September 17, 2018

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Re: condition of Ludlow Forest after successive gypsy moth defoliations and potential response

Dear Nicole,

As you know, a walk around the SWSC Ludlow forest at this time reveals that a vast number of oak trees are in a state of total or severe defoliation. I originally reported on this in a "brief note" with pictures on August 13, 2018. The defoliation occurred in the spring and early summer, and was caused by feeding of gypsy moth caterpillars which have been in outbreak mode. On July 4, 2018, defoliation was very evident and by then the feeding was complete. The fact that by now, at this later stage of the growing season, most oak trees have not responded by putting out a significant set of new leaves is very concerning. It means that we are looking at a significant degree of outright and imminent mortality. I went to the site on August 8 and again on August 20 and September 14, 17, 20, 21, 22 and 24 to continue to assess the conditions and prepare the findings and recommendations in this letter. On August 8, I saw extensive defoliation from the paved path. On August 20, I assessed backwoods conditions and saw extensive defoliation. On all other dates, as I was assessing options for accessing the property for purposes of logging, I continued to see extensive defoliation in all areas occupied by oak.

At the outset of the fieldwork I measured 9 sample points spread out across the property, while initially walking and observing more than 11 miles of the Ludlow forest between points. The sampling points and walking were adequate, I feel, to give me the up-to-date information needed to prepare this letter. In addition, I have walked on the paved path a number of times and driven its entire length. I combined this information with other information I had gathered in December, 2016, as well as from Google Earth aerial photos, various GIS layers provided by SWSC or obtained from MA GIS, older SWSC records, and in discussion with DCR's Forest Health Supervisor and various loggers.

In the interest of getting you relevant information in a timely manner, I thought it would be fastest to present my key thoughts in a letter. Any supporting pictures, tables and maps referenced in the body of the letter can be found in the attachments section. Going forward, this letter can be expanded into a report as needed.

Here is what we know:

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• This current phase of gypsy moth defoliation began as early as 2016. Defoliation was heavy in 2017 and 2018. It was thought that the population had crashed after 2017, but it did not. Currently, there are gypsy moth eggs cases on trees at the Ludlow site suggesting that the infestation is set to continue into 2019. The attached pictures with captions give an overview of the situation.

• 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.

• Oaks are ubiquitous and abundant at the Ludlow site, playing a significant role within the forest mix (See Table 1a). Oaks present at Ludlow are mainly red oak and scarlet oak, with less white oak and black 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 the visual effect of the forest. 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 this infestation, oaks have been the most severely impacted. Aspen (bigtooth poplar) may have been affected as well. Other species such as white pine, hemlock, maples, birches and hickories do not appear to have been affected so far.

• Based on field work in August and September, 2018, only about 7% of the oak trees appear to be in a state of normal health (c.f. "more or less normal vigor" in Table 2). About half of the oaks are either already dead or nearly dead. The remainder fall somewhere in between (See Table 2).

• A significant percentage of the oaks are currently dead or in very poor or poor health (See Table 2). About half of those oaks that are dead appear to have died during the current growing season. Many of the oaks in very poor health are likely to be dead by next spring or by the end of the 2019 growing season. Others will likely die over the next several years. Overall, forest-wide, of the 70 oaks per acre, about 38 oaks per acre are either dead, nearly dead, or likely to be dead within one year. Within one year there may be as many as 50,000 dead trees at the Ludlow site. More trees are likely to die in the few years to follow. This estimate is based only on impacts that

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have occurred so far. If another widespread defoliation occurs in 2019, as is anticipated, mortality levels will increase further.

• There is no action SWSC can take to reverse the negative health impacts to individual trees caused by defoliations that have occurred so far. There may be options to slow or spread future defoliations (including in 2019) by applying a microbial pesticide of some kind, perhaps a microbial pesticide (e.g. Btk (*Bacillus thuringiensis var. kurstaki*)), which is applied aerially over a wide area, or in a more focused way along roadsides from a spray truck. This would clearly be an extraordinary measure requiring a lot of research and preparation. Quite separately from this, there are normal, pro-active forestry actions which SWSC can take that can positively influence the future composition and development of the forest (these will be discussed below). It is unlikely that oak will be totally eliminated from the overstory, but when the infestation is finally over, oak will have a shockingly reduced presence and the forest will have been greatly altered.

