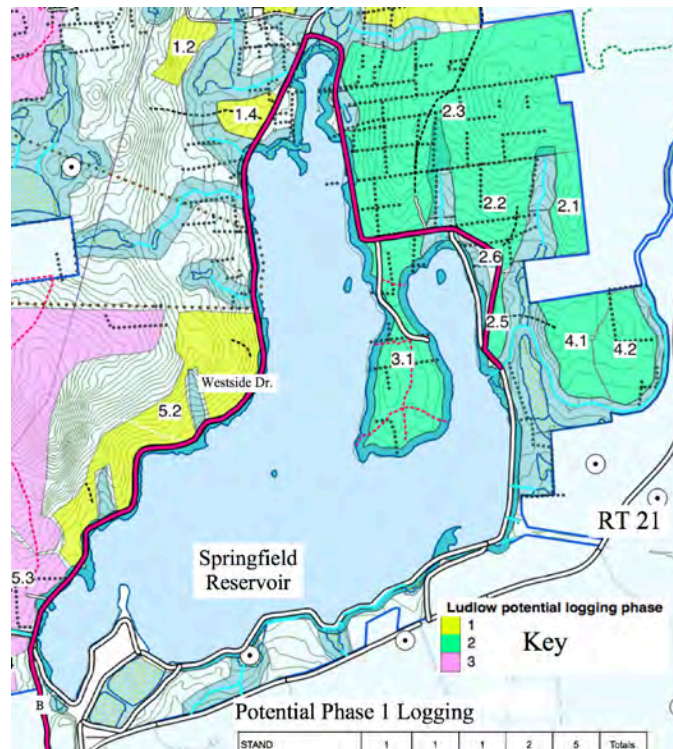


Forest Management Plan
The Ludlow Forest (Springfield Reservoir Tract),
Springfield Water & Sewer Commission,
Ludlow, MA



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Forest Management Overview: The Ludlow Forest (Springfield Reservoir Tract), Springfield Water & Sewer Commission, Ludlow, MA

Initial Considerations: Water Quality & Condition of the Watershed Protection Forest

As used in this plan, the term *Ludlow Forest* refers to that forested land surrounding the Springfield Reservoir that is owned and maintained by the Springfield Water and Sewer Commission (see the Locus Map and the map Ludlow Forest Features and Stands). Though not an active water supply, the Springfield Reservoir is actively maintained as a back up water supply. Because of the significant role that watershed forests play in protecting surface water quality, the Springfield Water and Sewer Commission has a primary interest in managing the Ludlow Forest as a watershed protection forest, i.e. maintaining the Ludlow Forest in a condition that promotes the long-term stability and quality of the water entering the reservoir. The development of this Forest Management Plan at this time is specifically prompted by the recent and ongoing outbreak of gypsy moth caterpillars, which have negatively impacted the health of all species of oak. In many respects, oaks may be considered the dominant tree in the Ludlow Forest (cf. Table 1a). With the rapid decline in the health of oaks in the Ludlow Forest, the Springfield Water and Sewer Commission is compelled to consider appropriate responses to the condition of the forest so that any negative impacts to water quality may be minimized, and any potentially beneficial aspects of this situation may be realized.

Initial Considerations: Conservation Restriction & Biodiversity

In 2002, the Springfield Water and Sewer Commission entered into a Conservation Restriction (CR) with the Commonwealth of Massachusetts, acting by and through its Department of Fisheries, Wildlife and Environmental Law Enforcement and its Division of Fisheries and Wildlife. The CR is recorded in the Hampden County Registry of Deeds at Book 12253, Page 407. Page 3 of the CR states the following purposes of the CR:

“The purposes of this Conservation Restriction are to assure that, while allowing continued use of the Premises as a Public Water Supply consisting of water withdrawal, treatment, and distribution, including construction and maintenance of necessary facilities in said water withdrawal, treatment, and distribution and permitting forestry and other permitted acts and uses described in Section III, the Premises will be subject to the prohibitions described in Section II hereof so that the Premises are retained in perpetuity predominantly in its natural, scenic, and open condition for fish and wildlife conservation, native habitat protection, hunting and fishing, management of forest resources as described herein, associated public recreation, and other conservation uses consistent with the spirit and intent of and subject to the protections of Article 97 of the Amendments to the Constitution of the Commonwealth of Massachusetts, and to prevent any use of the Premises that will significantly impair or interfere with the conservation values thereof.”

The CR anticipates the active management of the Ludlow Forest. Under the CR, the Springfield Water and Sewer Commission may manage the Ludlow Forest in a number of ways, including in the following:

- maintain, improve or relocate forest roads and related infrastructure
- cultivate and harvest forest products
- remove trees that are hazardous, diseased trees or insect-damaged trees
- control, manage or eradicate non-native invasive plants
- use herbicide as needed to accomplish objectives

The above practices are subject to criteria listed within the CR. Among these criteria are the following:

- unless otherwise authorized as provided in the CR, a forest management plan must be followed when logging occurs
- the logging must occur under an approved CH 132 Forest Cutting Plan
- the logging must follow the current MA Best Management Practices Manual (BMP Manual)
- the logging must follow the Forest Management Standards listed in Exhibit C, which is reproduced below. These standards have as their singular goal the enhancement and maintenance of native biological diversity.

EXHIBIT C

FOREST MANAGEMENT STANDARDS

GOAL: Enhance and maintain native biological diversity on managed forestlands.

OBJECTIVES:

- 1) Apply current and generally accepted scientific principles from the current Massachusetts Forestry Best Management Practices Manual (Kittredge & Parker, 1996) and subsequent versions if approved by the Commonwealth (the "Manual") to conserve soil and water quality on managed forestlands.
- 2) Apply current and generally scientific principles for native biodiversity protection as standards on managed forestlands.

STANDARDS:

- 1) Conduct all forest cutting operations under an approved Chapter 132 Forest Cutting Plan and in compliance with Chapter 131, the Wetlands Protection Act. Provide a copy of the Chapter 132 Forest Cutting Plan to the Commonwealth at least 20 days prior to the start of cutting for review of potential impacts on state-listed species and priority natural communities. Implement appropriate mitigation measures provided by the Commonwealth to limit impacts on state-listed species and priority natural communities.
- 2) Establish and maintain access roads, skid trails, and landing areas according to both required best management practices and recommended guidelines in the Manual.
- 3) Retain buffer strips along roads and filter strips along riparian areas according to both required best management practices and recommended guidelines in the Manual.
- 4) Avoid wetland resource area crossings during forest cutting operations if possible, establish and maintain stream crossings for logging machinery, and operate machinery within wetlands only when necessary and in strict compliance with both required best management practices and recommended guidelines in the Manual.
- 5) Locate and map all vernal pools within a proposed harvest area and plan harvest in strict compliance with both required best management practices and recommended guidelines in the Manual for certified vernal pools. Upon the request of the owner, the Commonwealth will assist Owner, at Commonwealth's expense, to locate, map and certify all vernal pools within a proposed harvest area.
- 6) Retain a portion of overstory trees on managed forestlands at all times. Vary amount of retention depending on slope. Minimum retention on all slopes shall consist of an average basal area of ≥ 10 square feet per acre in live trees $\geq 14''$ Dbh. Retain live trees in 2 groups per acre when possible, consisting of sound, relatively wind-firm trees, and existing den trees and/or snag trees when possible. Retain a mix of live [mature] mast-producing hardwoods, including oak and black cherry, and cover-producing softwoods including hemlock and white pine, where possible. On slopes $< 30\%$, the minimum retention shall apply. On slopes of 30% - 60% , retain $\geq 30\%$ of the overstory canopy during any forest cutting operation, including ≥ 10 square feet per acre in live trees $\geq 14''$ Dbh, and a waiting period of ≥ 5 years must elapse before another cut is made. On slopes $\geq 60\%$, retain $\geq 60\%$ of the overstory canopy well distributed over the area during any forest cutting operation, including ≥ 10 square feet per acre in live trees $\geq 14''$ Dbh, and a waiting period of ≥ 5 years must elapse before another cut is made, except as required for protection of the Public Water supply and/or forest health, and approved by the Department of Environmental Management Forester.

DEFINITIONS:

— Biological Diversity (Biodiversity) - The entire assemblage of native flora and fauna and their supporting habitats and natural communities.

— Dbh - Diameter at breast height (4.5' above the ground).

— Habitat - The biological and physical conditions necessary for the sustained occurrence of a given plant or animal species.

— Native - A species which occurs or has occurred within the Commonwealth which has not been deliberately or accidentally introduced by humans into the state nor introduced elsewhere and spread from that introduction into the state.

— Natural Community - A recurrent assemblage of plants and animals found in particular and relatively predictable associations with the physical environments.

— Manual - The most recent edition of "Massachusetts Forestry Best Management Practices Manual" (Kittredge & Parker, 1996), and subsequent versions if approved by the Commonwealth.

Combining Water Quality & Biodiversity Considerations

The twin objectives of promoting both water quality and biodiversity, i.e. the goal of maintaining the Ludlow Forest in a condition that promotes the long-term stability and quality of the water entering the reservoir, and the goal of enhancing and maintaining the native biological diversity, are to a large extent complementary and mutually compatible. Both objectives are best served by a forest that contains a variety of structural configurations (arrangements and groupings of trees occurring on a spectrum of disturbance ranging from minimal/gap-phase/closed-canopy to intermediate to severe/stand-initiating) and age class ranging from very young to very old. Both objectives are best served when the full array of site-adapted native vegetation is present and thriving. A diverse forest in terms of structure and native species is the desired condition, and is the **desired future condition** of any management approach or specific management action proposed in this plan for the Ludlow Forest.

Neither objective is served when non-native invasive plants overwhelm or replace native vegetation, when non-native insects or diseases of trees cause poor health or mortality on a large scale, when native herbivore populations are maintained at high levels such that native trees and shrubs are greatly compromised, or when native plants avoided by herbivores (e.g. hayscented fern) overrun large areas and create low-diversity monocultures. These are considered undesirable conditions and can be thought of as interfering factors.

The desired future conditions that sustain both water quality and biodiversity can be created and maintained through a forest management approach based on a thoughtful combination of passive management and active or direct management. Passive forest management often takes the form of avoidance or delay of disturbance, or of welcoming or at least tolerating conditions and processes as they are. Active or direct forest management often takes the form of silviculturally-based logging, but also includes efforts to curtail non-native invasive plants or reduce herbivore pressure on desired vegetation. In developing an appropriate forest management approach, the various pros and cons of passive and active approaches are evaluated on an area by area basis. In many cases there are merits to both active and passive approaches and it is important to try to identify which approach would have the greatest net benefit both in a particular location but also within the larger framework of the entire property.

This forest management plan assesses the condition of the Ludlow Forest as it currently stands (October, 2018), and makes recommendations that are intended to promote the twin objectives water quality and biodiversity. The recommendations are presented from both a water quality and biodiversity perspective (see Management Recommendations 2018-2028).

Background: the Immediate Concern at Hand

At this time, the Ludlow Forest is in the midst of an ongoing defoliation of trees (mostly oaks) and (less so) witch hazel, a shrub. This current phase of gypsy moth defoliation began as early as 2016. Defoliation was heavy in 2017 and again in 2018. It was thought that the population had crashed after 2017, but it did not.

The current gypsy moth outbreak is not limited to the Ludlow Forest, but is occurring in other parts of Massachusetts as well (see the red areas on the map 2018 Forest Health Survey provided by DCR). Statewide, gypsy moth damage was visible on about 292,000 acres. The Ludlow Forest happens to be located within what is probably the largest contiguous area of infestation. Further, almost 43,000 acres of oak mortality were observed (see purple areas on the above-referenced map), including some areas to the north, a figure that may increase in the near future.

Currently, there are gypsy moth eggs cases on trees at the Ludlow site suggesting that the infestation is set to continue into 2019. This situation was described to SWSC in a detailed letter provided in late September, 2018.

Gypsy moths have been a problem in Massachusetts since the 19th century. Over the decades, infrequent, irregular outbreaks of gypsy moth caterpillars in the spring and early summer have caused significant defoliation, especially of oaks. The last major outbreak in the Ludlow area was around 1980. Outbreaks “crash” when fungal and viral pathogens of the caterpillars reach critical levels. It is surprising that this has not happened yet.

When trees are defoliated they cannot photosynthesize and thus they do not produce energy for their own maintenance and growth. As an immediate response to severe defoliation, oaks put out a new set of leaves, drawing on stored resources from their root systems. With successive defoliations, the stored resources can be exhausted, and the tree may not be able to put out or maintain a good set of leaves. This is very evident at this time in Ludlow. Impacts of successive defoliation include outright mortality of individual trees or subsequent decline and mortality caused by secondary pathogens in years to come (see Major Findings section for a discussion of these).

Oaks are ubiquitous and abundant at the Ludlow site, playing a significant role within the forest mix (See Table 1a and the map Ludlow Forest - Forest Types at Sample Points). Oaks present at Ludlow are mainly red oak and scarlet oak, with less white oak and black oak, and a minor amount of chestnut oak. Oaks typically occur as large, old trees at the Ludlow site and are a significant component of the timber volume and value (See Table 1b), as well as of the visual effect of the forest. Most importantly, the oaks at the Ludlow site are a significant part of the forest cover that provides functions of water quality protection for the Springfield Reservoir resource.

So far in the current infestation, oaks have been the most severely impacted. Aspen (bigtooth poplar) may have been affected as well, but this is a minor component. Other species such as white pine, hemlock, maples, birches and hickories do not appear to have been affected by gypsy moths so far. Witch hazel, a shrub, seems to have been heavily impacted. In the future, if oaks become in short supply, gypsy moths have the potential to defoliate other species.

A significant percentage of the oaks are currently dead or in very poor or poor health (See Tables 2a-c). The health of oaks is discussed further in the Major Findings section. There is no action SWSC can take to reverse the negative health impacts to individual trees caused by defoliations that have occurred so far. A key action SWSC can take is to preserve, at least for now, those overstory oaks that are in better health, though ultimately they may not remain healthy. Perhaps more importantly, oak is also present as young trees in the understory and there are actions SWSC can take to try to cultivate these young trees so that oak can continue to play its important role in the future Ludlow Forest. This also applies to hickories, other young trees, and native shrubs.

