have lost tree cover. Though there are no plans to do this at this time, it can be kept in mind in case DPW is forced to try to reestablish trees in such situations (e.g., in case there is a severe blowdown near Avery Brook).

¹⁵ See pages 34-36 including Figure 3-5 and Table 3-8 in DCR Division of Water Supply Protection 2017 Land Management Plan.

¹⁶ Pers. Comm. 10-6-2023, Steve Gregoire, Town of Southbridge Water Manager, phone: 508-764-3207, ext. 4

- Exclusion of deer at larger scales: There is no intention to conduct larger-scale logging operations during the coming ten years. But, if for some extraordinary reason Northampton DPW is confronted with needing to cut a large number of trees in a large area, say, on a scale of acres to dozens of acres, for example in the wake of a major storm, there may be opportunities to construct deer- and moose-excluding walls out of logging residues (tree tops, rough trees, etc.). These walls exclude deer and moose and allow young trees to develop in the absence of browse impacts. Referred to as slash walls, these have proven effective in initial testing, when applied in circumstances with suitable quantities of material and suitable terrain features. See information at the Cornell Slash Wall Resource Center: <https://blogs.cornell.edu/slashwall/>. Of course, for these to be fully effective, interfering vegetation would need to be controlled as well.

Promote native trees by reducing the impacts of non-native invasive plants

This includes both passive and active approaches. The key focus is on non-native invasive plants. But certain native plants are also included in these treatments in some cases.

- Passively resist the spread of non-native invasive plants: To the extent possible, maintain forest cover that helps *passively* resist the spread and proliferation of non-native invasive plants, and avoid actions that make invasives worse. This is accomplished mostly by passively letting the vast majority of the forest grow. This policy dates back to the 2012 Forest Stewardship Plans and was a guiding principle in limiting the planned, proactive silviculture that took place in subsequent years. However, the effectiveness of this approach is under increasing assault by introduced pests, pathogens and diseases that threaten to reduce shade and reduce leaf litter, especially from trees such as beech and hemlock that cast particularly deep shade, or, trees such as beech and red oak that provide thick, slowly-decomposing leaf litter to cover the soil. And, of course, storms can and will undermine the desire to maintain dense shade (see Figure 5).
- Active responses: these are discussed in the next section.

Non-native invasive plant treatments by severity

The following set of practices is based on the perceived severity of the non-native invasive plant threat. For each stand (see Stand Descriptions section), in conjunction with a discussion of the threat, a treatment recommendation is made from the list below.

Maintain low level –Lowest severity

This is for stands with a very minor or zero level of infestation. All severe infestations of non-native invasive plants start with small individuals seeding in to a new location and becoming established. A key step in preventing the spread and proliferation of non-native invasive plants is to take decisive early action before such plants become well-established. With due diligence and consistent effort, it may be possible in these stands to prevent incursions of non-native invasive plants and largely eradicate any non-native invasive plants that are already established. Sometimes referred to as early detection and

rapid response, this method involves *active* efforts to constantly search for, discover and control small, isolated occurrences—even single seedlings— and infestations early and decisively. This involves systematic inspections and immediate mechanical treatment – pulling small plants where possible. Initial treatment of any existing invasives would need to be followed up on in subsequent years by revisiting, re-inspecting and potentially re-treating any site where small infestations have been found. Though existing non-native invasive plants would be controlled, the greater part of the management gain will be in *prevention* through ongoing due diligence and associated effort to detect and control new occurrences in the seedling stage before they escape ready control. Stands with this ranking are unfortunately the exception. This category corresponds most closely to a stand-level Severity Rank of 0 or 1.

Contain and control – Moderate severities

This is for stands that (still) contain large or relatively large areas that are not yet compromised in their function by non-native invasive plants. However, within these stands there are also multiple occurrences of invasives as well-established, scattered individuals or clumps and possibly in one or more larger pockets of greater concentration. From a management perspective, the scattered individuals and concentrations tend to be isolated enough such that they can be treated as distinct, discrete areas of infestation, rather than as a large expanses or stand-wide coverage. In most of these cases, though it is in theory not out of reach to control the infestations within these stands, provided an adequate effort can be devoted, the most realistic management goal is to prevent or greatly slow further spread of established invasives into adjoining non-infested areas. If a lot of the invasives are plants other than bittersweet, the prospects of success are greater.

Within this category, one can distinguish between moderate-low and moderate-high severities. Moderate-low reflects a spread and intensity of non-native invasive plants that is decidedly more discrete than for the Moderate-high. With a moderate-low level, one can hold out a greater hope of eradication. With a moderate-high level, eradication seems a remote possibility at best. This category corresponds most closely to a Severity Rank of 2 or 3, respectively.

Limit seed production - Last chance for control – High severity

This is for stands with a very high level of infestation of non-native invasive plants, but which are mostly in the understory (rather than in open canopy gaps), and which still possess a largely intact overstory. In methodology, the “last chance for control” differs from the contain & control approach in terms of scale and expectation: the footprint of the infestation within these stands is much greater than for stands with moderate severities, and there is little realistic hope of preventing non-native invasive plants from spreading to the remainder of the stand given available methods. Therefore, the main focus is to limit the production of seed from the mature invasives. In theory, as for lower levels of infestation, if the non-native invasive plants can be brought under control while the overstory is still alive, upright and casting shade, there may (in theory) be a chance to reverse the severity to a lower level. At this stage, a major disturbance such as a pest outbreak or a drought that kills a significant number of trees or a windstorm that knocks down a substantial portion of the overstory will likely result in a completion of the takeover by non-native invasive plants. This category corresponds most closely to a Severity Rank of 3.5 or 4.

Rehabilitate forest function – Beyond tipping point

This is for stands that lack, to a significant extent, an overstory with which to shade the non-native invasive plants over an appreciable extent of the stand. As a result, the non-native invasive plants are growing unchecked in full sun, and there is no apparent pathway to re-establish trees that can cast shade over invasives or become part of the overstory in these areas. The practical challenge is both to control the invasives while also establishing new trees for future shade. Though there can be an intention to rehabilitate such stands, there is no general methodology for how to do this. Solutions would need to be contemplated on a stand-by-stand basis. It may turn out that there is no good solution and such stands may need to be reclassified as “Transform and maintain”. However, that option may also not be feasible in some cases. This category corresponds most closely to a Severity Rank of 5 or a mix of 4 and 5.

Transform and maintain in an alternate state

The approach could apply in cases in which the objective of having maturing, complex forest occupy the site or stand (or portions of the site or stand) is largely unachievable due to factors that are beyond the current ability of Northampton DPW to successfully control. This would be the case for stands that have reached a point from which it does not seem feasible or otherwise desirable, under prevailing circumstances, to re-establish fully- and normally- functioning forest cover (within the foreseeable future). Tall trees may be present (allowing for an open-canopy, woodland-like structure) or completely absent (resembling a “field”). Examples of this are Mountain Street Stands 8 & 11. If a stand has reached the level of “Rehabilitate forest function” and there is no plan to rehabilitate it, it can be reclassified as “Transform and maintain” if there is a viable plan to carry out such work.

Special treatment for hotspots

Hotspots are very localized concentrations of high severity or beyond tipping point infestation that are included within a larger surrounding area of lower infestation. The occurrence of a hotspots is generally attributable to one or more distinguishing and underlying factors that contribute to a particular intensification of non-native invasive plants. For example, the infestation may occur within a softwood plantation found within an otherwise native forest, or it could occur within a large wetland within an otherwise upland forest). Recommendations for hotspots are made at the stand level and may differ from the general recommendation for the stand. Treatments can range from contain & control to transform & maintain.