• A key action SWSC can take is to preserve, at least for now, those overstory oaks that are in better health (c.f. the 7% of oaks with "more or less normal vigor" in Table 2). 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. The current young oak trees are under intense pressure (from browsers, the encroachment of hayscented fern, the threat of non-native invasive plants, and other interfering factors) and may only be present and viable for cultivation for a brief window of time. Timeliness is an important element in a response because the ability of the forest to produce more oak seedlings in the near future is greatly compromised by the reduction in the overstory seed source. The new growing space will quickly fill with opportunistic plants, many of which are not desirable. As the growing space left in the void of dead or dying oaks is filled, any steps SWSC takes to ensure that a diverse mix of desirable native vegetation occupies the growing space will have benefit for a long time to come. Undesirable vegetation is, by nature, both aggressive and recalcitrant (e.g. non-native invasive plants, hayscented fern, etc.), and can prevent the establish of oaks and other desirable native vegetation. Deer (and moose) often play a supporting role by selectively avoiding undesirable vegetation while eliminating oaks and other desirable native vegetation. Once undesirable vegetation occupies a site, especially in the presence of deer, it can be extremely difficult and costly to re-establish desirable native vegetation.

• A common reaction to widespread tree mortality is that one must go in on a property-wide binge and "salvage" the timber, i.e. cut and remove, or "log", all of the affected trees. This can have a number of unintended and excessive consequences (i.e. inadvertent over-harvesting and simplification of the forest, excessive site disruption including negative impacts on water quality, a negative public reaction to what seems to be excessive cutting, etc.). At the other extreme, a view of "letting nature take its course" runs its own risks, including the most obvious risks of:

— significant loss of timber value
— allowing hazardous and unsightly conditions to prevail in areas used by the public
— the perception of waste and neglect

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— allowing the site to become occupied by undesirable vegetation
— missing the window of opportunity to promote young oak trees

• In contemplating a response, SWSC will want to take a nuanced look at what to do, including whether, and if so, where, it makes sense to try to cut and remove (i.e. salvage) oak trees and where this does not make sense. In the latter case the decision would be to *tolerate* the mortality. SWSC will also want to take a nuanced look at the silvicultural approach that will guide any cutting so that it is not merely about removing dead or dying trees, but shaping future forest conditions. Factors to consider in making these types of decisions may include the following:

— taking steps that promote diversity and health going forward

— retaining those oaks that seem to be in the best health

— taking advantage of the window of opportunity of current oak seedlings (i.e. release these before these are overwhelmed by partial shade, interfering vegetation and browse)

— as part of the above, supporting any effort to promote young oak trees and overall forest diversity and health by ensuring that non-native invasive plants and other interfering factors do not overwhelm the young trees

— capturing the value of the timber that is dead or dying before it is lost

— reducing the safety hazard of dead trees near the paved pathway

— reducing the unsightliness of large numbers of dead trees

— limiting any salvage harvesting to suitable areas (e.g. areas that are not wet)

— not becoming narrow-minded in salvaging oak but rather using the opportunity of salvage harvesting to accomplish other goals such as thinning (e.g. in white pine)

— developing an outreach program to explain the situation to the public

• An initial, property-level GIS analysis of suitability suggests that about 590 acres are *unsuitable* for logging (e.g. due to being too wet or steep), leaving about 800 acres of potential "backwoods logging" (see Table 4). This backwoods logging acreage is reduced to about 750 acres if the gunnery is taken into account (see note below). Some of these areas have a pine or hemlock component; others are nearly pure oak. Many of the wetter areas (which are generally lumped within the *unsuitable* area) have a strong maple component and thus are not as heavily defoliated as oak areas. In areas near streams (which fall within the *unsuitable* acres), tolerating mortality will have the benefit of contributing large woody debris to streams and filter strips, adding complexity and helping to slow run off and thus protecting water quality. In actual

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implementation it is likely that not all of the potentially suitable acres are truly suitable for logging. Detailed decisions about suitability would be made on the ground and would be indicated with tree marking paint and flagging as in other, normal logging operations SWSC would be likely to do. (Note: An area of roughly 110 acres on the west side of the reservoir has been identified as the "Gunnery", which refers to a WWII-era shooting range fact for weapons fired across the reservoir. These trees may have too much metal in them for purposes of logging and selling timber. The estimated extent of the Gunnery is shown on the attached maps).

• The intensity of cutting could range from almost 4,000 board feet per acre for a "minimum salvage" (cutting most trees with < 25% live crown) to 6,500 board feet per acre for a "intermediate salvage" (cutting most trees with < 75% crown) (See Tables 3a & 3b). In actual implementation, the cutting intensity would most likely vary considerably between openings of various sizes, including large openings sufficient to release oak seedlings, thinned areas, and areas of no cutting.

• An initial estimate of the value to be harvested from a large-scale salvage operation would *normally* be $210,000 or more. This assumes a harvest covering only roughly *300 acres* at a *minimum-salvage* cutting intensity (see above). A salvage harvest at an *intermediate-salvage* intensity covering more acreage could bring in a value that is considerably higher. This value also assumes an average oak timber price of $175/Mbf, as assumption with many caveats (see next two notes below). With other assumptions, the value could be much lower or, potentially, higher. Please bear in mind that there are many contingencies within the above estimate.