The mechanism by which these young trees and native shrubs would be released would be through silviculturally-based logging. The logging would remove competing vegetation so that the young trees and native shrubs would be free to grow. This is discussed in the Major Findings section. The ability to carry out this logging depends largely on the positive net value that the oak timber has at this time. However, the timber value of the oak is at the beginning of an anticipated fast-paced decline as the trees die and begin to decay. Key stages as the condition of the timber deteriorates and the value progressively drops are: (1) the tree is still alive, but barely so, (2) the tree dies (i.e. has no

more live foliage), (3) the tree is dead but the bark is still tight, (4) the bark is loose or off but the wood is still sound, (5) the wood begins to decay or is impacted by insects and/or fungi. The quality of the dead oak will quickly deteriorate in hotter weather during a given growing season and with each additional growing season. A wild-card in the sequence of deterioration is when it is perceived, by buyers of oak timber or logs, that stain and discoloration have begun to negatively impact the wood, which may happen even before the bark begins to become loose. One major regional sawmill has announced that they will only accept logs from live trees (“All logs should be fresh cut from living trees” – Hull Forest Products price sheet, 9/12/2018).

Other factors impacting the value of the oak are logger availability and sawmill and foreign market capacity. All of these factors are beyond the control of SWSC. The only aspect of oak condition partially under the control of SWSC is the speed by which the logging process occurs. A full effort is being made by SWSC to expedite this process.

If favorable factors fall into place (e.g. timing, markets, weather conditions, etc.), there is potential for significant timber revenue. Timber revenue will be helpful in offsetting some of the costs associated with overall management of the Ludlow Forest, including road maintenance and improvements, invasive species control, boundary marking, outreach, permitting and timber harvest administration. Further, timber revenue can offset the cost of tree-service work that may be needed to remove those hazard trees near the path which cannot be accessed by logging. To the extent potential hazard trees can be removed by logging, there would be significant cost-saving through avoidance of tree service work.

At the same time as oak is deteriorating, white pine is also suffering from a number of fungal pathogens. Though not in as poor a condition as the oaks, the health of the pine is also worrisome (see Table 1d). Spring 2019 may see a further downturn. There is no remedy to this situation at this time other than the general practice of improving spacing around individual trees (i.e. thinning). Larger trees with larger crowns seem to be healthier than smaller-diameter trees that have been crowded (see Table 1d).

Special considerations at the Ludlow Forest include the CR held by MA DFW (discussed above) and the 3.2-mile-long, 10'-wide, asphalt-paved magnificent and unique public path that wraps around roughly $\frac{3}{4}$ of the perimeter of Springfield Reservoir. This is a popular walking trail. Suitable arrangements will need to be made to ensure that necessary operations in the management of the forest are compatible with permitted public uses, including the use of the path.

Response: Use Active Forest Management Where Appropriate to Release Regeneration (by Salvage-Harvesting of Oaks) and Improve the Vigor of Pines (by Thinning). Provide Necessary Support to these Operations.

See Management Recommendations 2018-2028.

Major Findings: Ludlow Forest (Springfield Reservoir Tract) Springfield Water & Sewer Commission, Ludlow, MA

The Ludlow Forest consists of a number of parcels and covers approximately 1,797 acres overall (excluding external canals), with about 1,366 acres of this occurring as forested upland and wetland (see Tables 4a & 4b and the map the map Ludlow Forest Features and Stands). The exact acreage cannot be known without a complete survey. The results presented below are based on a 65-point forest inventory conducted in October, 2018 (see the map Ludlow Forest 65-Point Sample Map) which was preceded by feature mapping (stone walls, cellar holes, roads) (see the map Ludlow Forest Features and Stands).

I. Overall Forest Composition and Structure

II. Forest Canopy Composition and Structure

III. Overstory Health and Vigor: Threats to Current Forest Composition and Structure

IV. Regenerative Capacity and Response to Future Disturbances: Long-Range Threats to Future Forest Composition and Structure

V. Opportunities for Management: a Range of Options to Influence Forest Conditions

I. Overall Forest Composition and Structure

The Ludlow Forest is covered by a closed-canopy, tall forest featuring an abundant understory in many areas. The leaf litter layer is somewhat deteriorated: With the exception of a large shrub swamp and other, smaller swamps or vernal pools, the forest has a tight upper canopy with occasional single-tree gaps due to mortality. These gaps are increasing rapidly as oaks decline and succumb to gypsy moth defoliation and its side effects. Hemlock is nearly absent as a midstory tree and no beech was observed. The 2011 ice/snow storm has left its mark on some trees – ripping off large branches – but did not seem to create appreciable gaps in the canopy. There was evidence of gypsy moth mortality dating back to the last major infestation around 1980. Some trees exhibit sweep attributable to the 1938 hurricane. The last round of logging seems to have occurred in the 1980s.

The forest canopy typically was at least 80' tall, though some of the forest atop High Hill (see Locus Map) is somewhat dwarfed. In most areas that were logged in recent decades, the canopy has closed back up and there is no regeneration free to grow. In some areas, most of the white pine seedlings established after the last round of logging

are dead, having succumbed to a combination of crowding, overtopping shade, drought and recent diseases of white pine.

Ground cover (herbaceous vegetation, ferns, seedlings, mosses) other than interfering vegetation (e.g. hayscented fern) was nearly ubiquitous and sometimes abundant. Especially common or abundant were wintergreen, partridgeberry, clubmoss, and evergreen woodfern. In wetter areas there was goldthread, sphagnum moss, poison ivy and cinnamon fern.

Throughout the Ludlow Forest the leaf litter was less thick than expected in an oak-dominated forest. As expected, the leaf litter consisted mainly of maple leaves and pine needles in wetter areas, or sometimes of nearly bare soil in wetter areas, but, in areas dominated by oaks, the leaf litter had a decidedly “chewed-down” appearance. In these areas, the top layer of oak leaves looked like the older layer that normally can be found decomposing below the surface. This is apparently the result of few oak leaves having been shed last year. There will be very few leaves to be shed this year. A thin leaf litter layer is less than ideal in a watershed forest situation because it is less resistant to the spread, by seed, of invasive plants. A thick leaf layer is able to buffer the impact of raindrops and slow the drying process between rain fall. A thin leaf litter layer is less able to provide these protections for the soil.

Native shrubs are an important part of the Ludlow Forest: Native shrubs were generally present and sometimes abundant. Altogether, shrubs were present at about 96% of plots. At about 15% of plots, typically wetter areas, shrubs were considered abundant (major). About 81.5% of plots had shrubs at a minor level, with the potential to increase.

Common shrubs were maple-leaved viburnum, beaked hazel, huckleberry and a tall lowbush blueberry, with highbush blueberry, shadbush, and hawthorn. Chestnut (sprouts) were common. In wetter areas there is spicebush, winterberry, and maleberry. Striped maple and mountain laurel were effectively absent.

Maple-leaved viburnum was one of the most ubiquitous shrubs. Almost every single individual of maple-leaved viburnum had been browsed by deer to a height of about 2’-3’, and very few had produced fruit (probably due to a combination of browsing and shade). Wild raisin was rarely taller than 2’. This suggests that deer are widespread enough to keep these shrubs in check but are not at a level that is eliminating these shrubs. Moose are present as well, though do not seem abundant at this time. The wide diversity of shrubs suggests the *potential* for a broad diversity of shrubs to be thriving and producing fruit at the Ludlow Forest under the right conditions.

Native woody shrubs can be long-lived and, with their ability to rapidly take up new growing space in the event of a major disturbance to the canopy, and with their woody root systems and, in some cases, with ability to expand in a creeping manner (e.g. beaked hazel, huckleberry, lowbush blueberry) can play an important fail-safe role as part of a watershed forest. Furthermore, native shrubs, with their flowers, fruits, insect-supporting foliage, and thick stem density, play an important part sustaining insect and bird communities and are an important part of the diversity that is linked with the long-term sustainability of a watershed forest. A thick native shrub layer is, further, a deterrent to seeding in by non-native invasive plants. Though not as striking as the tall, large trees, shrubs are an important feature of watershed-protection forest.

Desirable regeneration is present in the Ludlow Forest: Desirable regeneration (species includes oaks, maples, birches, hickories, white pine, ash and hemlock) were present at almost 90% of plots. One or more species of oak was present at almost 90% of plots. Red maple was also nearly ubiquitous. Regeneration, including oaks, was present in a range of sizes (cf. Table 1d). These size classes represent a rough progression of viability, which increases with size (cf. Table 1d). Seedlings <6’ would be the first to be drowned out by hayscented fern, browsed back by deer (as they poke upwards) or succumb to drought, and thus have the lowest probability of surviving. From an overall viability perspective, it would be nice to have a greater amount of larger regeneration than is currently present (for oaks and hickories, the pencil-cigar thickness or greater is the desired size for release). But this is what we have, and it does seem to present a viable opportunity for release.

As oaks in the overstory have declined, the regeneration has gotten a boost of increased sunlight but, as discussed below (see interfering vegetation below), so has competing vegetation. It seems that this may be a juncture at which the existing regeneration can be released before interfering factors render it less viable.

II. Forest Canopy Composition and Structure

The forest at the Ludlow Forest has a species-diverse, mixed hardwood and softwood

canopy: Red oak, scarlet oak, white oak and black oak, along with red maple, are the dominant hardwoods generally, though there are concentrations of sugar maple. White pine is the primary softwood; there is very little hemlock. Other hardwood species include yellow, paper and black birch, shagbark, pignut and bitternut hickory, and white ash, with very minor amounts of American elm, red pine and chestnut oak (cf. Table 1a).

The Ludlow Forest can be thought of as containing five forest types (cf. Table 4c and the map Ludlow Forest- Forest Types at Sample Points). The oak-hardwood type (Red oak, other oaks, red maple, other hardwoods, and sometimes white pine) is the primary type, occupying just over 50% of the acreage, or over 700 acres. This type occurs on drier soils. White pine can co-occur as scattered inclusions. Larger inclusions of white pine are lumped into the white pine – hardwoods type, which, along with the red maple type, each occupy about 18% of the forest area, or about 250 acres each (see “White pine areas” the map Ludlow Forest- Forest Types at Sample Points). The white pine type includes an appreciable amount of oak. The sugar maple type occupies about 8% of the forest area, or just over 100 acres, and is concentrated in the northern part of the forest, in close proximity to Westside Drive and its old cellar holes. Hemlock occurs as a type on only 2% of the forest area, mainly in small areas on the eastern-most and southwesterly portion of the Ludlow Forest.

The Ludlow Forest tree-canopy is crowded: With a basal area of 140 (square-feet per acre) and about 227 trees per acre (See Table 1a), the Ludlow Forest is full of trees and somewhat crowded. Only 3% of overstory trees in the Ludlow Forest are dominant (free to grow on at least two sides), whereas 33% are crowded (co-dominant) and 55% are suppressed (overtopped). Crowding reduces individual-tree photosynthesis, causing slower growth and lower resistance and resilience in the face of stress.

The forest at the Ludlow Forest contain a significant volume of live woody material: With over 300,000 live trees (See Table 1a), 17 million board feet of timber and over 12,500 cords of firewood, pulpwood, live cavity trees, and other types of live non-timber roundwood (not including topwood) (See Table 1b), there is a significant amount of woody material in the Ludlow Forest. Altogether, when timber is converted to cords and lumped with all of the products measured in cords, there are more than 46,000 cords of woody material, or about 34 cords per acre (not including topwood).

The Ludlow Forest is a significant timber and forest products resource that can be used to help drive forest management for water quality and biodiversity objectives: Averaging over 12,000 board feet of timber and 9 cords to the acre, there are about 6,000 tri-axle truckloads of timber and cord products (not including topwood). This is a significant concentration. About 35% of the timber is red oak; together with scarlet, white and black oak, oaks make up about 50% of the total timber. White pine makes up another 35% of the total timber. Together, oak and pine, which are valuable timber species, make up 87% of the timber (See Table 1c).

Timber data was generated using a 65-point non-biased sampling grid. Each point was intended to represent 20 acres, though after removing points that fell outside the intended sample area, the sampling intensity was approximately one plot per 21 acres. The reliability of the overall estimate of timber volume is as follows: one can be 90% certain that the average timber volume per acre determined by the inventory process used here lies within 12.5% of the true mean for the Ludlow Forest as a whole (see Forest Inventory Data Reliability: the Ludlow Forest).

There is significant value in the timber at the Ludlow Forest: There is a significant amount of merchantable and valuable timber in the Ludlow Forest (See Tables 1b & 1c). In a watershed forest context, the best use of the timber is as living, growing trees in the forest protecting water quality or as coarse woody dead structure. If timber value is recovered from a sale of timber, it is done so incidentally in the course of managing the forest for desired future conditions. A watershed protection forest is different from a timber production forest in that it will tend to carry trees that have exceeded their economic maturity. Furthermore, in a watershed protection, greater

mortality can be tolerated. The timber in this forested watershed, both as it exists as real trees on the ground and as abstractions in spreadsheets and on paper, cannot be thought of separately from the watershed forest *resource*, linking, as it inextricably does, the soil and climate through its function as a gathering and moderating pathway for the precipitation inputs falling on the land to the enter water supply. This essential link between climate and soil provides the necessary water quality functions we rely on forests for in general, and on this forest in particular, to provide. Recommendations in this plan to cut timber are made in light of these considerations. Any decision to cut timber involves trade offs. Reasons to *not* cut trees will generally prevail unless there is a compelling reason to do so. Because of unfavorable trade offs, there is no thought of cutting timber in general, over a broad acreage, as a general way of stimulating the forest or of capturing revenue. Instead, recommendations of cutting in this plan are made in specific response to perceived needs to respond to the current health of major species in the forest and promote biodiversity going forward. All management recommendations are made in that spirit.

Softwood plantations are a minimal or barely evident at the Ludlow Forest: There is a small plantation of red pine on the eastern shoreline. Several Norway spruce and Scots pine were observed. No special management is needed. Any management of these planted softwoods can be incidental to other, nearby management.

III. Overstory Health and Vigor: Threats to Current Forest Composition and Structure

Within the overall forest canopy a number of species are suffering declines in current health and have elevated future risk: Hemlock and white ash are at risk of pest-driven decline caused by introduced insects (hemlock woolly adelgid and elongate hemlock scale in hemlock, and emerald ash borer – not yet detected – in white ash). Hemlock and white ash comprise only a small portion of the total forest and do not require special management at this time. On the other hand, oaks (all species), which are suffering from ongoing gypsy moth defoliation, and white pine (which is suffering from needle disease syndrome and also caliciopsis canker in the stem) are currently in a state of compromised health. The decline is most obvious in the oaks, with mortality already occurring. Almost 2/3 of oaks are in a state of mortality or imminent death, and only 5% of oaks look relatively healthy (cf. Table 2a-2c). Though not as severe, white pines are in an alarming state as well, with 20% of dominant and co-dominant pines having less than 25% of a full crown of needles (this statistic applies to pine in white pine-dominated areas shown on the map Ludlow Forest- Forest Types at Sample Points).