Additional approaches to address non-native invasive plants

Native interfering vegetation treatments

In some cases, in conjunction with the stand-level approaches to treating non-native invasive plants described above, there is an additional recommendation to treat native interfering vegetation. Mostly, this would be a recommendation to cut native grape vines (see discussion of silviculture below). Though native grape vines are a valuable component of wildlife habitat, their proliferation within a watershed forest is incompatible with the goal of maintaining tall, layered canopy structure. As part of helping to control non-native invasive plants, efforts to cut native grape vines would

mostly be the case in conjunction with occurrences of bittersweet. Grapes and bittersweet have a broadly overlapping distribution. The reason to cut grapevines is both to reduce the climbing structure for co-occurring bittersweet vines and to limit occurrences of gap process failure in which grapes contribute to large trees being pulled down or broken off, creating open glades of vines in which young trees cannot become established. In some special cases, there could be a recommendation to treat hayscented fern or mountain laurel, both of which would be the case only in an extraordinary measure to establish young trees (see below).

Policies to clean equipment coming from other sites

When bringing in equipment to a site, ensure that it is cleaned to the extent that it is free of soil, mud or plant matter from other sites.

Coordinated control of non-native invasive plants at neighborhood level

Non-native invasive plants are not limited by property boundaries. Further, non-native invasive plants appear to spread from one property to another, following roadsides and being carried by birds. The area around the Northampton DPW watersheds contains a number of large forest owners that have a vested interest in the long-term health and function of their forests for a variety of reasons, including a need to prepare for further climate change. This group includes DCR, DFW and Smith College. As a group, these abutters may share similar concerns about the negative impacts of non-native invasive plants. Likewise, there are numerous smaller landowners in the neighborhood who are also likely to be grappling with non-native invasive plant issues. This may provide an opportunity for cooperation or coordination amongst neighboring landowners. A first step would be to reach out to abutters to see if there is interest in forming a contact group to discuss the issue of non-native invasive plants (and the topic of high deer populations—see above).

Promote the health and survival of native trees using silvicultural techniques

Silvicultural methods are often used in watershed forests both to establish new trees and to improve the growth of existing trees.

Establish young trees

One of the key uses of silviculture is to intentionally establish young trees. Ideally, we would continue to use silvicultural methods to pro-actively stimulate the establishment of a diversity of young trees in the coming 10 years, infusing these into the framework of the existing mature forest. This would help prepare the forest to continue to provide a high level of water quality functions, and would also be a primary method of recruiting young trees that may be better adapted to anticipated climate change. Special efforts would be directed toward establishing young trees of less common species that have been identified as having strong potential to thrive in future climate scenarios predicted by scientists. Ideally, through a managed set of circumstances provided through silviculture, better outcomes – i.e., greater levels of successful and diverse tree establishment – can be achieved than those that might have occurred naturally and without management in the same situation. This type of silviculture was embarked on in 2012 in what was, already at that time, a very limiting set of restrictions intended to avoid overlapping with non-native

invasive plants and unsuitable soils and terrain. A rigorous process was used to identify suitable sites for silvicultural practices designed to establish young trees, and silviculture was carried out from 2013 to 2015 toward that end.

At this time, however, the impediments to the success of this type of approach are considered to exceed a level that is reasonably feasible to overcome, and so this Forest Stewardship Plan does not include any general recommendation that logging-based silviculture be used to establish young trees. However, there could be forced circumstances that do call for this. If so, it would most likely be in response to some extraordinary occurrence, such as major storm damage necessitating a hazard-reduction response that includes tree cutting. For example, if Northampton DPW is confronted with needing to cut a large number of trees in a large area in the wake of a major storm, or in anticipation of future storm damage. Or, for example, if Northampton DPW needs to address roadside hazards in a larger area. In such cases, it may be possible to design the response so that young trees become successfully established. As an example, the lower Dry Hill Road area in the Ryan and West-Whately watershed has seen repeated blowdown of tall pines onto Williamsburg and Dry Hill Roads in recent years, including several times within the past 12 months, and may be an example of a situation calling for some sort of pro-active silvicultural hazard tree response.

Reduce competition around existing canopy trees

The other key use of silviculture is to improve general growing conditions for large numbers of individual trees. Thinning is a standard silvicultural method to promote the vigor and growth of existing trees by reducing crowding around them. This is typically done through logging, which can remove useful forest products at the same time that have a value to society, in many cases. However, at the same time as thinning reduces competition around trees, it also lets more sunlight reach the forest floor. Together with the disturbance to the leaf litter caused by the logging process, this can trigger the establishment of tree seedlings and other desirable native vegetation in the understory. However, when thinning happens in the presence of elevated populations of deer, and in the presence of abundant seed and propagule sources of interfering vegetation, an unfortunate and unintended result can be that, in the end, the forest understory sees an increase in interfering vegetation, whether native or non-native, and little or no addition of desirable trees. Therefore, because of the wide distribution and reach of interfering factors identified in this Forest Stewardship Plan, thinning by logging is not recommended for the Northampton DPW watershed forests at this time. An exception would be as part of a forced response to a hazard or to some other extraordinary circumstance that requires the cutting of trees. In such cases, the tree cutting could potentially be designed to have a thinning benefit, or, to have a combined thinning and regeneration benefit (see discussion above).

An alternative to thinning by logging is to simply cut or in some cases girdle trees and leave them in place. This accomplishes the benefit of the thinning without any of the disruption generally associated with logging, including the movement of large vehicles through the forest. This is referred to as non-extractive thinning. It can be as simple as someone walking into the woods with a chainsaw to girdle selected trees in settings far

from public access. One extreme variation of this method was used along Borowski Brook in Mountain Street watershed Stand 1 to address a roadside hazard brought to DPW's attention by the Town of Whately, which perceived a legitimate risk from the tall, dead and dying trees adjacent to Haydenville Road in Stand 1 at the Mountain Street Reservoir. After careful study of the site, it was concluded that using logging or even crane-based tree service methods to cut the trees would have caused unacceptable impacts to the site, the remaining trees, or to public life (e.g., closing the road for 5 days). In the end, in a great service to the City, over 300 tall red pine trees were climbed by Dave Cotton of Cotton Tree Service, carefully felled away from Haydenville Road, cut into sections, and were left on the ground to begin decomposing. These logs are and will continue to be making a positive contribution to the infiltration capacity of the soils in the riparian area along Borowski Brook, even if they appear, to some, somewhat unsightly. In this situation, using non-extractive thinning made a lot of sense. However, there are a number of pitfalls to using this method at a broader scale, including out of pocket expense that cannot be recouped through the sale of timber, the difficulty and risk of doing this work, and the potential messy appearance, especially to those members of the public who are aware of the value and usefulness of wood products, of wasting a resource (a few of whom came forward to say so during the project). Thus, there may be a need to support the use of non-extractive thinning with public outreach to give the public an opportunity to learn about the practices and why it is being used. In any case, this is not a method that can be used on a widespread basis, but it could be used in special circumstances to promote the health of less-common trees in remote areas.