Oak decline, mortality and secondary pests and pathogens of oaks: As mentioned previously, with successive defoliations, the stored resources of a tree can become exhausted, and the tree may not be able to put out or maintain a good set of leaves, resulting in mortality as a direct cause of defoliation. Alternatively, trees may put out new leaves and persist at first in a weakened state only to be subsequently overwhelmed by one or more secondary pests and pathogens. Though usually not harmful to healthy trees, secondary pests and pathogens are attracted to distressed trees, in some cases further weakening them to the point of death and/or diminishing their economic value. Going forward, one or more of the following secondary pests or pathogens may be active on any given oak tree at the Ludlow Forest:

Twolined chestnut borer, *Agrilus bilineatus* (Weber): this beetle attacks and kills stressed oaks by feeding on the phloem (inner bark), interrupting the transportation of sap from the crown to the roots. The twolined chestnut borer also feeds in the cambium (the growing layer of new wood). One indication of a twolined chestnut borer attack is the sudden browning of foliage in late summer. The foliage tends to remain on the tree rather than fall right off. Approximately 6% of oaks at the Ludlow Forest were observed in this condition in 2018 (see Tables 2a-c).

Armillaria spp., also known as shoestring root rot, or butt rot, refers to a group of species of fungal pathogens that can infest the large roots and the butt of a stressed tree, interrupting the flow of sap and consuming resources. Over time, as decay in the wood at the base of the tree becomes advanced, the tree may simply collapse. Significant timber value can be lost in the course of an infestation by *Armillaria spp.* In mixed oak forests of Western MA, the primary species of *Armillaria* may be *A. gallica* (cf. Brazee and Wick, *Armillaria species distribution on*

symptomatic hosts in northern hardwood and mixed oak forests in western Massachusetts, *Forest Ecology and Management* 258 (2009). One indication of *Armillaria* spp., is a network of black, thick, shoelace-like rhizomorphs, a root-like structure, under the bark at the base of the tree. *Armillaria* spp. spreads by growing outward from infested roots and trunks toward neighboring trees.

Red oak borer, *Enaphalodes rufulus*, (Haldeman), does not tend to kill oak trees, but bores into the wood of living trees, causing economic loss and allowing other insects, such as carpenter ants, as well as decay organisms to gain entrance to the heartwood. Red oak borer has been identified at the nearby Quabbin forest.

IV. Regenerative Capacity and Response to Future Disturbances: Long-Range Threats to Future Forest Composition and Structure

Interfering native vegetation is becoming dominant in the understory in some areas:

Interfering native vegetation, as used here, refers to *native* plants that inhibit the growth of other, generally more desirable native plants. In the Ludlow Forest, the biggest risk appears to come from hayscented fern, with witch hazel also posing a concern. Hayscented fern was present at roughly 50% of the sample plots; at about half of these plots (25% of the plots overall), hayscented fern was dominant in the understory (i.e. a ranking of 2 on a scale of 0-3, where 3 = a total monoculture and 2 = very abundant). Hayscented fern seems to be expanding and thriving. The successive defoliation of the oaks, which has been letting in increasing amounts of light, seems to have given hayscented fern a significant boost. Over time, this is likely to continue. The wet summer of 2018 has also been favorable to hayscented fern. Areas with hayscented fern in the Ludlow Forest at this time also have pre-established desirable young trees and shrubs. Over time, if these are not released, the hayscented fern is likely to overwhelm much of the desirable young trees and shrubs and preclude the establishment of new desirable young trees and shrubs. This is especially true on the moister half of the upland soil moisture spectrum.

On the drier half of this spectrum, hayscented fern tended to be absent and instead there is a tendency to form huckleberry thickets. These, in the presence of heavy deer browse, can also become diversity-excluding monocultures.

Witch hazel mainly occurred in wetter areas and seems to have suffered from heavy defoliation from gypsy moths as well. In general, deer avoid witch hazel, giving it an advantage over other woody plants. Witch hazel grows vigorously and has a spreading crown that casts fairly dense shade, significantly inhibits the growth of young trees and shrubs in wetter areas.

Red maple is widespread and, with 90 trees per acre (40% of all trees $\geq 1''$ are red maple), is by far the most abundant tree (see Table 1a). Many of these trees are small (about half of the red maples are less than 6'' in diameter). As the oaks rapidly decline, red maple is perfectly positioned to take up a lot of the newly freed growing space. Red maple is a desirable tree, but there is a risk that too much of the potential oak, hickory and native shrub diversity will be shaded out by red maple. The shade of red maple will give a further advantage to hayscented fern (over oak, hickory and native shrub diversity). Red maple (especially small trees) will resprout vigorously if cut. If logging occurs to release the understory, and red maple is cut at the same time, it is likely to regrow with the other trees and form part of a new *mixed species* canopy, which would be a desirable outcome.

White pine is also abundant as a tall understory component at this time. As with red maple, white pine is poised to benefit from the decline of oaks and quickly take up growing space, some of which will be taken away from the potential oak, hickory and native shrub diversity. White pine, especially understory and suppressed trees, are suffering from fungal diseases and many have died in some areas. As with red maple, white pine is desirable, but is most desirable as part of a diverse mix of trees.

Black birch is not widespread in the Ludlow Forest, but this can change. Not-preferred by deer, and somewhat shade tolerant, black birch can become a default tree that can thrive in small openings. A risk of a default (passive)

approach to management at this juncture is that, increasingly, an opportunity to regenerate a diverse mix of trees and shrubs will tend to become lost, instead, to a mix of three species (red maple, white pine, and black birch) and an understory of hayscented fern.

Recent browsing by deer and, less so, moose, has had, and is having, a significant impact on the understory: This phenomenon was observed with remarkable consistency in all locations throughout the Ludlow Forest tract (see discussion of maple-leaved viburnum above). At this time, probably as a partial result of hunting that is allowed on the property, the browsing pressure seems to be occurring at a level that is suppressing, but not eliminating, desirable trees and shrubs, including oaks. Browsing pressure at the Ludlow Forest is not as extreme as in many surrounding forests, but further relief from browsing pressure during the phase of establishing young trees and shrubs would be very welcome.

Non-native invasive plants are present at the Ludlow Forest, but currently at a relatively low and potentially controllable level. Winged euonymous and oriental bittersweet are the most common invasives at the Ludlow Forest. Invasives are likely to increase substantially over time in the absence of significant precautions and control, especially in moister areas, including riparian areas.

Non-native invasive plants were *absent* from 74% of the sample plots at the Ludlow Forest. That is the good news. When present at all, invasives were typically at the lowest level (level = 1, “extremely minor”, which means at least one individual was noted). On 5% of the plots, however, the invasives were at level = 2, “minor but readily treatable”. However, several hotspots were noted while traversing the property that did not fall into any of the sample plots (i.e. the infestation was not visible from the plot center). These include a major infestation of winged euonymous, a major infestation of oriental bittersweet, and two areas of mixed invasives (winged euonymous, oriental bittersweet, multiflora rose, autumn olive, Norway maple, etc.) (see the map Ludlow Forest - Noted Concentrations of Invasive Plants). There is also a concentration of Japanese knotweed on one of the old log landings (at the western end of the old woods road heading west).

Beech is nearly entirely absent from the Ludlow Forest and is not a concern. Beech does not pose a threat to future biodiversity at the Ludlow Forest.

V. Opportunities for Management: a Range of Options to Influence Forest Conditions

The idea of forest management in a watershed context is to passively derive the benefits of natural forest conditions and processes as much as possible over as broad an area as possible, and to intervene only as much as needed where natural forest conditions and processes are not accomplishing or sustaining the desired conditions.

We find ourselves at a point over 100 years or so into a massive forest recovery process (i.e. since work began on the reservoir in 1873) that has created a mature and maturing forest on land that was once in agriculture. This almost goes without saying, but it is important to keep in mind as an example of the tremendous capacity of the forest to grow (and grow back) after a (from a forest perspective) catastrophic event. In thinking about this, it is important to keep in mind differences between conditions that prevailed during the early stage of forest recovery and conditions that prevail now. Key differences between then and now include the abundance of browsers, the influence of invasive plants and native interfering plants, the scales of disturbance and the availability of sunlight associated with this, the lack of fire, and the arrival of numerous pests and pathogens. These various effects combine, sometimes acting in compounding ways, to drive the forest forward towards a series of future conditions, each of which will have its own impact, whether beneficial or less so, on water supply.

Opportunity for management: Currently we are witnessing the rapid decline of the overstory oak component and potential decline in the overstory pine component. At the same time, there is existing understory of desirable young trees and shrubs. Over time, in the absence of a major disturbance that will let in significant light and reduce

competing vegetation, the desirable young trees and shrubs will tend to increasingly be replaced with a less diverse set of native and non-native interfering vegetation. This set of circumstances points to a window of opportunity to use silviculturally-based logging as a tool to promote the desirable young trees and shrubs and perpetuate native biodiversity going forward. Because the condition of the timber that would be cut is quickly deteriorating, the primary window of opportunity is the next 1-3 years. With an adequate scale and intensity of logging, there is a chance that the factors of the progressively increasing impact of interfering vegetation and the excessive browsing of desirable vegetation can be overcome. This effort should be supported by a policy of ongoing hunting and by focused control of non-native invasive plants. This effort should be further supported by an outreach program to the users of the paved pathway and backwoods hunting areas, as well as to the neighbors and the public at large. The outreach program would provide an explanation of the situation including a sense of what to expect.

Specific recommendations are presented in the Management Recommendations section.

Management Recommendations 2018-2028

Overview of silvicultural practices implemented through logging

The site- and situation-specific rationale for forest management at Ludlow Forest, along with a range of corresponding options, are presented in part V of the Major Findings section, *Opportunities for Management: a Range of Options to Influence Forest Conditions*. What follows below is a best-set of recommendations based on knowledge available as of the submission date of this plan.

The overall purpose of these operations is to contribute to the overall promotion and maintenance of a structurally complex bio-diverse forest of vigorous native trees, shrubs, and affiliated vegetation in a configuration that is well suited to watershed protection over the long term. These operations are in response to current tree health conditions at the Ludlow Forest affecting, at this time, primarily all species of oaks and white pines. A number of logging operations are recommended (see table 6a&b).

In all, harvesting is recommended on about 602 acres, or about 44% of the total Ludlow Forest acreage, with no harvesting recommended for the remaining 763 acres (or about 56% of the total Ludlow Forest acreage) (See Tables 6a and 6b). Harvesting is recommended for 5 of the 7 stands (See Table 5 for an overview of stands) and would occur within subsection foot prints shown on the map Ludlow Forest Recommended Logging Operations. The harvest units were delineated using current BMPs as well as the intention to avoid wet or steep soils, so that harvesting will primarily occur on well-drained soils (see Table 4b).

Recommendations call for accomplishing the forest structure goals by cutting about 5,373 Mbf of timber and 3,615 cords of firewood, or about 1,860 truckloads of potential forest products. In addition, a significant quantity of lower-grade material (from tops and poor-quality logs) is intended to remain in the forest, on the ground, where it will have a greater positive impact than out in the forest products marketplace. The recommended cutting would harvest about 31% of the total timber and 44% of the total cord products (not counting topwood) currently standing on the Ludlow Forest tract. Areas outside the proposed harvesting areas will remain essential unchanged by the logging.

The scope of this plan is 10 years. No other cutting is anticipated, at this time, over the next 10 years. However, if the health of trees continues to deteriorate, further harvesting may come under consideration.

On about 20% of the harvest acreage, the canopy would be opened slightly to provide better spacing for selected trees (primarily white pine) that exist now, with the aim of improving their vigor. On about 80% of the total Ludlow Forest harvest acreage, young trees and shrubs would be established through an early-successional framework. The intention of the regeneration harvesting is to enhance and sustain diversity, structural complexity and vigorous growth in the watershed forest. Though not an explicit intention, this harvest will provide a significant ancillary benefit to declining wildlife species that depend on early-successional habitats to breed, as well as for a significant number of other birds that do not breed in early-successional habitat but do make use of it for foraging.

Harvesting Practices

See Table 6a for an overview of subsections & acres, priority ranking, timber sale groupings, timing / phase, and notable considerations. See Table 6b for an overview of volumes to cut by subsection. See Tables 6e &d for a breakdown by species of cutting (by % basal area) and overall type-level basal area retention. The “keep” basal area represents the projected post-harvest residual stand composition. See

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“Compliance with CR” below for a discussion of how this level of retention satisfies the terms of the CR. See the map Ludlow Forest Potential Logging Subsections for the locations of the proposed logging. For a potential sequence of logging, see the map Ludlow Forest Potential Logging Phases.

Potential Adaptive Update to Harvesting Practices

The harvesting proposed here is intended to retain more overstory trees than the minimum threshold set forth in the CR. However, if tree condition deteriorates further, the amount of salvage cutting within the harvesting subsections shown on the map Ludlow Forest Potential Logging Subsections could increase, with retention approaching the CR-threshold 10 square-foot per acre basal area level. Additional salvage harvesting would draw primarily from trees *currently* within the upper half of the 25%-75% live-crown level. Additional would consist of trees that would by then have dropped into the lower half of the 25%-75% live-crown level or below and are, as a result, not expected to survive.

Concepts applying to all harvests

Practice purpose (how it helps create desired future condition): Most of the harvesting is salvage harvesting designed to serve as a regeneration harvest to release the established young trees and shrubs discussed previously. This type of harvesting is intended to establish new trees representing the full spectrum of canopy tree diversity as well as a significant component of native shrubs and other understory vegetation so that diversity can be sustained into the future. This is a particular priority at this time given the declining health of both oaks and white pine. In other areas, thinning is intended to improve the vigor of existing canopy white pine trees.

***Silviculture / harvesting:** Two silvicultural systems are recommended: Salvage/REGEN and Thinning/salvage.

Salvage/REGEN harvesting in the Ludlow Forest is used in a general way to refer to the final cut (overstory removal) in a one-cut shelterwood system intended to release shade-intolerant tree seedlings, sprouts and saplings as well as to cause a general flourishing of native shrubs. The cutting is focused on dead or dying oaks and midstory red maples. It is important to release these shade-intolerant trees and shrubs before they become shaded out by other species (e.g. red maple, white pine, black birch, witch hazel, hayscented fern) or browsed back (by deer and/or moose) to a non-viable condition. Significant seeding in of pioneer species (e.g. paper birch, pin and black cherry, and blackberries/raspberries) is expected to occur as well. This system requires large openings. The intention is to create large areas in full sun so that a significant pulse of young trees, including species such as paper birch, become established in sufficient abundance to overwhelm deer and moose browse. The open areas will exceed wherever possible 2.5 acres in size so that shade does not hinder the desired effects. However, the realization of opening sizes of set size will be imperfect and irregular as driven by tree retention guidelines see Tables 6c&d: CH 132 Narrative Page designation of Trees.

In on-the-ground implementation of this concept, large, open patches would be created, by logging, in the area between groves of trees to be retained. These groves would be identified at the outset and would be chosen to capture a representative mix of species so that their value to the watershed forest, including their diverse seed production and their structure, is retained. Groves will generally consist of or include the largest or most vigorous trees within an area, but also snags. Groves can also be designed to include any special tree that is discovered (i.e. unique stature, huge tree, very old tree, trees with notable cavities, stick nests, etc.), to surround historic features (e.g. cellar holes), etc.

The intention is to leave those groves in place going forward so that there is a two-aged structure in these areas. The term REGEN is used here to emphasize the regeneration aspect of this system, which is

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effected by logging, but the retention aspect, which is effected by the *avoidance* of logging, is also essential to ensure that overall forest structure is not simplified. Retention of snags and coarse woody debris in the harvest area is also essential, and is discussed below.

As a result, tree retention will be clumped rather than evenly distributed.

Thinning is used here to refer to a crown-level thinning that tries to create improved spacing around selected trees (in this case white pines) present in the canopy so that these trees are able to be more vigorous going forward. This is not a timber-oriented approach that would favor the most valuable trees; instead, this is a tree-health approach that will attempt to ensure that those white pines with fuller crowns are free to grow and thrive.

Trees to be removed & retained (types, conditions, sizes): see Tables 6c&d: CH 132 Narrative Page Designation of Trees. Please see Annotated Exhibit C: Application of Forest Management Standards for further discussion of this topic.

Areas in which to carry out harvesting: Within the ca. 1,366 acres of forest, logging subsections were delineated to capture areas in which a net benefit is expected by logging. These areas were delineated by a process of elimination from the grand total acreage. About 73 acres falling within 100' of Springfield reservoir were taken out. Another 394 acres of land with wet soil or that fell within about 125' of any stream or wetland was removed as well. The "Gunnery" (Stand 7) and Stand 6 were removed in their entirety (see Table 4b). Of the 837 acres remaining, remote areas requiring the crossing of a stream were also removed, leaving about 602 acres of forest in which to practice active silviculture (See Tables 4a&b for an accounting of acreage and Table 6b for an overview of volumes to cut by subsection. See the map Ludlow Forest Potential Logging Subsections for the locations of the proposed logging).

Special regeneration considerations (scarification and pressing down of acorns, seed source, etc.): In regeneration-harvest areas, cutting or crushing small, unmerchantable red maples and white pines will help ensure that these do not dampen the response of the desired regeneration. There is no crop of acorns at this time. Normal scarification occurring during the process of logging will help provide a seed bed for paper birch and is expected to trigger blackberries/raspberries, pin cherry and black cherry from seed-bank seed.

Special operational considerations (soils, erosion, access, seasonal timing, cultural, etc.): By and large the silvicultural areas have been delineated to exclude areas of wet soils and erosion risk. Normal care is required to make sure logging activity does not inadvertently fall during times of wet or unstable soil. This is generally handled through logging contract language, performance deposits, forester supervision of the ongoing logging, selection of appropriate loggers, and, as needed, by matching equipment to sites. The project areas have good road access, though there will generally be a need for further upgrading of some areas or modifications to stabilize roads and to accommodate modern trucks. The roads are protected by gates and a security patrol that keep out jeeps, and ATVs in the lower areas. Harvests will be designed (using paint and flagging) so that cultural features such as cellar holes will not be at risk during logging operations.

Special equipment/logging-system considerations: This is discussed above in light of scarification. If any specific determinations are needed, they will be made in the marking, permitting and selling phase of the logging operation.

Special boundary considerations: The boundaries have been historically well-maintained by SWSC though could use refreshing in this area. SWSC has the in-house capacity to do this, and this is in process at this time.

Special invasive species considerations: See discussion below for actions pertaining to invasives.

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Special habitat improvements (anything particular to accomplish): Harvesting recommended here will most notably benefit birds that use forest-interior early-successional and intermediate-disturbance forest. Birds that use closed-canopy interior forest will continue to have significant areas of forest for breeding, but it is anticipated that these will make heavy use of the early-successional forest for foraging.

Other Practices:

- Continue to allow deer hunting; potentially appeal to DFW for the issuance of increased doe permits in the Ludlow Forest area to create a 5+-year window of reduced browsing pressure on desirable young trees and shrubs. Potentially work with MA DFW where possible to expand accessibility/awareness of hunting options at Ludlow Forest.
- Work with MA DFW (as per CR) to develop an Invasive Species Management Plan. Control non-native invasive plants, both within harvest areas (mostly Phase 3 areas) and in non-harvest areas (e.g. Stand 6 and e.g. the northern stretch of Westside Drive) – see the map Ludlow Forest - Noted Concentrations of Invasive Plants.
- As needed, and in accordance with CH 132 permitting where applicable, upgrade and stabilize roads to accommodate modern trucks. This may include adding base material (to gravel roads) or widening curves on the asphalt trail.
- Boundary maintenance / ensure ATVs do not enter harvest areas and impact roads or regeneration.
- Provide outreach to the users of the paved pathway and backwoods hunting areas, as well as to the neighbors and the public at large, to help ensure clarity about the rationale and nature of the above practices, and how, if at all, they will affect the public.

Compliance with CR:

The management practices have been developed to comply with the CR. This is explained item by item in Annotated Exhibit C: Application of Forest Management Standards (next section).

ANNOTATED EXHIBIT C

APPLICATION OF FOREST MANAGEMENT STANDARDS DEMONSTRATING COMPLIANCE WITH THE CR

GOAL: Enhance and maintain native biological diversity on managed forestlands.

The Forest Management Plan will meet the goal of enhancing and maintaining native biological diversity on managed forestlands by providing a full range of forested habitats ranging from closed-canopy and late-successional forest conditions to areas of intermediate and stand-replacing/stand-initiating disturbance, thereby adding early-successional / young-forest habitat to the current forested habitat mix (for the importance of this, see State Wildlife Action Plan, Chapter 4, Habitats of Species of Greatest Conservation Need, Medium Scale Habitats, Young Forests and Shrublands, p. 267).

This approach will allow for a full diversity of native forest plant species to thrive, including hard- and soft-mast-bearing trees and shrubs with particular wildlife value, and will provide the vegetation structure for a broad range of forest-interior breeding birds (cf. Table 4, Focal Species Disturbance Associations, below extracted from Managing Forests for Trees and Birds in Massachusetts published by Mass Audubon and provided by Mass Audubon, DCR, and the Franklin Land Trust, 2016).

The early-successional habitat will be created in the course of trying to successfully regenerate and release a desirable mix of oaks, hickories, red maple, and mast-bearing upland shrubs *from pre-established plant individuals* (seedlings, saplings, shade- or browse-suppressed individuals, and re-sprouting). Chestnut will be released from pre-existing sprouts. Birches, red maple, pin cherries and black cherries, blackberries and other pioneer species will fill in gaps from seed. White pine will be released from established seedlings and saplings and will seed in. This will be accomplished primarily with openings ranging from 2.5 at the smaller end (see Table “Focal Species Disturbance Associations” below) to 20 acres or more at the larger end. A tendency toward larger openings will help overcome the impact of deer and moose browsing (cf. Leak et al, 2017, Ecology and Management of Northern Red Oak in New England, which recommends “large harvest areas including clearcuts of at least 20-acres or numerous group or patch harvests to overwhelm the herd” (p.34) and again that managers “overwhelm the deer and moose with large harvest areas of 15 to 20 acres and larger or numerous groups and patches in a given area” (p. 42).

Yet, due to the anticipated retention of healthier oaks, healthier pines, and a number of less-common species (e.g. hickories, yellow birch, hemlock, etc.) it may in reality be difficult to achieve complete openings of this size, with the result that anticipated retention will be well-above the minimum threshold set forth in this CR (see below as well as Tables 6c and 6d), though if the health of oaks worsens still, the retention could approach the minimum threshold in some areas.

Wetland, riparian and vernal pool habitats will remain essentially undisturbed.

In further support of native biodiversity, this plan also proposes to control non-native invasive plants and recommends the continuation and possibly the intensification (through doe permits) of deer-hunting on the property to help reduce herbivore pressure during the 3-5-year window of tree and shrub establishment and release.

In conjunction with CH 132 Cutting Plans to be filed, this plan also proposes to improve access roads, skid roads and landings as needed to carry out the logging and related trucking.

Focal Species Disturbance Associations

Table 4. Focal Species Disturbance Associations*

Natural Disturbance Regime	Management Objective	Canopy Cover	Deciduous to Mixed Forest	Coniferous to Mixed Forest
Stand-replacing disturbances >2.5 acres in size	Maintain patches of young forest, 5-15 years old, >2.5 acres in size	Open (0%-30%)	Eastern Towhee Chestnut-sided Warbler Mourning Warbler Ruffed Grouse American Woodcock† Brown Thrasher Northern Bobwhite† Northern Flicker	Mourning Warbler Northern Bobwhite†
Canopy gaps and pockets of regeneration 0.25-0.75 acres in size	Create canopy gaps to encourage dense regeneration in pockets 0.25-0.75 acres in size	Intermediate (30%-80%)	Black-and-white Warbler Black-throated Blue Warbler Canada Warbler Eastern Wood-pewee Ruffed Grouse Veery Wood Thrush Northern Flicker	White-throated Sparrow Canada Warbler
Small and infrequent disturbances that maintain an average of >80% canopy cover	Minimize gap size and frequency. Favor large, old trees and snags. Maintain >80% average canopy cover in the stand.	Closed (80%-100%)	Black-and-white Warbler Black-throated Blue Warbler Canada Warbler Eastern Wood-pewee Wood Thrush Yellow-bellied Sapsucker	Black-throated Green Warbler

* Focal Birds are grouped according to habitat features they strongly associate with. They may be found in a wider variety of conditions than shown here.

† These species require other nearby habitat types in addition to early successional forest.

Proposed cutting is shown in Tables 6a-d and on the map Ludlow Forest Recommended Logging Operations.

OBJECTIVES:

- 1) Apply current and generally accepted scientific principles from the current Massachusetts Forestry Best Management Practices Manual (Kittredge & Parker, 1996) and subsequent versions if approved by the Commonwealth (the "Manual") to conserve soil and water quality on managed forestlands.

The current BMP manual was issued in 2013 and will be followed.

- 2) Apply current and generally scientific principles for native biodiversity protection as standards on managed forestlands.

See summary discussion above and details below.

STANDARDS:

- 1) Conduct all forest cutting operations under an approved Chapter 132 Forest Cutting Plan and in compliance with Chapter 131, the Wetlands Protection Act. Provide a copy of the Chapter 132 Forest Cutting Plan to the Commonwealth at least 20 days prior to the start of cutting for review of potential impacts on state-listed species and priority natural communities. Implement appropriate mitigation measures provided by the Commonwealth to limit impacts on state-listed species and priority natural communities.

CH 132 plans will be filed for all cutting areas. Cutting will only occur under approved CH 132 plans. Adherence to approved CH 132 plans will ensure compliance with CH 131 Wetlands Protection Act.

Approved CH 132 plans will be filed to the Commonwealth at least 20 days prior to the start of cutting for review of potential impacts on state-listed species and priority natural communities. Any required mitigation measures will be observed.

- 2) Establish and maintain access roads, skid trails, and landing areas according to both required best management practices and recommended guidelines in the Manual.

Adherence to approved CH 132 plans including DCR sign off at the completion of operations will ensure access road, skid trail and landing area BMPs are followed.

- 3) Retain buffer strips along roads and filter strips along riparian areas according to both required best management practices and recommended guidelines in the Manual.

Adherence to approved CH 132 plans will ensure that filter strips are implemented. The internal roads of the Ludlow Forest are forest management roads and thus no buffer strip is required (cf. BMP manual p. 12: "Buffer strips will be left along the edges of publicly maintained ways, except along forest management roads in federal, state, county, or municipal forests, parks, or reservations." It will be important to cut some trees near the road to reduce hazards.

- 4) Avoid wetland resource area crossings during forest cutting operations if possible, establish and maintain stream crossings for logging machinery, and operate machinery within wetlands only when necessary and in strict compliance with both required best management practices and recommended guidelines in the Manual.

Through the delineation of harvesting subsections, the forest management plan precludes most wetland areas from any active silviculture or any crossings. By and large these areas will remain completely unaffected. Most wetland and stream crossings will occur on existing roads and culverts/bridges. Some of these may need to be improved (e.g. by adding stone or gravel or by placing a portable bridge over a culvert or old stone bridge). A small number of new crossings may be needed.

- 5) Locate and map all vernal pools within a proposed harvest area and plan harvest in strict compliance with both required best management practices and recommended guidelines in the Manual for certified vernal pools. Upon the request of the owner, the Commonwealth will assist Owner, at Commonwealth's expense, to locate, map and certify all vernal pools within a proposed harvest area.

The forest management plan identifies known or anticipated vernal pools (see the map Ludlow Forest Recommended Logging Operations) based on the MA GIS layers of certified and potential vernal pools. Any new vernal pools identified by MA DFW can be incorporated into this mapping. Adherence to

approved CH 132 plans will ensure that vernal pool protections are implemented.

- 6) Retain a portion of overstory trees on managed forestlands at all times. Vary amount of retention depending on slope. Minimum retention on all slopes shall consist of an average basal area of ≥ 10 square feet per acre in live trees ≥ 14 " Dbh. Retain live trees in 2 groups per acre when possible, consisting of sound, relatively wind-firm trees, and existing den trees and/or snag trees when possible. Retain a mix of live [mature] mast-producing hardwoods, including oak and black cherry, and cover-producing softwoods including hemlock and white pine, where possible. On slopes $< 30\%$, the minimum retention shall apply....

Two types of silviculture will be applied. The majority of the silviculture will occur in oak-dominated areas. Some of the silviculture will occur in pine-dominated areas. Forest-type areas dominated by red maple, sugar maple, or hemlock will be kept out of any cutting.