Reduce competition around uncommon trees

A number of important concentrations of tree species biodiversity have been identified across both watersheds. These species are important as part of the larger mix of species for their contribution to water quality functions at this time, and may increase in importance due to their potential to thrive in changing climate conditions (i.e., warmer and/or wetter conditions) as has been observed over the past century and as is currently predicted by science to increasingly to be the case. As a potential seed source for the establishment of young trees for future overstories over the course of time, their value reaches across the individual watersheds. For practicality's sake, these species are grouped according to similarity. From a watershed forest management perspective, the minimum silvicultural practice would be to ensure that these trees are not choked by grape vines or bittersweet vines. A more advanced practice would be to ensure that these trees are not overcrowded or outcompeted by neighboring trees, especially by trees of certain common species, such as white pine, red maple or black birch. The species groupings are as follows:

Oaks

While red oak is classified as "common" in the Northampton DPW watershed forests and is often abundant, three other species of oak are much less common. These are: white oak, chestnut oak, and scarlet oak. These uncommon species are currently found almost exclusively at the Mountain Street watershed. All three of these uncommon oak species have natural ranges that extend well to the south of Massachusetts and may, therefore, have an enhanced ability to cope with predicted changes in the climate.

Hickories

Three species of hickory are found in the Northampton DPW watershed forests, none of which are considered “common.” These species are: bitternut, pignut and shagbark hickory. Bitternut hickory, Shagbark hickory and Pignut hickory. Bitternut hickory has a fairly broad distribution across both watersheds, with notable concentrations in a number of locations, including parts of RWW Stands 5, 7 and 17. Shagbark hickory also occurs across both watershed forests, but is less widespread. It has notable concentrations in parts of RWW Stands 7 & 11. Pignut hickory is primarily found in the Mountain Street watershed forest, with a notable concentration in MTN Stands 1,2, 9, 12 & 13. Some of the Pignut hickory is found along Chestnut Mountain Road. All three of these hickory species have natural ranges that extend well to the south of Massachusetts and may, therefore, have an enhanced ability to cope with predicted changes in the climate.

Pitch pine

The presence of pitch pine is strongly associated with a history of fire. By the same token, pitch pine may be well adapted to future scenarios with increasing fire, should this occur. Pitch pine was found in only two locations. It occurs in a larger run mixed with white pine on Poplar Hill (RWW Stand 20) as well as in a small section of RWW Stand 2 (former Boone parcel).

Red spruce

Red spruce is generally thought of as a cold-climate species. Therefore, it was surprising to find it several locations at Ryan in the West-Whately watershed forest. The primary occurrence, which included a number of large trees as well as saplings and seedlings, was on Walnut Hill (RWW Stand 7). Much smaller occurrences were found in RWW Stands 8 & 16, and a red spruce sapling was found on Poplar Hill. The potential importance of red spruce may be counter-intuitive within a climate change scenario, but a very redeeming fact is that deer seem to avoid red spruce. It is a remote possibility, but not out of the question, that red spruce could help substitute for hemlock someday, especially in cooler riparian settings, if hemlock ultimately succumbs to introduced pests, pathogens and diseases. Unlike the hickories and uncommon oaks referenced above, red spruce is at the southern end of its range (though it can occur at high elevations further south). In that sense, it does not seem well-adapted to the prospect of a warming climate. It is too soon to know, however. Historically, red spruce tended to be very heavily cut, and may be lacking in some areas due to local extirpation. In some cases, red spruce is re-expanding its range. It is not yet out of the question that red spruce may find a continued or expanding niche in the future Northampton DPW forest, and therefore it should be treated as a valuable component of biodiversity. Deer and moose avoid feeding on red spruce.

Norway spruce

Norway spruce is a non-native spruce that is currently found only where it has been planted. This is in a number of small plantations in the vicinity of the Henhawk Trail, in RWW Stands 7 & 9. As evidenced by the large, tall trees in these plantations, Norway spruce grows well in the Northampton DPW forest. Also, Norway spruce has a tendency to seed in, though not in an aggressive, invasive manner, suggesting a possibility of Norway spruce becoming compatible part of a mix of tree species. Furthermore, deer and moose avoid feeding on Norway spruce. Finally, Norway spruce is grown successfully in areas as far south as Kentucky and the Carolinas, suggesting a possibility of thriving in

the changing climate conditions that are predicted. Thus, there is perhaps some potential to make use of Norway spruce in the future, especially if the native pines, hemlock and spruce are in decline, perhaps with an emphasis on riparian areas. One option would be to plant Norway spruce not in plantations, as has been traditionally done, but as future seed trees in areas that may lose coniferous forest cover, especially hemlock cover. This could result, long term, in natural seeding of Norway spruce into these areas.

Reduce competition around existing young trees

Additionally, one specific area that should be treated with non-extractive thinning is the deer enclosure in RWW Stand 19. In order to release the oaks established within the enclosure, several tall nearby trees should be cut. At most, 3 – 5 trees would be cut. If a very low impact method can be found to take them, such as by horse logging, or using a small winch, then this removal of the logs be an option as well.

Finally, support should be provided to the rare occurrences of well-established oak saplings in MTN ST-3. Here, the risk from a combination of grape vines, glossy buckthorn and potentially other hardwood trees. Using hand tools, these saplings can be freed from competition.

In a related sense, large grape vines also compete with established trees, including established canopy trees, and can also be cut to promote the health of canopy trees in general, and the health of uncommon trees in particular. Northampton DPW has carried out grape vine cutting in the past and can continue to do this internally, or can bring in an outside crew to do this in designated areas. Note that wild grape vines are a native, woody, flowering and fruiting plant that plays a positive role in supporting native wildlife and biodiversity. There is no intention to eliminate grapes from the Northampton DPW forest. The intention is merely to promote the health and growth of overstory trees which may be compromised by the presence of grapes, to prevent bittersweet from using grapes as climbing structures, and to limit the extent to which grapes climb on, smother and pull down young trees or even mature trees. If, in the future, non-native invasive plants such as bittersweet have been eliminated and deer populations are in a better balance with native tree seedling understories, the concern about grapes will be greatly reduced, and their role in creating open glades in the forest will be able to be better appreciated.

For each project area, the forester should designate any trees to be cut in a non-extractive thinning, and should delineate the area in which to cut grapes. Recommendations of non-extractive thinning and grape cutting are presented in the Management Practices Table.

Prioritization approaches for forest management practices

Given the reality of budget limits and the vast amount of need for management of forest conditions, there will need to be a prioritization of practices. There are numerous ways to prioritize. The simple numbering system presented below can be used to prioritize any of the practices included in this plan. Prioritization is as follows:

- 1 – Top priority: This refers to actions located within the Ryan Reservoir watershed and to other actions considered to be of particular importance in the other hydrologic watersheds.
- 2 – Second priority: This refers to actions in the West Whately and Mountain Street watersheds that are not included above.
- 3 – Third priority: This refers to actions outside the active watersheds or otherwise of low priority for other reasons.
- NA – not a priority at this time or not included in this Forest Stewardship Plan

Management Practices – Mountain Street watershed forest

Practices and prioritization by stand

Management practices are listed below in tabular form below. Refer back to the Stand Descriptions for discussion at the stand level of these practices. The Stand Descriptions do not contain a prioritization of the practices. Prioritization is addressed below in the table, based on the preceding discussion of prioritization.

Table 6.1 – Stand-Level Forest Management Practices

Stand	Invasives Treatment	Invasives Priority	Cut grapes ?	Grapes Priority	Silviculture to promote existing uncommon trees	Silviculture Priority	Special MGMT approach needed? *
1	Last chance control	2	YES	1	YES	2	
2	Maintain low level	1	NO	NA	YES	2	
3	Contain & control	1	YES	1	YES	1	
4	Last chance control	1	YES	1	NO	NA	YES
6	Contain & control	3	NO	NA	NO	NA	
7	Last chance control	2	YES	1	YES	2	
8	Mow	1	YES	1	NO	NA	
9	Contain & control	3	NO	NA	YES	1	
10	Last chance control	3	NO	NA	NO	NA	
11	Mow	1	YES	2	NO	NA	
12	Maintain low level	1	YES	1	YES	2	
13	Maintain low level	1	YES	1	YES	2	
14	Last chance control	1	YES	1	NO	NA	YES
EX 5	NA	NA	NA	NA	NO	NA	
EX WTP	NA	NA	NA	NA	NO	NA	

* See discussion below.