The silviculture in oak-dominated areas will seek to release a mix of pre-established oaks, hickories, other native trees including red maple and chestnut, as well as a mix of native shrubs, including blueberries/huckleberries, viburnums, and beaked hazel. Large openings are required to maximize the chances of overcoming herbivory and competing vegetation. Basal area retention standards for live trees will be met by the use of mixed-species groves with a subsection-wide minimum average of 10 square feet per acre. Retention groups or groves may be bunched (i.e. some acres may have no groups in which case groups will consist of more trees so that the overall CR-intended average of nine to ten 14"-trees on each acre (or, alternatively, for example, or four to five 20" trees) (i.e. the total number of trees to be retained) will be achieved in fewer, larger groups. Groups, where possible, will be built around those few oaks with good crowns and/or hickories so that the mast-bearing portion of the overstory is maintained. Oak snags with tight bark may be cut but oak snags that have obvious rot or loose bark will be retained. Hemlocks (which are very few) will be retained. About half of the white pine will be retained in oak areas. Basal area retention in oak-hardwood areas is expected to be 31 square feet per acre, which is well in excess of the 10 square feet per acre minimum (see Table 6c), but retention could approach the threshold if tree health continues to worsen.

The silviculture in pine-dominated areas will seek to preserve pine overstories by creating better spacing around those pines with healthier crowns. This is a thinning to improve the health of the remaining pines. Oaks in poor health may be salvaged incidentally in these areas, but oak snags that have obvious rot or loose bark will be retained.. About half of the pines are in poor health (based on crown condition) and would be cut. Basal area retention in White-Pine Hardwood areas is expected to be 58 square feet per acre, which is well in excess of the 10 square feet per acre minimum (see Table 6d).

Harvesting is not anticipated on any slopes $> 30\%$.

Table 1a: Forest Composition Ludlow

All Live Trees ≥ 1"Diameter (Dbh.)

SWSC Ludlow Compartment, Ludlow MA, October 2018, 65 plots

Species Listed from Highest to Lowest % Basal Area

Species	Basal Area			Trees per acre			Total Trees	Size (Dbh, inches)	
	BA	% of all BA	% of BA oak only	All species per acre	Oaks per acre	Oak as % of total trees per acre		Dbh	Dbh Oaks Only
Oak RED	40.0	29%	29%	31	31	13.5%	41,916	15.5	15.5
Maple red	28.0	20%		90			123,040	7.6	
Pine WHITE	25.5	18%		15			21,179	17.4	
Oak scarlet	10.8	8%	8%	7	7	3.2%	9,824	16.6	16.6
Oak white	7.7	5%	5%	11	11	4.7%	14,459	11.6	11.6
Maple sugar	6.8	5%		15			20,339	9.1	
Birch yellow	5.8	4%		28			38,288	6.2	
Oak black	3.7	3%	3%	3	3	1.5%	4,533	14.3	14.3
Birch black	2.8	2%		8			11,409	7.8	
Ash white	2.2	2%		4			4,899	10.5	
Hemlock	2.2	2%		2			2,531	14.6	
Birch paper	1.5	1%		4			5,974	8.0	
Hickory pignut	1.5	1%		3			3,748	10.2	
Hickory bitternut	0.6	0%		1			877	13.3	
Oak chestnut	0.3	0%	0%	0	0	0.0%	124	25.0	25.0
Pine red	0.3	0%		0			214	19.0	
American elm	0.3	0%		4			4,830	4.0	
Hickory shagbark	0.3	0%		2			2,147	6.0	
Totals	140	100%	45%	227	52	23%	310,332	10.7	14.9

Table 1b: Timber Volume and Value Ludlow
 All Live Trees ≥ 1" Diameter (Dbh.)

SWSC Ludlow Compartment, Ludlow MA, October 2018, 65 plots

Species Listed from Highest to Lowest % Basal Area

Species	Timber Volume				
	Timber per acre (bf)	Total timber (bf) based on 1,370 acres	% of total timber	Total Cords (not including top-wood)	Timber Oak Only Per Acre (bf)
Oak RED	4,394	6,019,711	35%	1,640	4,394
Maple red	897	1,228,418	7%	4,114	
Pine WHITE	4,346	5,953,514	35%	1,677	
Oak scarlet	1,157	1,584,506	9%	672	1,157
Oak white	615	842,985	5%	485	615
Maple sugar	296	404,976	2%	1,008	
Birch yellow	67	91,771	1%	804	
Oak black	259	355,261	2%	187	259
Birch black	63	86,074	1%	408	
Ash white	132	180,555	1%	356	
Hemlock	75	102,587	1%	321	
Birch paper	-	-	0%	371	
Hickory pignut	40	54,331	0%	293	
Hickory bitternut	24	32,539	0%	96	
Oak chestnut	28	37,759	0%	-	28
Pine red	70	96,242	1%	-	
American elm	-	-	0%	32	
Hickory shagbark	-	-	0%	32	
Tract Total	12,461	17,071,227	100%	12,496	6,453

Table 1c: Oak and Pine Timber Volume and Value Ludlow
All Live Trees ≥ 1" Diameter (Dbh.)

SWSC Ludlow Compartment, Ludlow MA, October 2018, 65 plots

Species Listed from Highest to Lowest % Basal Area

Species	Timber per acre (bf)	% of total timber			
All oaks	6,453	52%			
White Pine	4,346	35%			
Oak & Pine	10,798	87%			

Table 1d: Presence of regeneration (potentially viable young trees) Ludlow

SWSC Ludlow Compartment, Ludlow MA, October 2018, 65 plots

Species Listed from Greatest to Least Number of Occurrences

Species	Seedling < 6",	Seedling 1-4'	Seedling (pencil-cigar-thickness)	Sapling 1"-2" dbh	Very small pole 2"-4" dbh	Small pole 4"-6" dbh	Grand Total
Oak RED	49	35	3	3	1		91
Maple red	4	15	7	15	15	2	58
Hickory shagbark	11	20	5	4	1		41
Oak white	8	19	10	1			38
Pine WHITE	2	10	6	8			26
Maple sugar	1	3	2	6	2	1	15
Birch black		1	4	5	1	1	12
Cherry black	2	6	1				9
Ash white		5		1	1	1	8
Birch yellow			2	3	2	1	8
Hemlock		1			1		2
Oak scarlet	2						2
American elm				1			1
Gum black			1				1
Grand Total	79	115	41	47	24	6	312
% of total regen*	25%	37%	13%	15%	8%	2%	100%

*E.g. 25% of the regen types observed at any plot were seedlings <6". This is not a count of individuals - multiple occurrences were possible at any point (for example red oak < 6" and red oak sapling 1"-2" could occur at the same plot). By count (estimated), most regen was in the <6", 1"-4" and pencil-cigar size, not larger.

Note: most regeneration of the red-scarlet-black group was lumped as "red".

Note: Actual white pine occurrence is probably higher as this was not part of the initial focus.

Species	Seedling < 6",	Seedling 1-4'	Seedling (pencil-cigar)	Sapling 1"-2"	Very small pole 2"-4"	Small pole 4"-6"	Grand Total
All Oak	59	54	13	4	1	0	131
Oak as % of total	75%	47%	32%	9%	4%	0%	42%

E.g. 42% of the regen types observed at any plot were oak.

Table 2a: Apparent Health of Oak Trees (All Species), Ludlow Forest

All Live Trees ≥ 1"Diameter (Dbh.)

SWSC Ludlow Compartment, Ludlow MA, October 2018, 65 plots

Species Listed from Best to Worst Health

Crown Condition of Oaks (all species)	Basal Area of Oaks	Percent of Oak Basal Area	Oak trees per acre	Percent of oak trees	Size (QMD in ")
100% live crown (more or less normal vigor)	0.0	0.0%	0.0	0.0%	NA
>75% live crown (health is compromised but may survive)	4.9	7.9%	2.8	5.4%	17.8
25%-75% live crown (poor health, many unlikely to survive)	15.7	25.2%	14.2	27.5%	14.3
<25% live crown (very poor health, may be dead next year)	18.2	29.2%	14.7	28.4%	15.1
0%-1% live crown (probably will die this year)	4.6	7.4%	7.0	13.5%	11.0
Leaves totally brown (tree just died)	5.5	8.8%	3.0	5.8%	18.4
Snag, bark tight (probably died in 2018, leafless but with fine bra	12.9	20.7%	9.4	18.2%	15.9
Snag, bark loose (probably died pre-2018, no fine branches)	0.6	1.0%	0.6	1.2%	13.9
Totals	62.4	100%	51.7	100%	14.9

Range: Dead to very poor health (< 25% live crown)

42

67%

35

67%

Table 2b: Apparent Health of RED Oak Trees, Ludlow Forest

All Live Trees ≥ 1"Diameter (Dbh.)

SWSC Ludlow Compartment, Ludlow MA, October 2018, 65 plots

Species Listed from Best to Worst Health

Crown Condition of Red Oaks	Red Oak BA	% of red oak BA	Red Oak TPA	% of red oak trees	Red Oak QMD
100% live crown (more or less normal vigor)	0.0	0%	0	0%	NA
>75% live crown (health is compromised but may survive)	3.7	9%	2.4	8%	16.8
25%-75% live crown (poor health, many unlikely to survive)	10.5	26%	8.7	29%	14.8
<25% live crown (very poor health, may be dead next year)	12.3	31%	9.6	31%	15.3
0%-1% live crown (probably will die this year)	2.2	5%	2.2	7%	13.4
Leaves totally brown (tree just died)	4.0	10%	2.1	7%	18.9
Snag, bark tight (probably died in 2018, leafless but with fine branches)	7.4	18%	5.5	18%	15.6
Snag, bark loose (probably died pre-2018, no fine branches)	0.0	0%	0	0%	NA
Totals	40.100	100%	30.50	100%	15.5

Range: Dead to very poor health (< 25% live crown)

25.9

65%

19.4

64%

Table 2c: Apparent Health of SCARLET Oak Trees, Ludlow Forest

All Live Trees ≥ 1"Diameter (Dbh.)

SWSC Ludlow Compartment, Ludlow MA, October 2018, 65 plots

Species Listed from Best to Worst Health

Crown Condition of Scarlet Oaks	Scarlet Oak BA	% of scarlet oak BA	Scarlet Oak TPA	% of scarlet oak trees	Scarlet Oak QMD
100% live crown (more or less normal vigor)	0.0	0%	0	0%	NA
>75% live crown (health is compromised but may survive)	0.6	6%	0.2	3%	23.8
25%-75% live crown (poor health, many unlikely to survive)	3.7	34%	2.5	35%	16.6
<25% live crown (very poor health, may be dead next year)	2.2	20%	1.7	24%	15.4
0%-1% live crown (probably will die this year)	0.3	3%	0.2	3%	18
Leaves totally brown (tree just died)	1.5	14%	0.9	13%	17.3
Snag, bark tight (probably died in 2018, leafless but with fine bra	2.2	20%	1.4	19%	16.9
Snag, bark loose (probably died pre-2018, no fine branches)	0.3	3%	0.3	4%	13
Totals	10.8	100%	7.2	100%	16.6

Range: Dead to very poor health (< 25% live crown)

6.5

60%

4.5

63%

Note: Health of red and scarlet oak very similar - no species-level resistance evident at this stage.

Table 2d: Apparent Health of White Pine Trees IN POTENTIAL SALVAGE AREAS, Ludlow Forest Dominant & Co-Dominant Trees Only

SWSC Ludlow Compartment, Ludlow MA, October 2018, 13 plots in pine type

Species Listed from Best to Worst Health

Crown Condition of White Pine	Basal Area of Pine	Percent of Pine Basal Area	Pine trees per acre	% of pine trees	Size (QMD in ")
100% live crown (more or less normal vigor)	2.0	2.7%	0.1	0.3%	25.0
>75% live crown (health is somewhat compromised)	23.0	31.1%	9.2	26.8%	21.4
25%-75% live crown (compromised health)	38.0	51.4%	18.0	52.5%	19.8
<25% live crown (very poor health)	11.0	14.9%	7.0	20.4%	16.8
0%-1% live crown (probably will die this year)	0.0	0.0%	0.0	0.0%	NA
Needles totally brown (tree just died)	0.0	0.0%	0.0	0.0%	0.0
Snag, bark tight	NA	NA	NA	NA	NA
Snag, bark loose	NA	NA	NA	NA	NA
Not Called	NA	NA	NA	NA	NA
Totals	74.0	100%	34.3	100%	19.8

% of live pines in very poor health (< 25% live crown) 11 15% 7 20%

Note trend that larger trees are healthier

Table 3c: Midpoint Salvage-Harvest Scenario* in OAK TYPE, Ludlow Forest

All Live Trees ≥ 1"Diameter (Dbh.)

SWSC Ludlow Compartment, Ludlow MA, October 2018, 34 plots in oak type

		Type TPA	209				
		Type BA	131				
Prescription: Minimum Salvage							
Crown Condition of Oaks	Basal Area of Oaks to Cut	Percent of Oak Basal Area	Oak trees per acre	Percent of oak trees per acre	Oak Volume (bf/ac) to cut	% of total oak volume (bf) to cut	Total Oak Volume To Cut
100% live crown							
>75% live crown							
25%-75% live crown	12.0	12.6%	10.0	12.8%	1,260		627,480
<25% live crown	29.0	30.5%	24.0	30.8%	3,045		1,516,410
0%-1% live crown	5.0	5.3%	9.0	11.5%	525		261,450
Leaves totally brown	9.0	9.5%	5.0	6.4%	945		470,610
Snag, bark tight	20.0	21.1%	15.0	19.2%	2,100		1,045,800
Snag, bark loose	0.0	0.0%	0.0	0.0%	NA		
Totals	75.0	79%	63.0	81%	7,875	78%	3,921,750

Species to cut	BA to cut	% of total type BA	Trees to cut per acre	% of total trees per acre in type	Volume (bf/ac) to cut	% of total volume (bf) to cut	Total Volume To Cut
Oaks	75.0	57%	63.0	30%	7,875		3,921,750
Maple red	15.9	12%	97.0	46%	175		87,150
Pine WHITE	4.5	3%	3.0	1%	725		361,050
Birch black	3.5	3%	12.0	6%	60		29,880
Total to cut	99	76%	175	84%	8,835	75%	4,399,830

Species to keep	BA to keep	% of total type BA	Trees to keep per acre	% of total trees per acre in type
Oaks	20.0		15.0	
Pine WHITE	4.5		3.0	
Hemlock	0.6		0.6	
Birch yellow	0.6		0.9	
Maple sugar	0.6		0.7	
Hickory pignut	1.2		1.5	
Birch paper	2.9		8.3	
Hickory shagbark	0.6		3.0	
Total to keep	31	24%	33	16%

*=salvage most living oaks with <25% foliage plus snags w/tight bark at time of marking plus approx 50% of oaks w/crowns 25%-75% full. Tend to keep oaks with crowns on the upper half of 25%-75% crown fullness. Retention distribution will follow crown condition and will tend to be irregular.

Table 3d: THINNING Scenario* in WHITE PINE TYPE, Ludlow Forest
 All Live Trees ≥ 1"Diameter (Dbh.)

		Type TPA	200				
SWSC Ludlow Compartment, Ludlow MA, October 2018, 34 plots in pine type		Type BA	155				
Prescription: Minimum Salvage							
Crown Condition of White Pine	Basal Area of Pine to Cut	Percent of Pine Basal Area	Pine trees per acre	Percent of Pine trees per acre	Volume (bf/ac) to cut	% of total volume (bf) to cut	Total Volume To Cut
100% live crown							
>75% live crown							
25%-75% live crown (cut 50%)	19.0	25.7%	9.0	26.2%	3,610	25.7%	375,440
<25% live crown	11.0	14.9%	7.0	20.4%	2,090	14.9%	217,360
0%-1% live crown	NA	NA	NA	NA	NA	NA	NA
Leaves totally brown	NA	NA	NA	NA	NA	NA	NA
Snag, bark tight	NA	NA	NA	NA	NA	NA	NA
Snag, bark loose	NA	NA	NA	NA	NA	NA	NA
Totals	30	41%	16	47%	5,700	41%	592,800

Species to cut	BA to cut	% of total type BA	Trees to cut per acre	% of total trees per acre in type	Volume (bf/ac) to cut	% of total volume (bf) to cut	Total Volume To Cut
Oaks	35.0	23%	33.0	17%	3,150	17%	327,600
Maple red	18.0	12%	65.0	33%	503	3%	52,312
Pine WHITE	30	19%	16	8%	5,700	30%	592,800
Misc White pine suppressed, etc	9	6%	22	11%	0	0%	0
Birch black	3.0	2%	7.0	4%	NA	NA	NA
Total to cut	95	61.3%	143	72%	9,353	50%	972,712

Species to keep	BA to keep	% of total type BA	Trees to keep per acre	% of total trees per acre in type
Oaks	9.0		8.0	
Pine WHITE	44.0		18.3	
Hemlock	2.0		1.0	
Birch yellow	3.0		29.0	
Total to keep	58	37.4%	56	28%

Table 4a: Approximate Acreages, Ludlow Forest

Acres	Feature
1,797.6	Total Ludlow property not including canals
-402.7	Springfield Reservoir
-28.9	Operations facilities including buildings, filters and ponds
1,366.0	Ludlow forest area

Table 4b: Approximate Acreage for Normal Silviculture, Ludlow Forest

Acres	Feature
1,366.0	Ludlow forest area
-73.3	100'-buffer around reservoir (not include treatment area)
-393.6	Combined wet soils plus streams, wetlands and 100'+ filter strip buffer around streams & wetlands
466.9	Area not suitable for normal logging
899.1	Area potentially available for logging
-62.0	Gunnery (may contain metal fragments)
-87.3	Stand 6 (interpersed wet areas & invasives)
837.1	Area <i>potentially</i> available for logging after deducting Gunnery & Stand 6
602.4	Approximate Acreage Selected for Normal Silviculture
44.1%	Approximate Acreage Selected for Normal Silviculture as % of Total Land Forest Area
72.0%	Approximate Acreage Selected for Normal Silviculture as % of Area Potentially Available for Logging
763.6	Area of Ludlow Forest not included in Normal Silvicultural acreage
55.9%	Area of Ludlow Forest not included in Normal Silvicultural acreage as %

Table 4c: Forest Types and Approximate Acreages, Ludlow Forest

Type	Acres	% of Total Forest Acres	Description
OH	736	54%	Red oak, other oaks, red maple, other hardwoods, and sometimes white pine
WP	252	18%	White pine with red oak, other oaks, red maple, other hardwoods
RM	252	18%	Red maple with yellow birch, also red oak, sugar maple, white ash, a minor amount of hemlock, and sometimes white pine.
SM	105	8%	Sugar maple with red maple, yellow birch, white ash, and sometimes white pine
HK	21	2%	Hemlock overstory and midstory with a hardwood mix and white pine
Total	1,366	100%	

Table 5: Forest Stands, Ludlow Forest

Section	Acres	Approximate Acres Recommended for Logging	% of stand acres
1	403.8	145.5	36%
2	283.4	205.4	72%
3	43.7	33.4	76%
4	57.7	36.4	63%
5	351.6	181.8	52%
6	87.3	0	0%
7	104.9	0	0%
Total	1,332	602.5	45%

Table 6a: Logging by Subsections

STAND	Sub-section	Total AC to cut	Priority	Group (sections possibly grouped into single sale)	Phase (based on timing)	Timing	Considerations
1	1.1	51.1	1	1	1	winter 2018-2019	chance to regenerate
1	1.2	7.5	1	1	1	winter 2018-2019	chance to regenerate and develop landing / turn around
1	1.3	80.3	2	2	3	unknown	remote, chance to regenerate & thin, invasives at landing and truck road, need to improve road
1	1.4	6.6	1	3	1	winter 2018-2019	roadside area
2	2.1	10.6	2	4	3	summer 2019	remote, but private abutter, chance to regenerate
2	2.2	22.4	1	4	3	summer 2019	roadside area, chance to regenerate
2	2.3	122.6	1	4	3	summer 2019	roadside area plus chance to regenerate & thin
2	2.4	45.1	1	5	1	winter 2018-2019	chance to regenerate
2	2.5	3.8	1	4	2	Spring 2019	roadside, chance to regenerate
2	2.6	0.8	1	6	2	Spring 2019	roadside area plus chance to regenerate
3	3.1	33.4	1	7	2	Spring 2019	roadside area plus chance to regenerate
4	4.1	17.5	1	6	2	Spring 2019	chance to regenerate
4	4.2	18.8	1	6	2	Spring 2019	chance to regenerate
5	5.1	110.7	2	8	3	unknown	remote, chance to regenerate, invasives at landing
5	5.2	49.1	1	3	1	winter 2018-2019	roadside area plus chance to regenerate
5	5.3	15.3	3	8	3	unknown	invasives, chance to thin
5	5.4	6.7	3	8	3	unknown	small but chance to thin, possible landing for 5.1 & 5.2
Total	17	602.4					

Table 6b: Volumes to Cut by Subsections

Sub- section	Total AC to cut	Estimated Total Timber to Cut in Sub- section (Mbf)	Estimated Total Cords to Cut in Sub- section (cords)
1.1	51.1	453	307
1.2	7.5	66	45
1.3	80.3	720	482
1.4	6.6	58	40
2.1	10.6	95	64
2.2	22.4	204	134
2.3	122.6	1,109	736
2.4	45.1	400	271
2.5	3.8	34	23
2.6	0.8	7	5
3.1	33.4	295	200
4.1	17.5	155	105
4.2	18.8	170	113
5.1	110.7	979	664
5.2	49.1	434	295
5.3	15.3	135	92
5.4	6.7	59	40
17	602.4	5,373	3,615

Table 6c: CH 132 Narrative Page designation of Trees

Oak-Hardwood Forest Type: Salvage & Regeneration Release

Describe Trees To Cut			Describe Trees To Keep			%BA/AC	
Species	Size	Quality	Species	Size	Quality	CUT	KEEP
Oaks	any	poor health		any	healthier	79%	21%
Maple red	all	all				100%	0%
Pine WHITE	any	poor health		any	healthier	50%	50%
Birch black	all	all				100%	0%
Hemlock	None			all		0%	100%
Birch yellow	None					0%	100%
Maple sugar	None					0%	100%
Hickory pignut	None					0%	100%
Birch paper	None					0%	100%
Hickory shagbark	None					0%	100%
Total as % of BA						76%	24%
Total BA						99	31

Table 6d: CH 132 Narrative Page designation of Trees

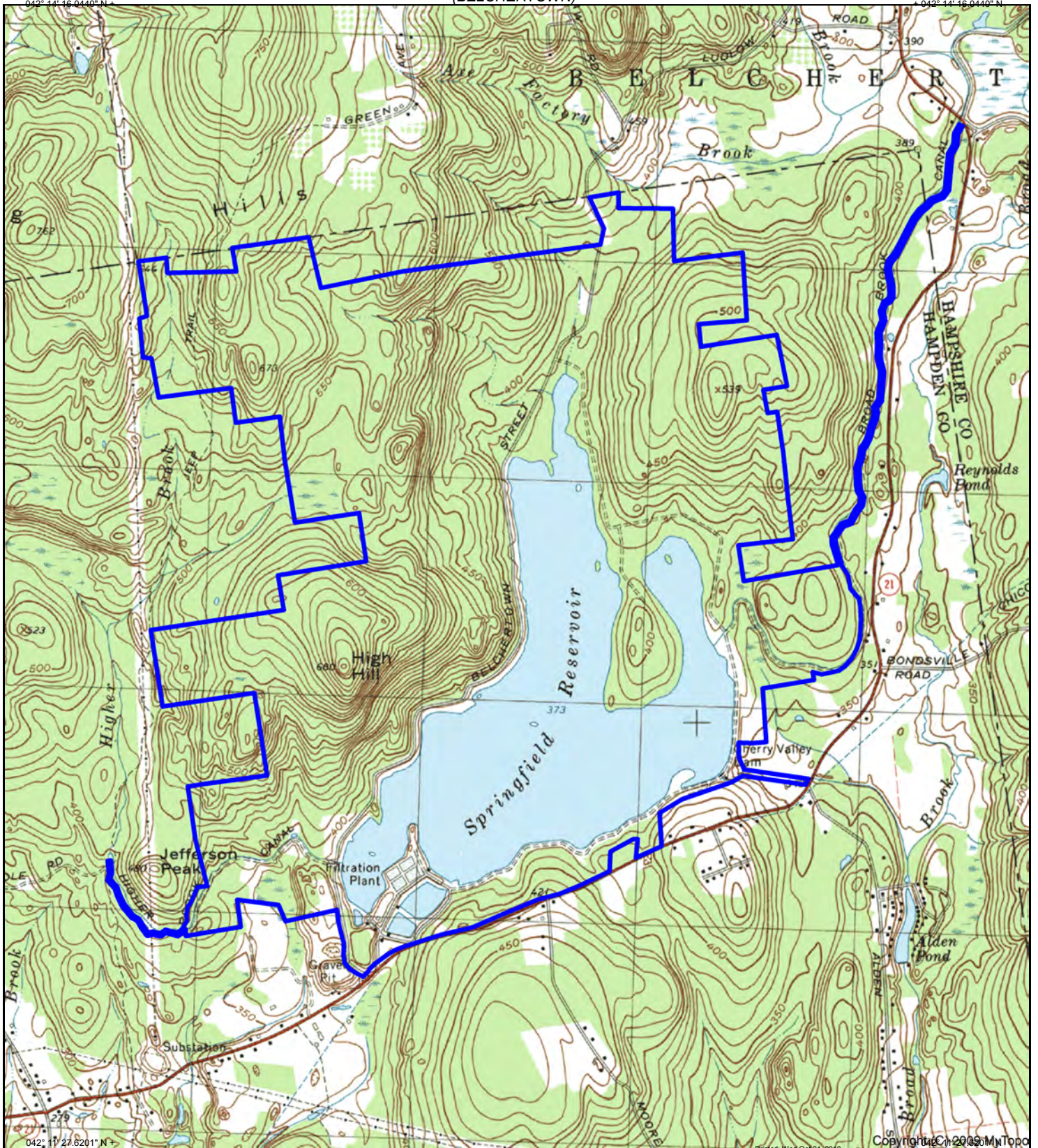
White Pine & Hardwood Type: Thin & Salvage

Describe Trees To Cut			Describe Trees To Keep			%BA/AC	
Species	Size	Quality	Species	Size	Quality	CUT	KEEP
Oaks	any	poor health		any	healthier	78%	22%
Maple red	all	all				100%	0%
Pine WHITE	any	poor health		any	healthier	47%	53%
Birch black	all	all				100%	0%
Hemlock	None			all		0%	100%
Birch yellow	None			all		0%	100%
Total as % of BA						61%	37%
Total BA						95	58

072° 27' 16.3310" W
 042° 14' 16.0440" N

(BELCHERTOWN)

072° 23' 52.1727" W
 042° 14' 16.0440" N



042° 11' 27.8201" N
 072° 27' 16.3310" W

072° 23' 52.1727" W
 042° 14' 16.0440" N

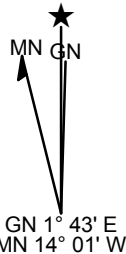
(SPRINGFIELD SOUTH)

Produced by MyTopo Terrain Navigator
 Topography based on USGS 1:24,000
 Maps

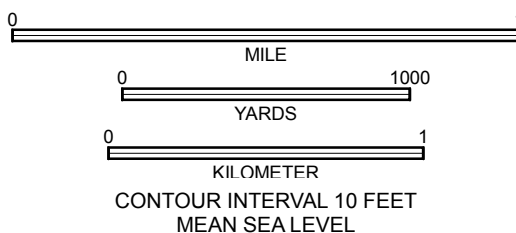
North American 1983 Datum (NAD83)
 Polyconic Projection

To place on the predicted North American
 1927 move the projection lines 10M N and
 39M E