Special management approach situations

This category is for management practices that do not fit in squarely with normal practices to promote the health of trees or which require an extraordinary level of management.

- Make a forestwide effort to locate and control Amur cork tree (*Phellodendron amurense*) before it continues to spread. Though it is currently contained mainly in MTN Stand 4, this can change. The vast bulk of the effort will be concentrated on control of Amur cork in Stand 4, but surrounding areas should be scouted as well, with control occurring on the spot. P-1.

- Hazard trees along Haydenville Road – Review and address roadside tree hazards along Haydenville Road. This primarily true for Stand 7 but includes Stands 1 & 14 as well. Work in conjunction with the responsible highway department as needed. P-1. Note: some hazard trees may be removed in conjunction with MA DOT road work anticipated within the coming few years.

Management practices and prioritization organized by other criteria

Other management practices that are not organized at the single-stand level are listed below. A recommended priority level is listed for each practice.

- Research and develop the possibility of deer hunting off Chestnut Hill Road (*Stands 1 & 13). If this is successful, do the same for the area off Laurel Mountain Road (Stands 7, 8, 9 & 10). P-1. Note: Much of Stands 7 & 8 are within 500' of a buildings/dwelling or within 150' of the road, which would limit but not entirely preclude hunting. MA DFW posts the following prohibitions pertaining to hunting on their website:
 - Prohibited: discharge of any firearm or release of any arrow upon or across any state or hard-surfaced highway, or within 150 feet of any such highway.
 - Prohibited: possession of a loaded firearm, discharge of a firearm, or hunting on the land of another within 500 feet of any dwelling or building in use, unless permitted by the owner or occupant. [Click here for additional gun laws.](#)

Maintain property boundaries with clear marking

All external boundaries should be marked or remarked over the coming 10 years. The purpose of boundary marking is to identify the boundary on the ground so that people approaching the boundary can clearly see where it is. Boundary marking serves to help prevent unwanted uses such as timber trespass or other encroachment and thus directly supports the maintenance of water quality. Boundary marking also serves to help with orientation and navigation in the woods, both for DPW staff or contractors and for the public, and thus is a further service to the community. Most of the boundaries have been blazed and painted in the past and are in need of refreshing with new paint. Before re-applying paint, or adding or refreshing blaze-marks or posting signs, due diligence should be carried out to confirm that the location of the boundary is supported by legal documents.

Maintain necessary internal roads

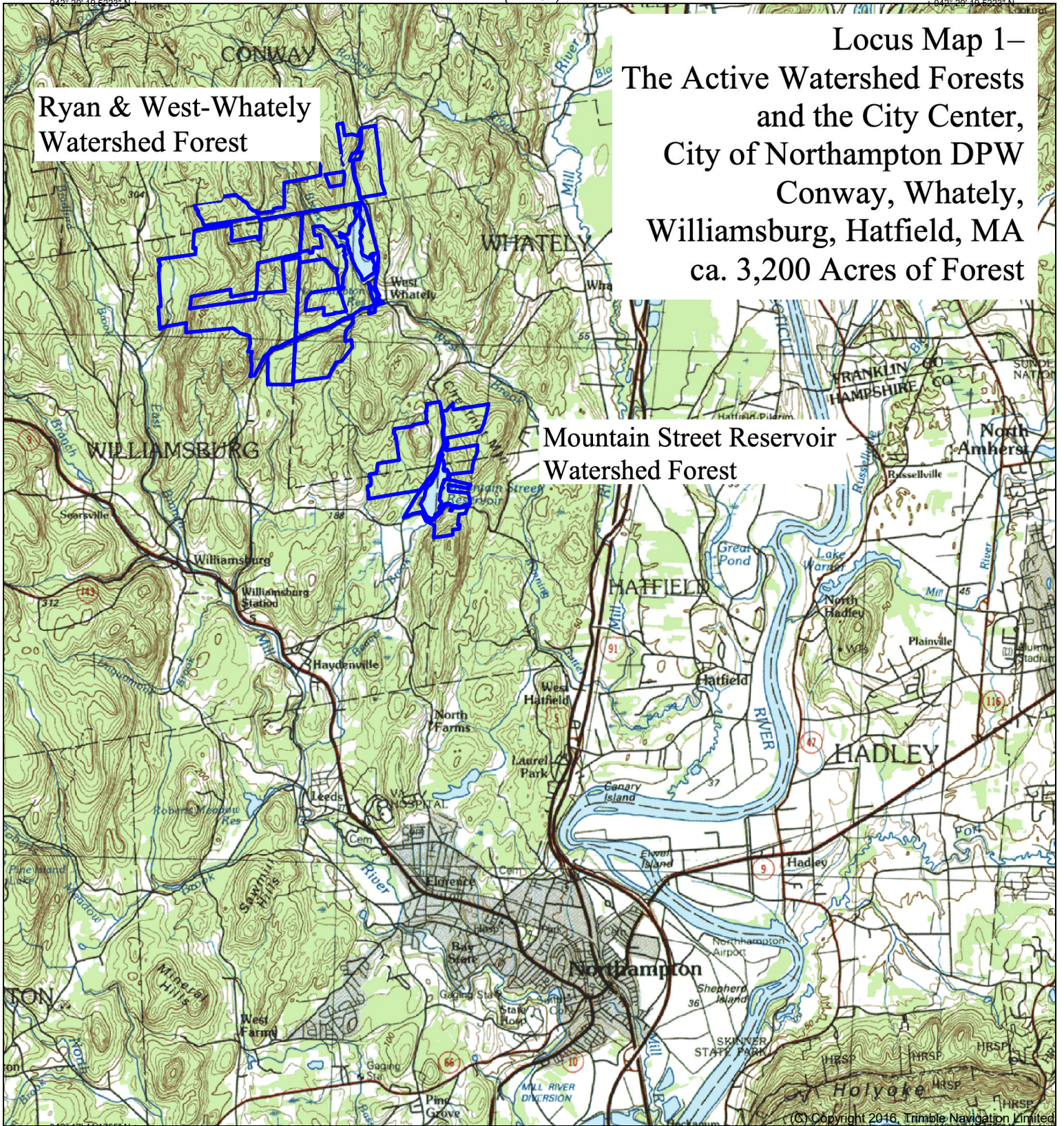
This is part of normal DPW practice and is only mentioned here to underscore its importance for water quality purposes and for purposes of accessing the forest.

Continue to monitor and study the watershed forest

Over time, as needed, continue to assess the forest to chart its development, and research aspects of the forest, such as new introduced pests, pathogens and diseases, and measures to minimize their impact on the forest.

Update Forest Stewardship Plan in 10 years

During the coming 10-year period, the forest will be monitored in a variety of ways in response to specific questions or needs for specific sites, stands or situations. But this will not be done in a forestwide, comprehensive manner. After 10 years, a comprehensive re-monitoring is recommended, similar in scope to the re-assessment carried out for this current Forest Stewardship Plan. The data gathered during the comprehensive re-monitoring should be analyzed and interpreted and presented within the framework of a Forest Stewardship Plan to cover the subsequent 10 years.