Declination

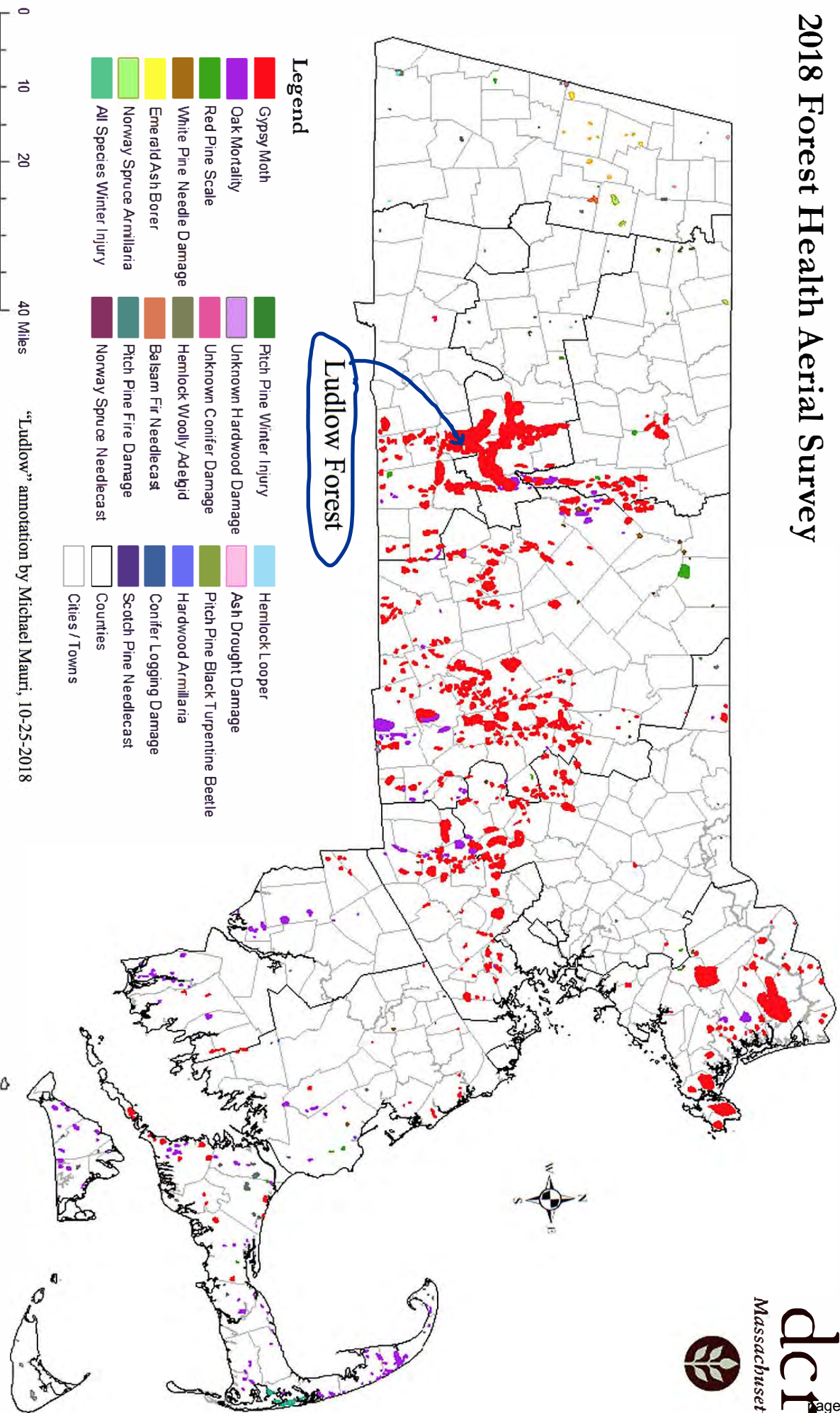


(HAMPTON)
 SCALE 1:24000

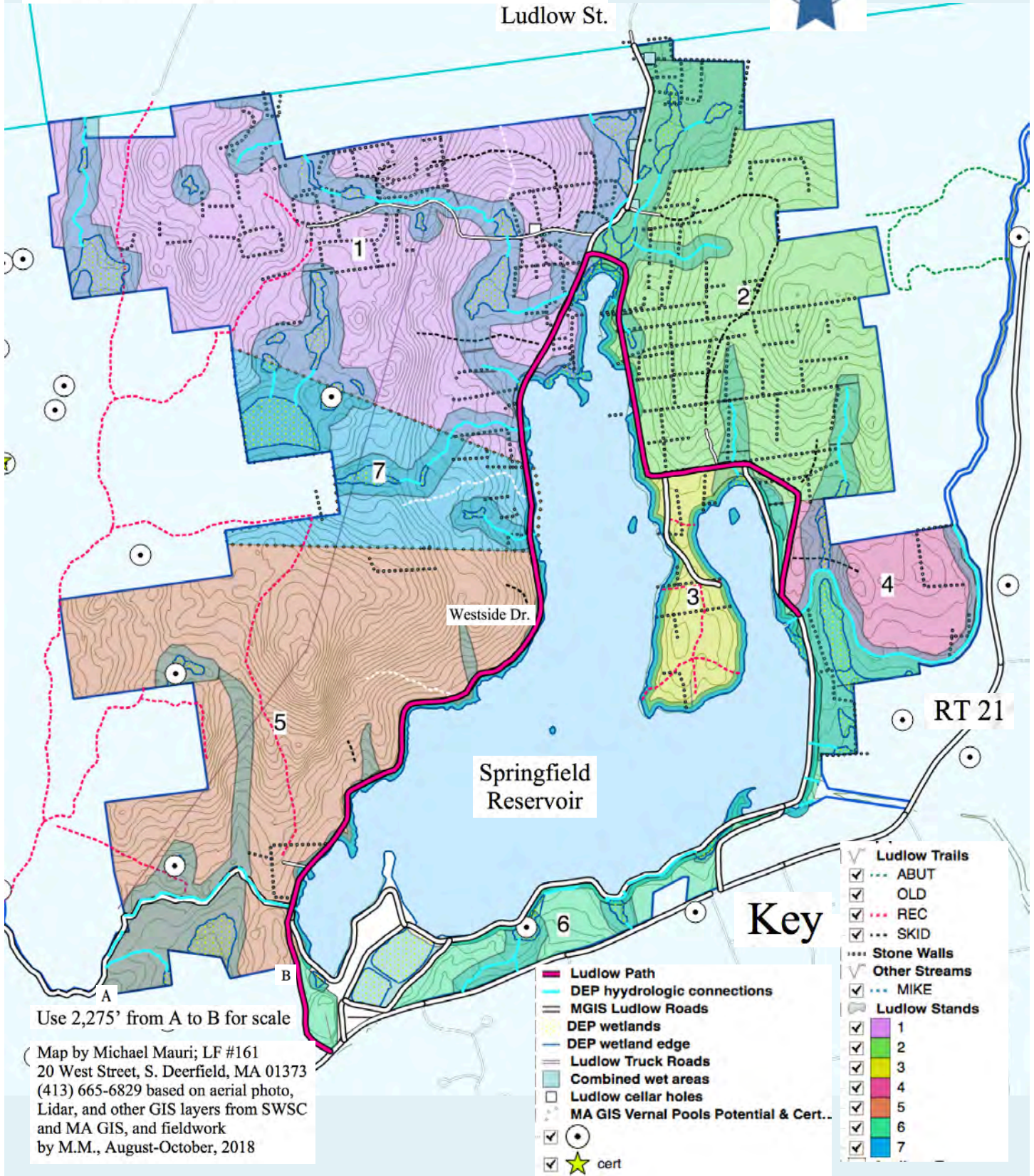


LOCUS MAP, LUDLOW
 FOREST, SPRINGFIELD
 WATER AND SEWER
 COMMISSION, CA. 1,800
 ACRES, LUDLOW, MA; MAP
 BY M.M. 10-24-2018
 page 39

2018 Forest Health Aerial Survey



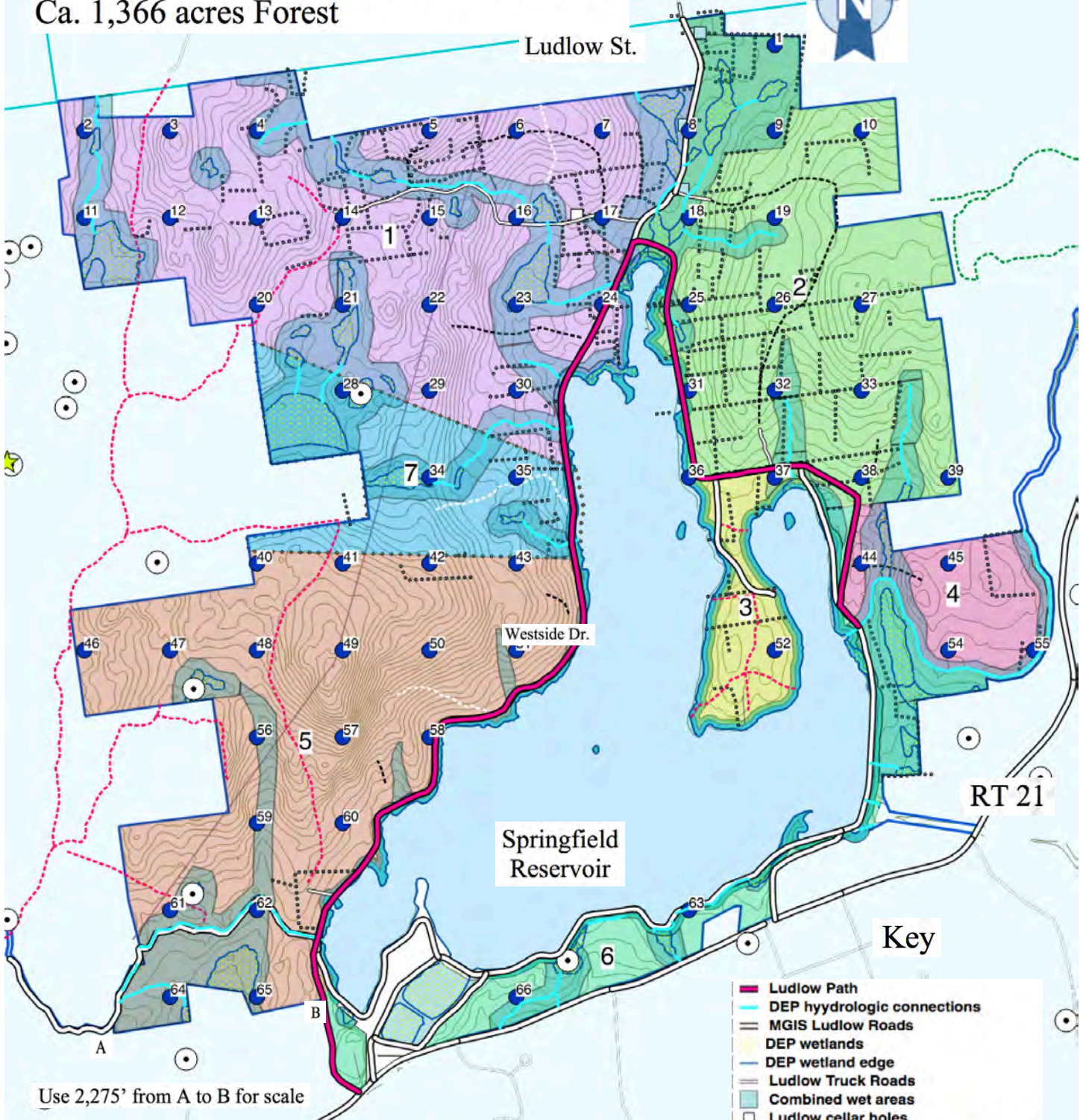
Ludlow Forest Features and Stands
 Springfield Water and Sewer Commission
 Ludlow, MA,
 Ca. 1,800 acres



Use 2,275' from A to B for scale

(Map by Michael Mauri; LF #161
 20 West Street, S. Deerfield, MA 01373
 (413) 665-6829 based on aerial photo,
 Lidar, and other GIS layers from SWSC
 and MA GIS, and fieldwork
 by M.M., August-October, 2018

Ludlow Forest 65-Point Sample Map
 Springfield Water and Sewer Commission
 Ludlow, MA, Ca. 1,800 acres Total Tract,
 Ca. 1,366 acres Forest



Use 2,275' from A to B for scale

Map by Michael Mauri; LF #161
 20 West Street, S. Deerfield, MA 01373
 (413) 665-6829 based on aerial photo,
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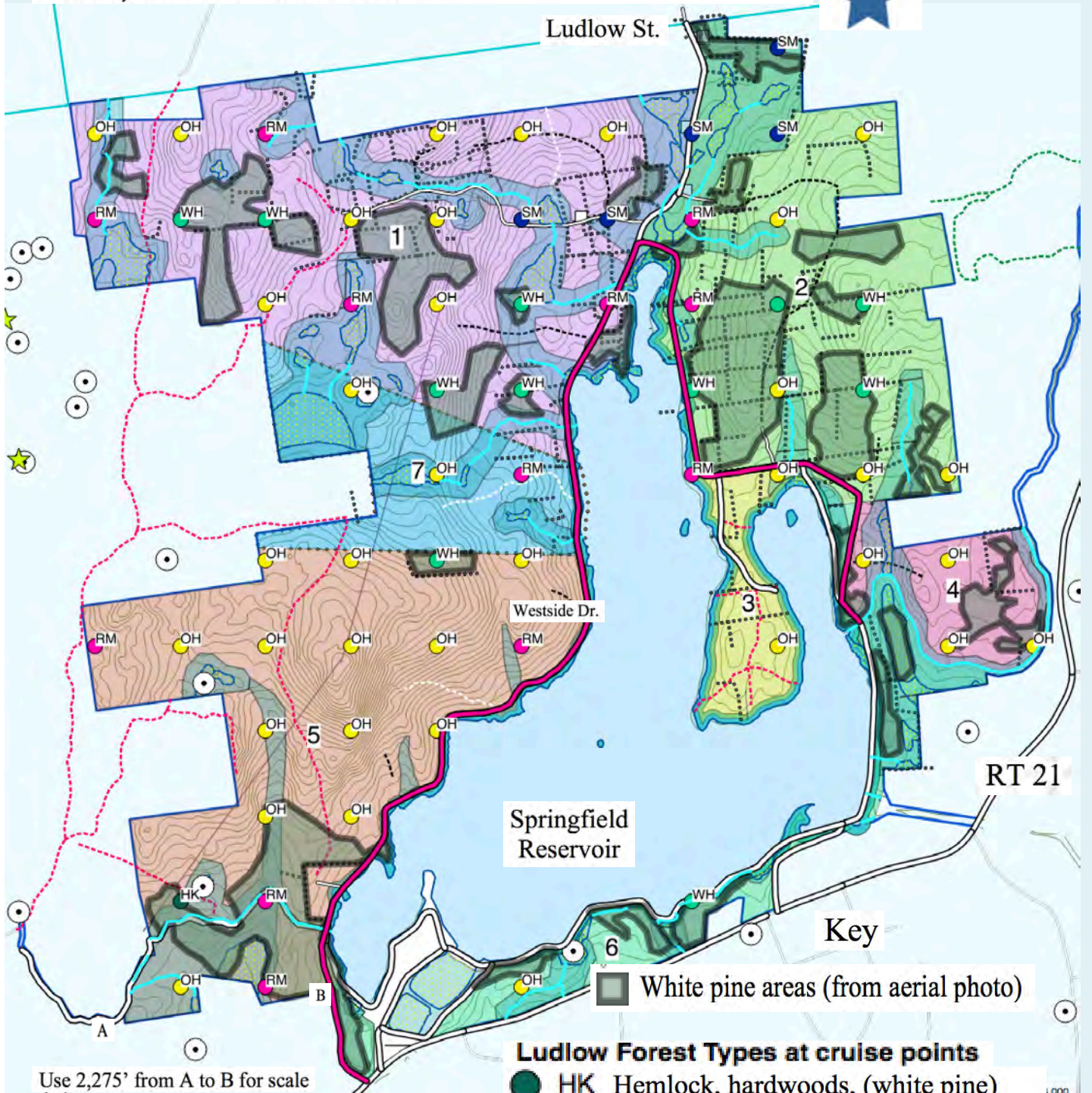
- Key**
- Ludlow Path
 - DEP hydrologic connections
 - MGIS Ludlow Roads
 - DEP wetlands
 - DEP wetland edge
 - Ludlow Truck Roads
 - Combined wet areas
 - Ludlow cellar holes
 - MA GIS Vernal Pools Potential & Cert...
 -
 - ★ cert

● Ludlow cruise points 21-acre

Ludlow Forest - Forest Types at Sample Points

Springfield Water and Sewer Commission

Ludlow, MA, Ca. 1,800 acres Total Tract,
Ca. 1,366 acres Forest



Use 2,275' from A to B for scale

Map by Michael Mauri; LF #161
20 West Street, S. Deerfield, MA 01373
(413) 665-6829 based on aerial photo,
Lidar, and other GIS layers from SWSC
and MA GIS, and fieldwork
by M.M., August-October, 2018

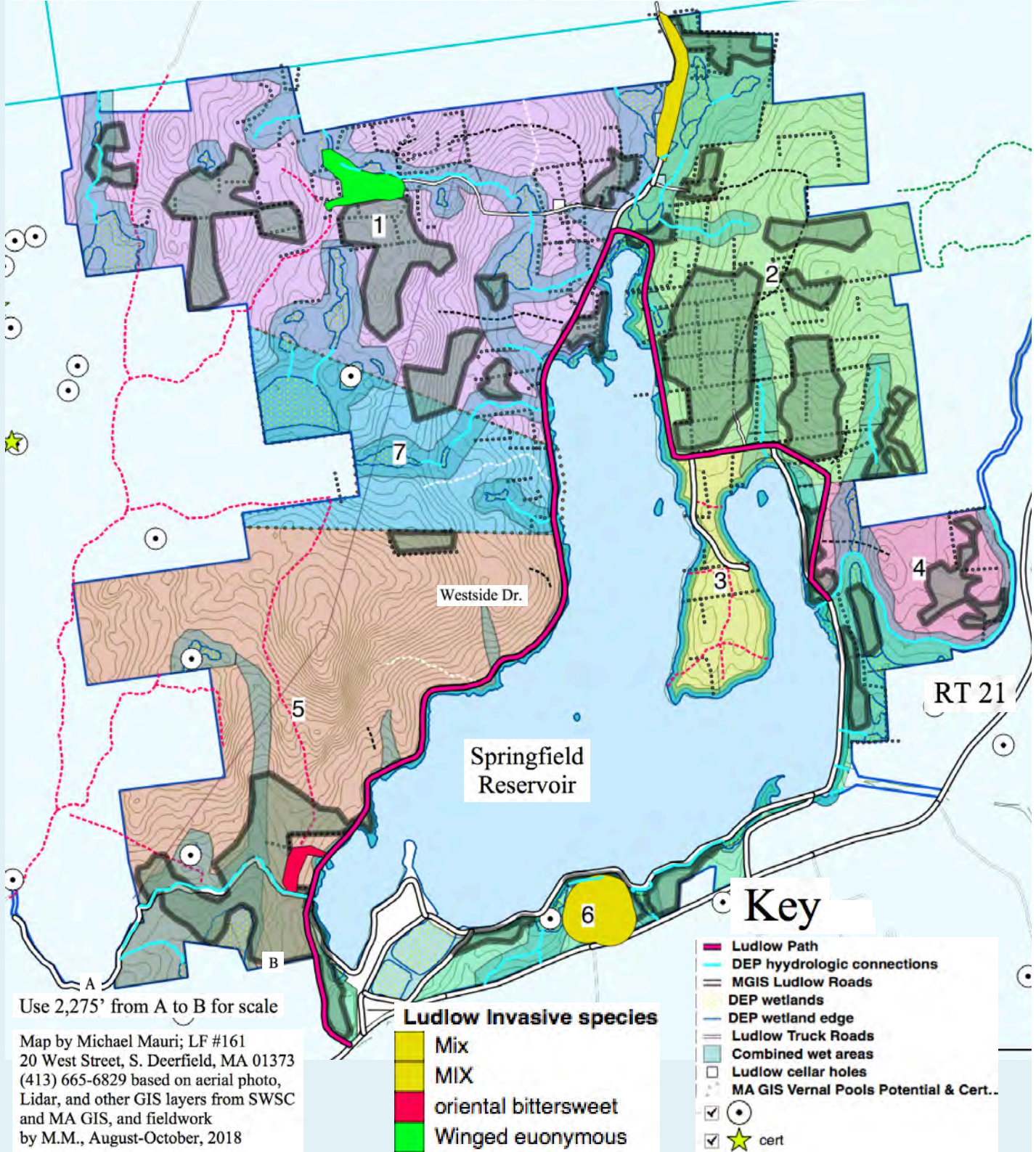
Ludlow Forest Types at cruise points

- HK Hemlock, hardwoods, (white pine)
- OH Oaks, hardwoods, (white pine)
- RM Red maple, hardwoods, (white pine)
- SM Sugar maple, hardwoods, (white pine)
- WH White pine, hardwoods, (hemlock)

White pine areas (from aerial photo)

Ludlow Forest - Noted Concentrations of Invasive Plants
 Springfield Water and Sewer Commission
 Ludlow, MA, Ca. 1,366 acres Forest

(extent of invasives as shown is approximate)



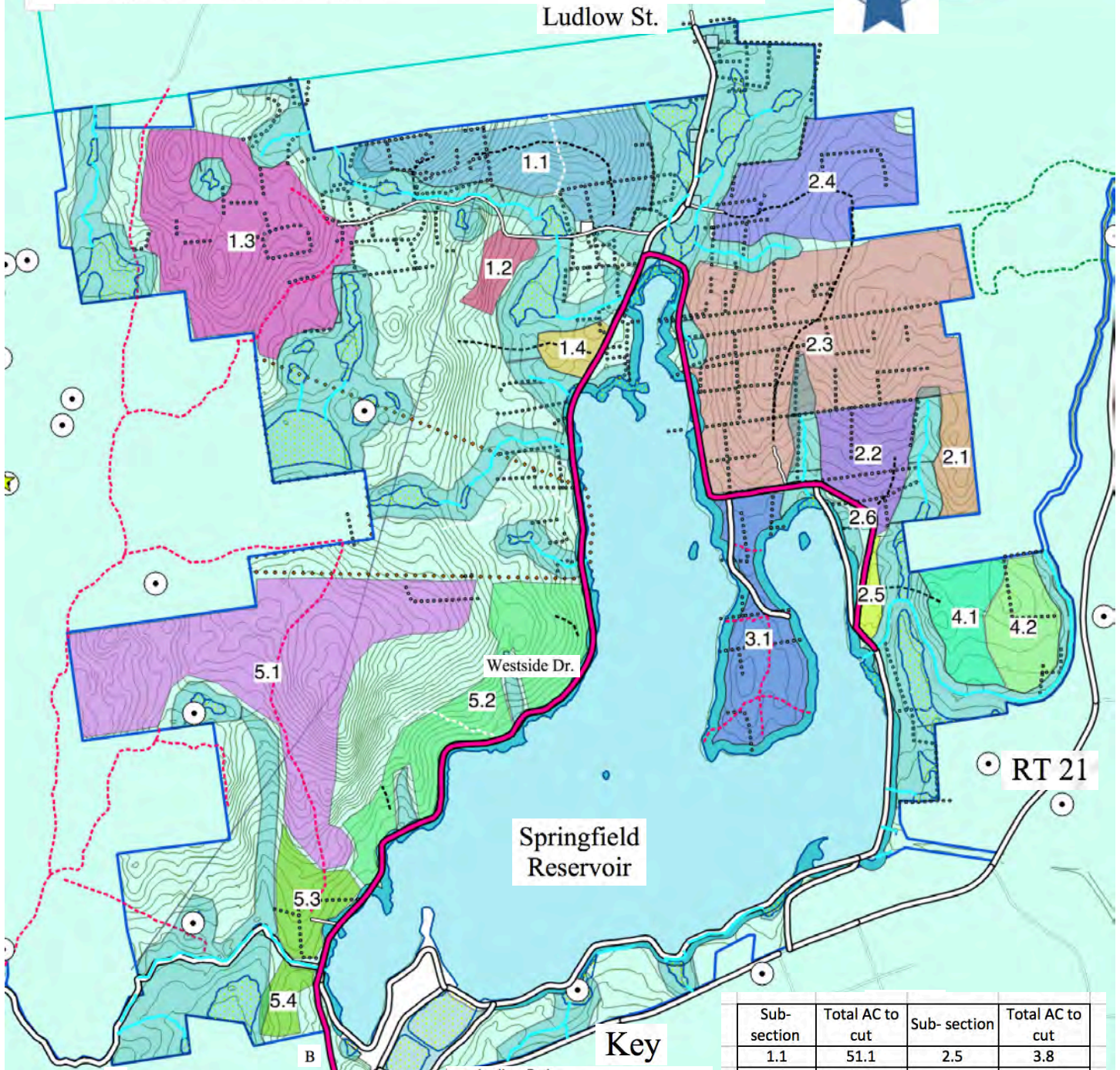
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Ludlow Forest Potential Logging Subsections

Springfield Water and Sewer Commission

Ludlow, MA, Ca. 1,800 acres Total Tract, Ca. 1,366 acres Forest



Use 2,275' from A to B for scale

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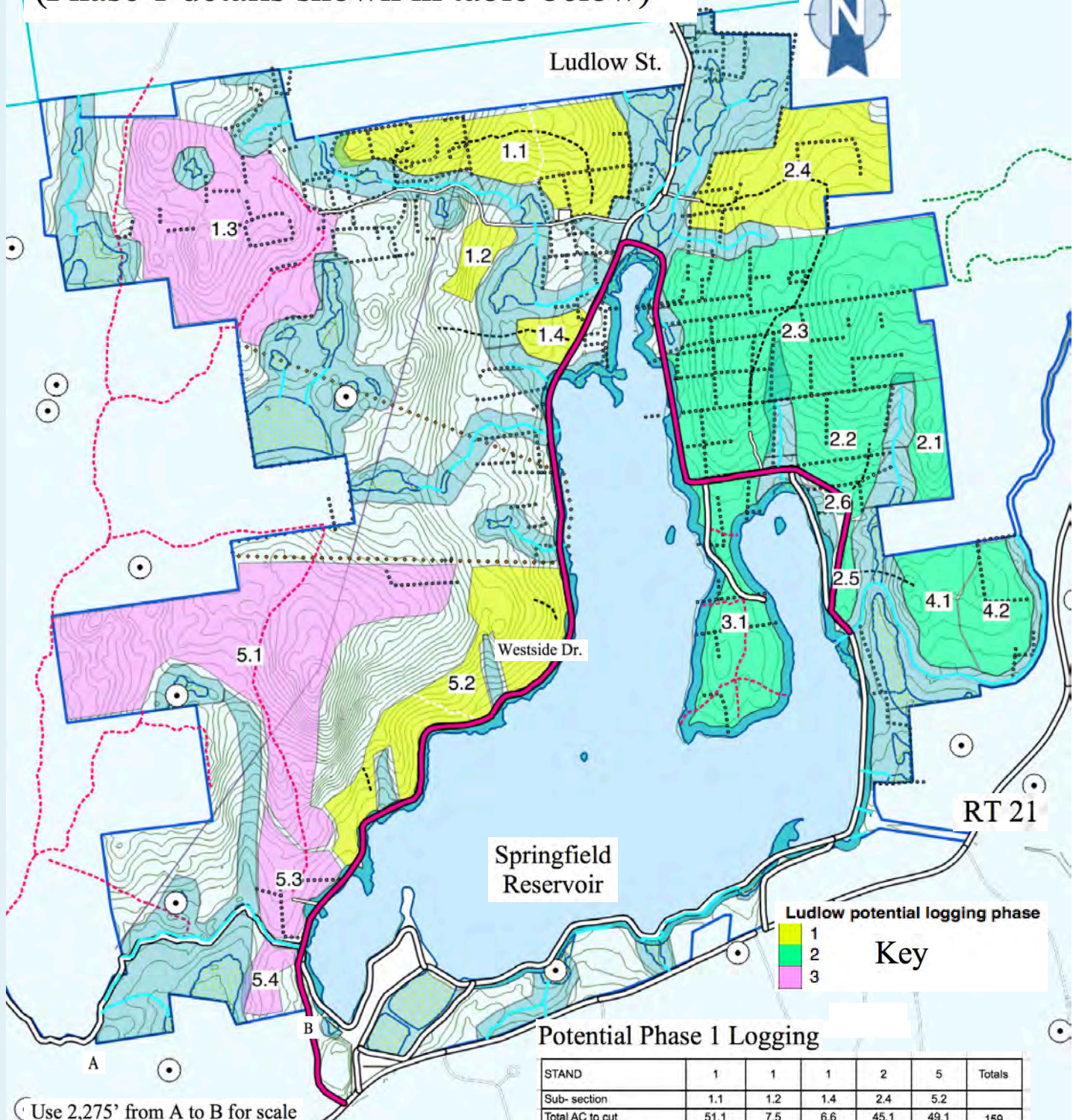
- Key**
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 - cert
 - cert

Sub-section	Total AC to cut	Sub-section	Total AC to cut
1.1	51.1	2.5	3.8
1.2	7.5	2.6	0.8
1.3	80.3	3.1	33.4
1.4	6.6	4.1	17.5
2.1	10.6	4.2	18.8
2.2	22.4	5.1	110.7
2.3	122.6	5.2	49.1
2.4	45.1	5.3	15.3
		5.4	6.7
		17	602.4

Ludlow Forest Potential Logging Phases

SWSC, Ludlow, MA

(Phase 1 details shown in table below)



Ludlow potential logging phase

Key

- 1 (Yellow)
- 2 (Green)
- 3 (Pink)

Potential Phase 1 Logging

STAND	1	1	1	2	5	Totals
Sub- section	1.1	1.2	1.4	2.4	5.2	
Total AC to cut	51.1	7.5	6.6	45.1	49.1	159
Red Oak (Mbf)	287	43	38	249	286	903
Scarlet Oak (Mbf)	60	9	8	53	58	187
White Oak (Mbf)	34	5	4	30	33	105
Black Oak (Mbf)	11	2	1	10	10	34
White Pine (Mbf)	49	5	5	48	36	142
Other Hardwood (Mbf)	13	2	2	11	12	39
Total Timber (Mbf)	453	66	58	400	434	1,410
Total Wood	307	45	40	271	295	957

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