Ryan & West-Whately
 Watershed Forest

Locus Map 1—
 The Active Watershed Forests
 and the City Center,
 City of Northampton DPW
 Conway, Whately,
 Williamsburg, Hatfield, MA
 ca. 3,200 Acres of Forest

Mountain Street Reservoir
 Watershed Forest

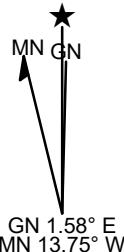
(WATERBURY)

Produced by Trimble Terrain Navigator Pro
 Topography based on USGS 1:100,000
 Maps

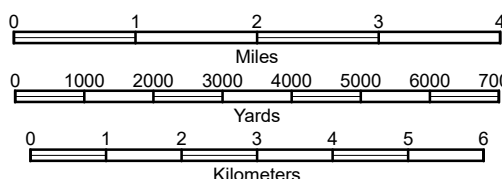
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To place on the predicted North American
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 38M E

Declination



(HARTFORD)
 SCALE 1:100000



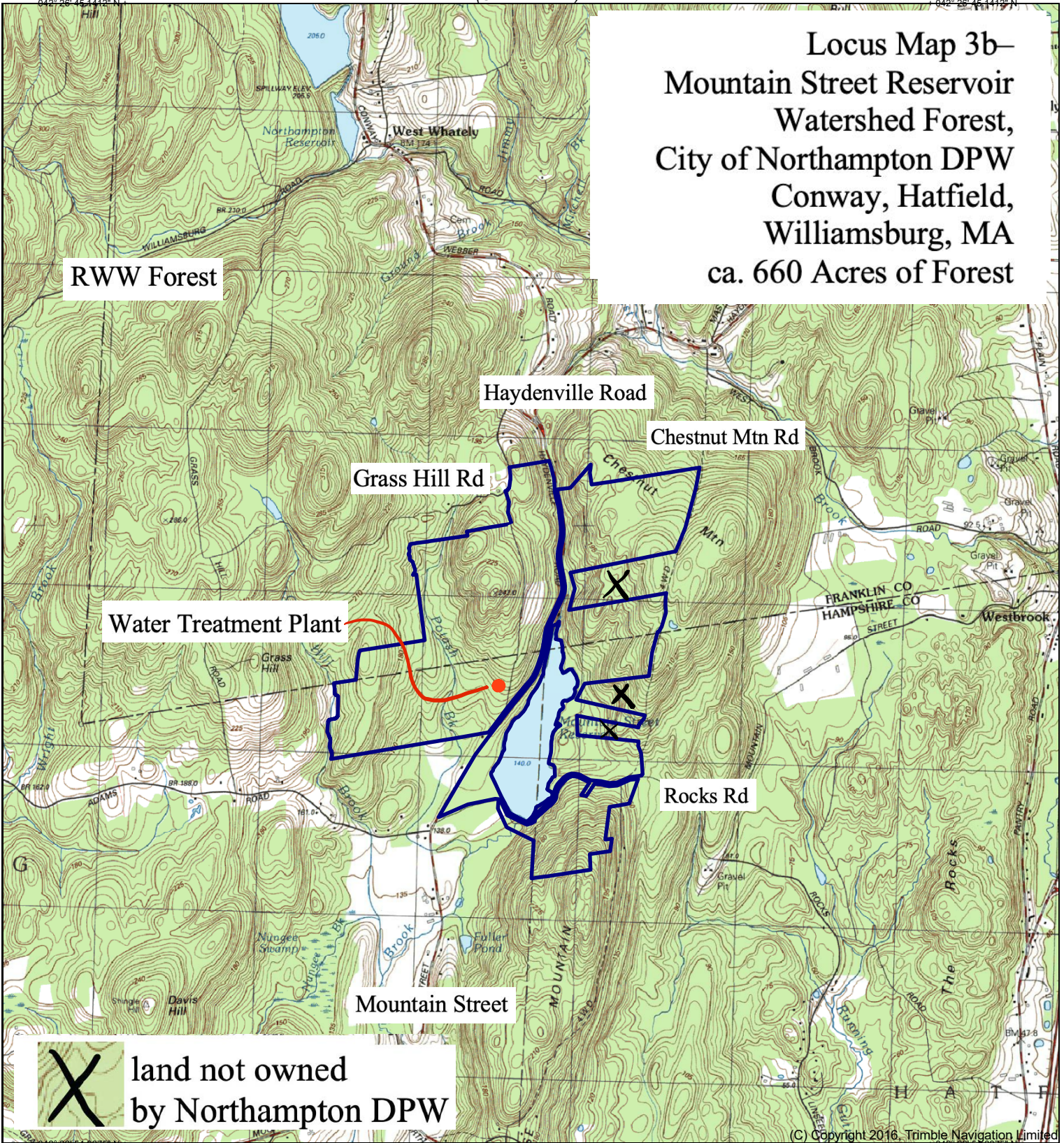
CONTOUR INTERVAL 33 FT

Map by Michael Mauri, L.F.
 20 West St. S. Dfld., MA 01373
 (413) 665-6829 based on
 parcel shapefile provided
 by Northampton DPW on 2-15-2023,
 3-2023

(GREENFIELD)

042° 26' 45.1412" N

**Locus Map 3b—
 Mountain Street Reservoir
 Watershed Forest,
 City of Northampton DPW
 Conway, Hatfield,
 Williamsburg, MA
 ca. 660 Acres of Forest**



RWW Forest

Haydenville Road

Chestnut Mtn Rd

Grass Hill Rd

Water Treatment Plant

Rocks Rd

Mountain Street

X land not owned
 by Northampton DPW

(C) Copyright 2016, Trimble Navigation Limited
 Printed: Mon Mar 20, 2023

(CHESTER)
 072° 42' 36.9105" W

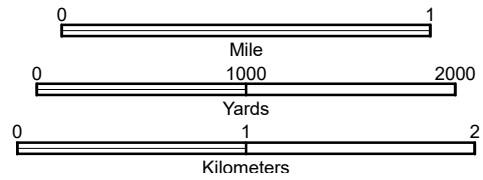
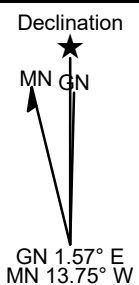
(EASTHAMPTON)
 SCALE 1:33000

072° 37' 47.4687" W
 (BELCHERTOWN)

Produced by Trimble Terrain Navigator Pro
 Topography based on USGS 1:25,000
 Maps

North American 1983 Datum (NAD83)

To place on the predicted North American
 1927 move the projection lines 10M N and
 38M E



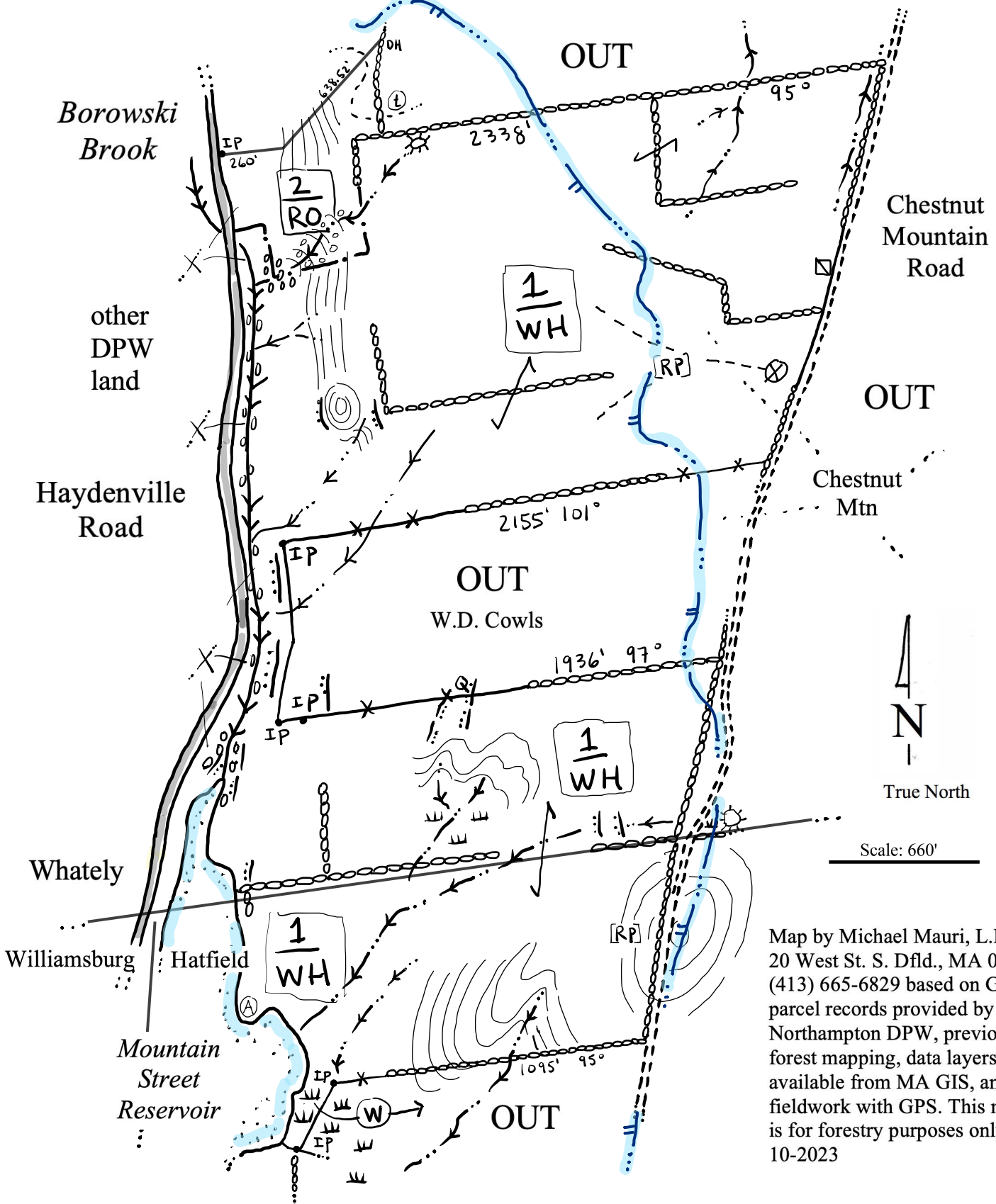
CONTOUR INTERVAL 10 FT

Map by Michael Mauri, L.F.
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 3-2023

Forest Stand and Boundary Map
 City of Northampton, DPW
 Mountain Street Reservoir
 Hatfield & Whately, MA

Chestnut Mountain
 Stand 1 — 168.8 acres
 &
Delano & Martiniano
 Stand 2 — 8.2 acres

Key
 See Master Key



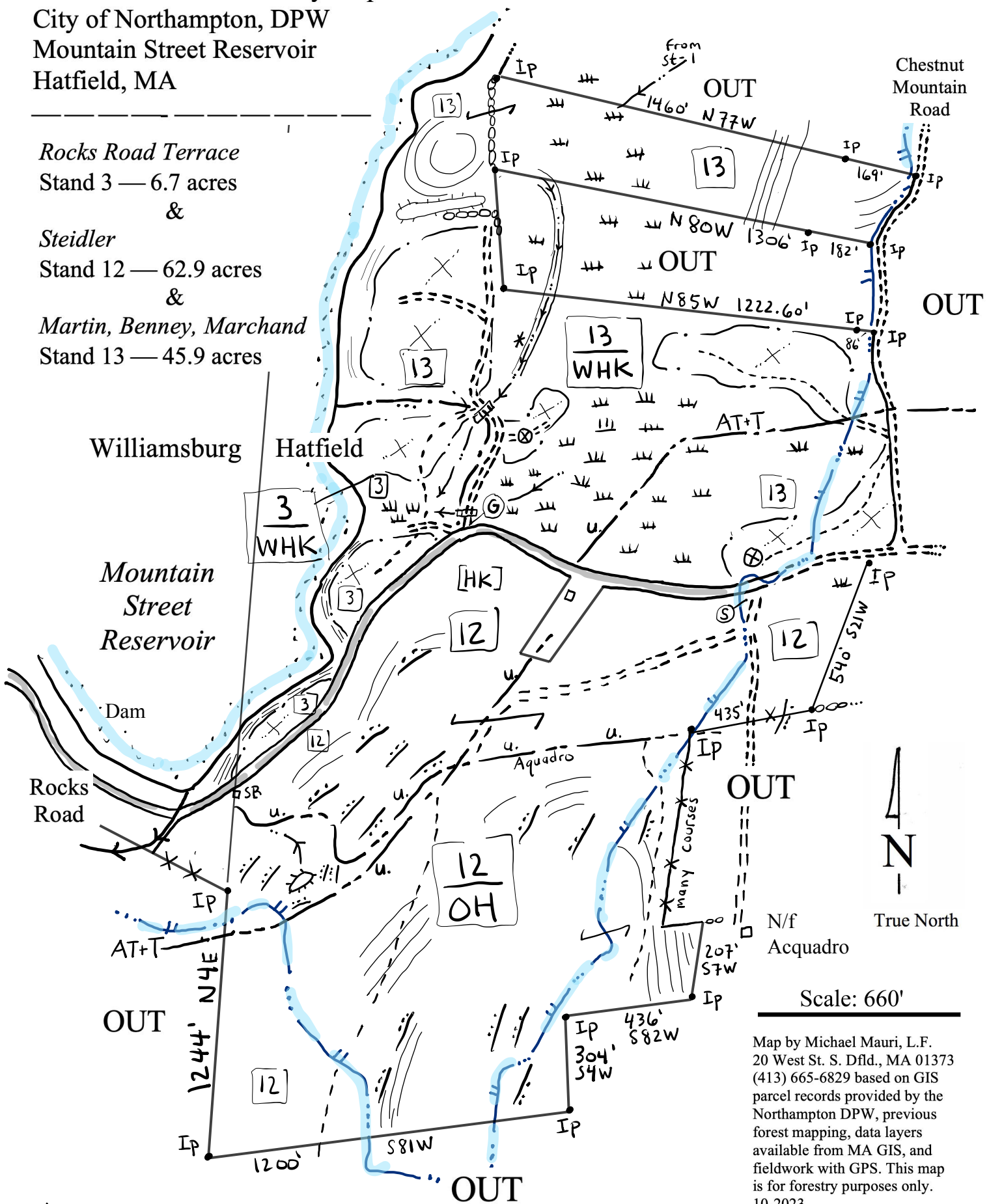
Map by Michael Mauri, L.F.
 20 West St. S. Dfld., MA 01373
 (413) 665-6829 based on GIS
 parcel records provided by the
 Northampton DPW, previous
 forest mapping, data layers
 available from MA GIS, and
 fieldwork with GPS. This map
 is for forestry purposes only.
 10-2023

Forest Stand and Boundary Map
 City of Northampton, DPW
 Mountain Street Reservoir
 Hatfield, MA

Rocks Road Terrace
 Stand 3 — 6.7 acres
 &

Steidler
 Stand 12 — 62.9 acres
 &

Martin, Benney, Marchand
 Stand 13 — 45.9 acres



Map by Michael Mauri, L.F.
 20 West St. S. Dfd., MA 01373
 (413) 665-6829 based on GIS
 parcel records provided by the
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 10-2023

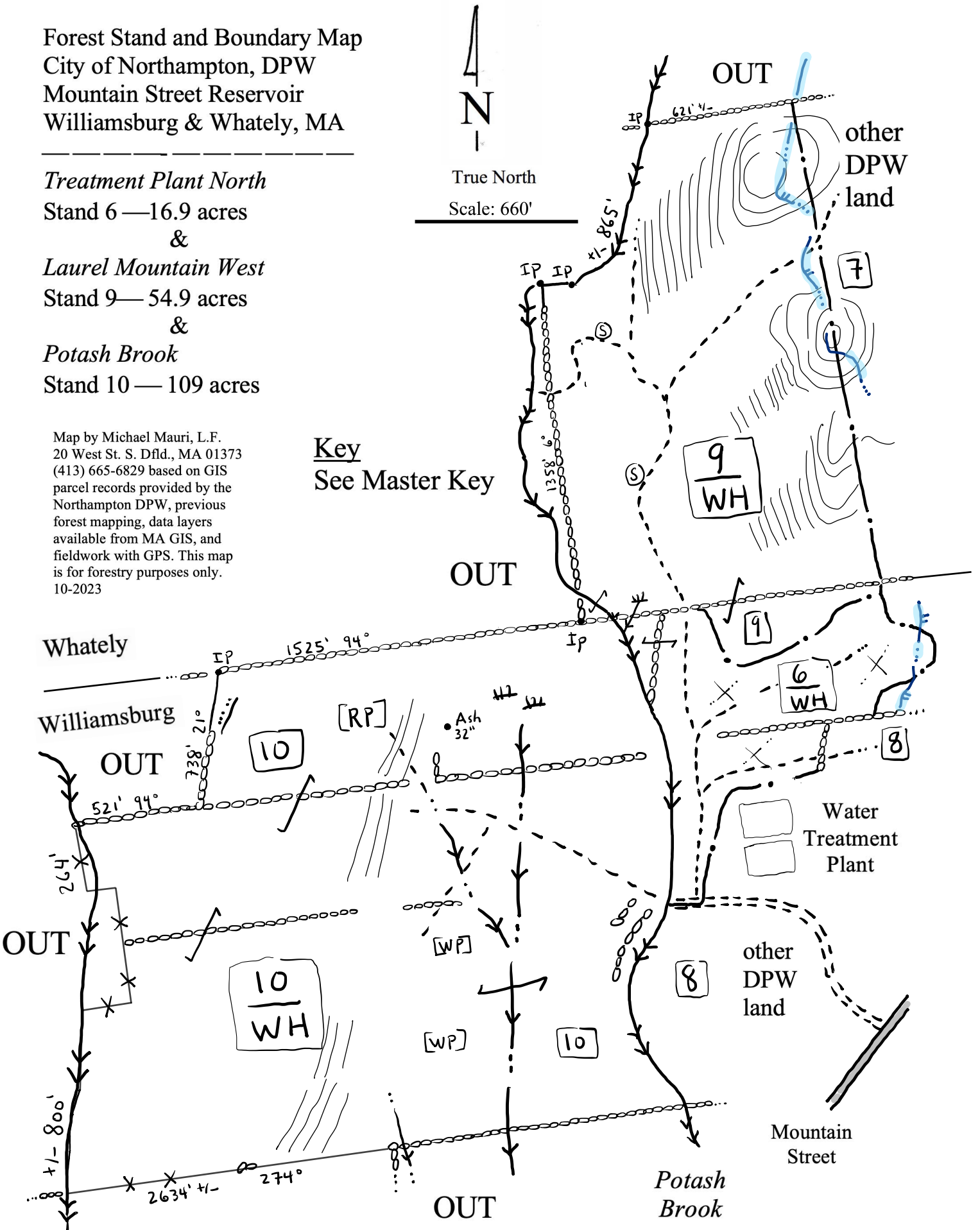
*

Forest Stand and Boundary Map
 City of Northampton, DPW
 Mountain Street Reservoir
 Williamsburg & Whately, MA

Treatment Plant North
 Stand 6 — 16.9 acres
 &
Laurel Mountain West
 Stand 9 — 54.9 acres
 &
Potash Brook
 Stand 10 — 109 acres

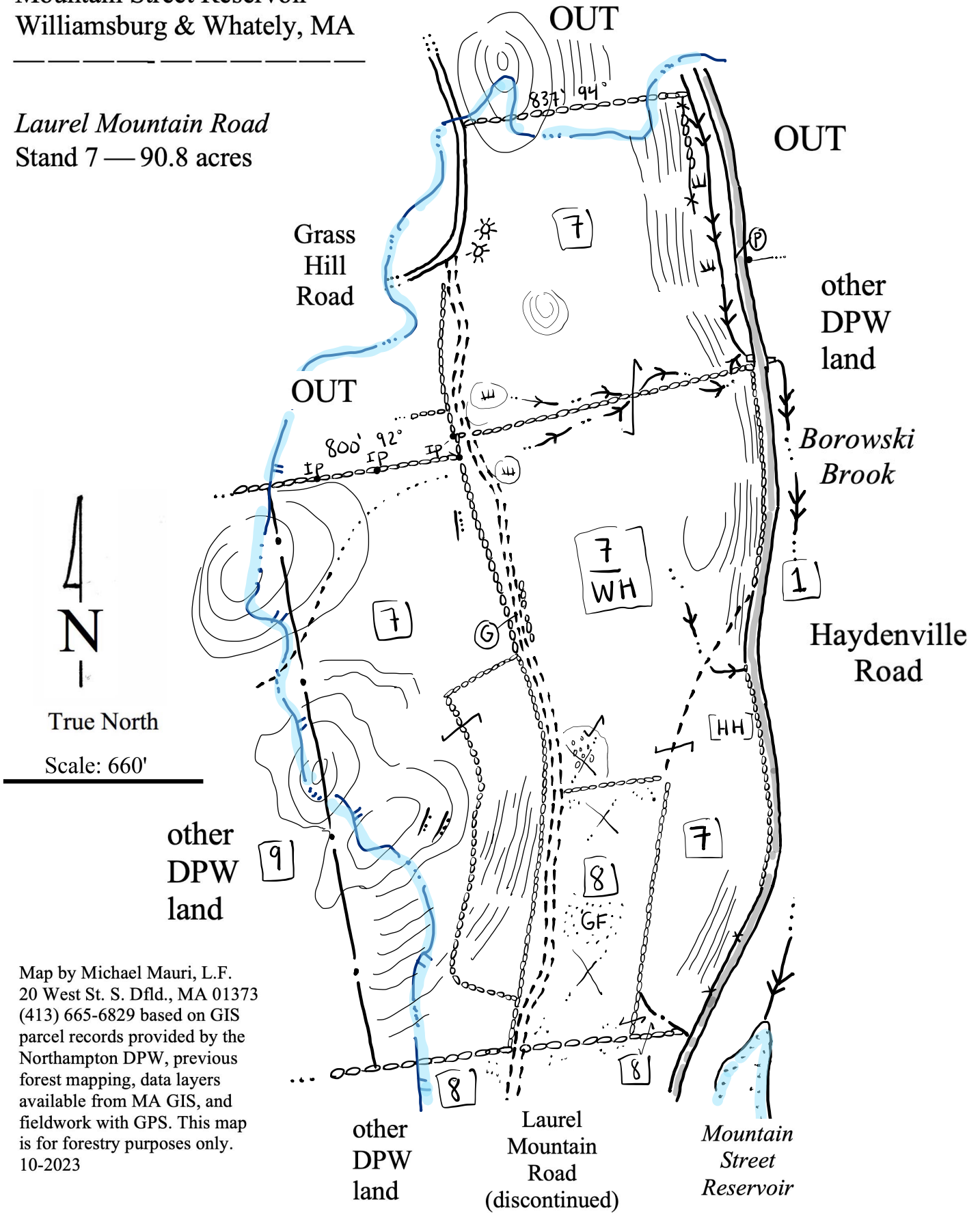
Map by Michael Mauri, L.F.
 20 West St. S. Dfld., MA 01373
 (413) 665-6829 based on GIS
 parcel records provided by the
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 fieldwork with GPS. This map
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 10-2023

Key
 See Master Key



Forest Stand and Boundary Map
 City of Northampton, DPW
 Mountain Street Reservoir
 Williamsburg & Whately, MA

Laurel Mountain Road
 Stand 7 — 90.8 acres



Map by Michael Mauri, L.F.
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 (413) 665-6829 based on GIS
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 10-2023

Forest Stand and Boundary Map
 City of Northampton, DPW
 Mountain Street Reservoir
 Williamsburg & Whately
 & Hatfield, MA

*Former Red Pine Plantations
 and Old Orchard*

Stand 8 — 54.2 acres
 &

Mountain Street Meadow

Stand 11 — 6.2 acres
 &

Mountain Street West Shore Pines

Stand 14 — 3.2 acres

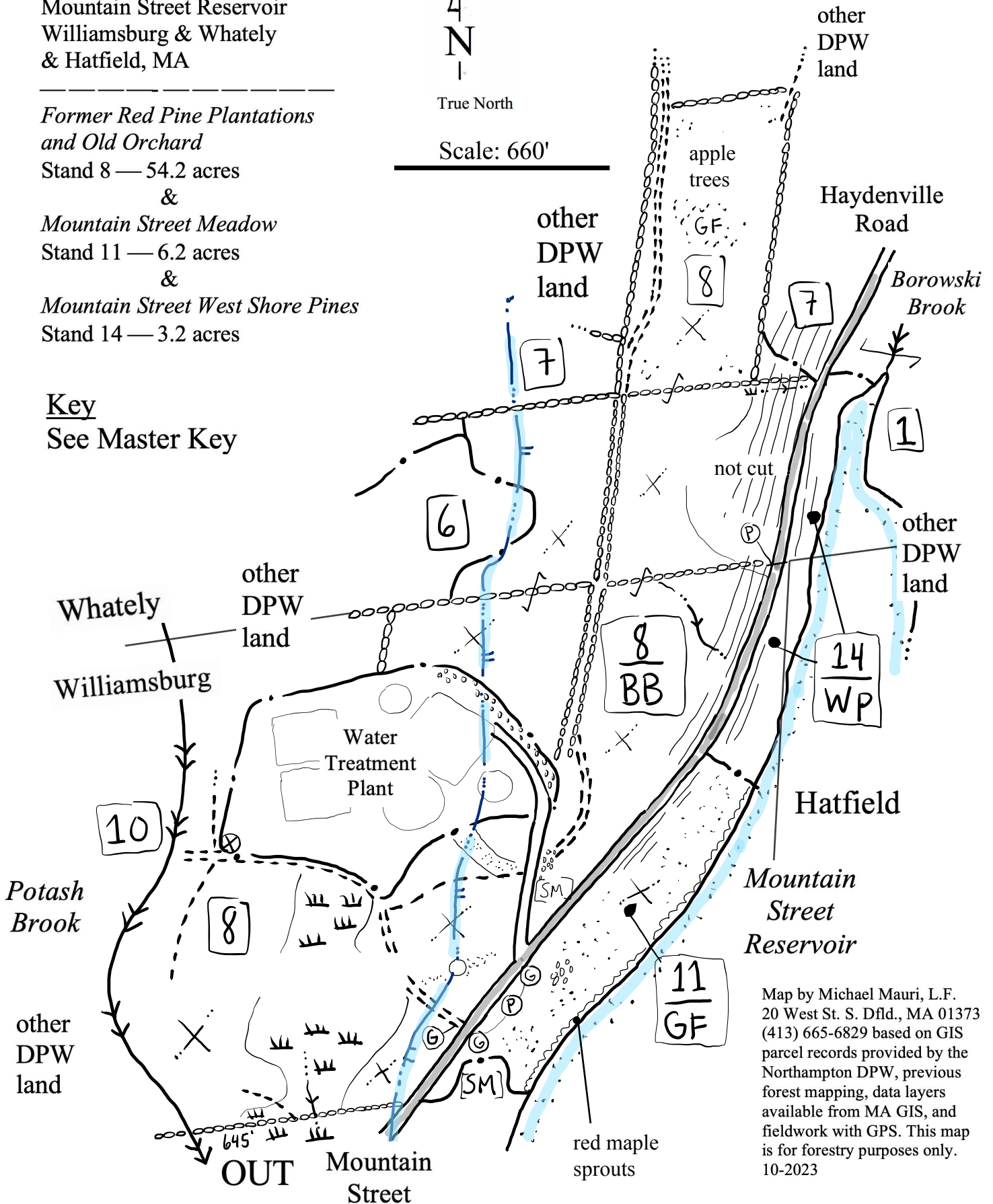
Key

See Master Key



True North

Scale: 660'



Map by Michael Mauri, L.F.
 20 West St. S. Dfld., MA 01373
 (413) 665-6829 based on GIS
 parcel records provided by the
 Northampton DPW, previous
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 available from MA GIS, and
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 is for forestry purposes only.
 10-2023

CH. 61/61A/61B Management Plan I attest that I am familiar with and will be bound by all applicable Federal, State, and Local environmental laws and /or rules and regulations of the Department of Conservation and Recreation. I further understand that in the event that I convey all or any portion of this land during the period of classification, I am under obligation to notify the grantee(s) of all obligations of this plan which become his/hers to perform and will notify the Department of Conservation and Recreation of said change of ownership.

Forest Stewardship Plan. When undertaking management activities, I pledge to abide by the management provisions of this Stewardship Management Plan during the ten year period following approval. I understand that in the event that I convey all or a portion of the land described in this plan during the period of the plan, I will notify the Department of Conservation and Recreation of this change in ownership.

Signed under the pains of perjury: Mountain Street Reservoir Watershed

Owner(s) [Signature] Date 3-22-24

Owner(s) _____ Date _____

I attest that I have prepared this plan in good faith to reflect the landowner's interest.

Plan Preparer [Signature] Date 3-21-24

I attest that the plan satisfactorily meets the requirements of CH61/61A/61B and/or the Forest Stewardship Program.

Approved, Service Forester [Signature] Date 6-18-2024

Approved, Regional Supervisor [Signature] Date 6/18/24

In the event of a change of ownership of all or part of the property, the new owner must file an amended Ch. 61/61A/61B plan within 90 days from the transfer of title to insure continuation of Ch. 61/61A/61B classification.

Amendment

Signed under the pains of perjury:

Owner(s) _____ Date _____

Plan Preparer _____ Date _____

Description of Amendment: _____

Approved, Service Forester _____ Date _____

The City of Northampton, Whately, Hatfield,
Owner(s)_ Department of Public Works (DPW) ___Town(s)___ Williamsburg