• In making any effort to estimate the value of a salvage-harvest, it is important to bear in mind the uncertainty of the market for oak at this time and the downward pressures this brings in terms of price, logger availability, and sawmill capacity. 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. There is a risk that some mills will not take dead oak (cf. Hull Delivered Price Sheet effective September 12, 2018) or will not take oak with no bark, or that they will take the oak but the price will drop significantly.

• The estimate above assumes an average oak timber price of $175/Mbf at this stage for the typical timber at the Ludlow site. Over the recent years, oak has been selling for a much *higher* price. Without current bidding, it is difficult to gauge the value of oak likely to be achieved at this moment. Fortunately there is some current bidding that can serve as a guide. In bidding on oak timber at the Quabbin and Ware River watersheds that closed on September 11, 2018, lots with a significant percentage of dead oak saw competitive bid prices for oak, for four separate lots, as follows:

$239 - $262/Mbf
$177 - $211/Mbf

$100 - $172/Mbf
$80 - $100/Mbf

Each lot had only two bidders. For SWSC logging projects at Ludlow, the average oak timber price could certainly go as low as $100/Mbf, or lower, depending on the condition of the timber at that time, the difficulty of the logging, and the perceived ability of the market to absorb the oak at the time of bidding.

• In the end, the actual volume of timber to be cut would be determined on a tree by tree basis as trees are marked with paint and measured. The actual value would be determined by a competitive bidding process.

• The backwoods logging can be broken down into five separate main projects with separate log landings (See Table 5 and the Potential Salvage Logging Areas map). The main access would be from the north, from the gate at the Belchertown line. Most areas cannot be accessed without trucking on the paved public path.

• The backwoods logging can be further broken down into smaller subsections that typically connect to their own log landing (See Table 6 and the Subsections Most Likely to be Logged map, which shows these areas in pink). This area covers about 462 acres of forest that has a high concentration of oak in poor health and that is also relatively accessible for logging. 19 *potential* landings are shown. Landings are areas where logs are stacked after being brought out of the woods. Log trucks drive onto the landings to pick up loads of logs to be transported to sawmills.

• All operational details (e.g. the exact location of skid roads, landings, etc. as well as the feasible extent of logging) would be worked out during an implementation phase.

• It is important to note, and to explain to the public, that even with significant salvage harvesting, many dead trees will remain at the site, and further decline in live trees may occur. It would be impossible to salvage every dead tree.

• The paved public path at the Ludlow site presents a formidable operational challenge, both in terms of access (i.e. to what extent can the paved path be used during logging?) and aesthetics (the trail is a 3.2-mile-long, 10'-wide, asphalt-paved public vantage point into the forest). Potential salvage harvesting at the Ludlow site falls into two broad categories: normal "backwoods logging" and "trailside logging".

• Much of the trailside area with oak can potentially be accessed by logging in these subsections (see green strips shown alongside the paved path in the Subsections Most Likely to be Logged map) — at least in part. The green strips cover relatively accessible areas falling within 100' of the path which could, potentially, be accessed by backwoods logging. Alternatively, some of these areas may need to be logged using a special logging system designed to minimize impacts to the pavement on the path. This may require some involvement and clean up by the in-house

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crew of branches and other debris that is minor to a logging operation but significant to a trail. It is important to keep in mind that, no matter how good the quality of logging is, it cannot produce the same degree of finish as tree service work. Logging leaves a decidedly much rougher appearance and thus there is a risk in using logging as a tool to cut trees in aesthetically sensitive areas. The potential benefit of logging, if there is one, lies in the ability to get the trees removed without having to pay a significant out of pocket cost.

• On September 15, I conducted a windshield count of oaks estimated to be within 25' edge of the path. A distance of 25' was picked as a one of greatest threat to the safety of people on the path. There are about 229 oaks, most of which or on the outside of the path (i.e. not between the path and the reservoir). The immediate path area has less oak per acre than the forest as a whole. If a greater distance is selected to capture all oaks that could possibly impact the safety of the path, e.g. 100 feet, the number of oaks would increase substantially and would likely be well in excess of 1,000 trees.

• Any trailside area with oaks that cannot be addressed by logging in some form would probably need to be addressed using normal tree service methods – which could be very expensive given the large number of trees to be cut – or perhaps by a hybrid logging approach to be developed for this purpose. One potential hybrid logging approach could be to operate on the paved path using rubber-tired logging equipment (rather than tracked equipment or rubber-tired equipment with chains). There are many questions that would need to be answered, including how to effect adequate clean up and how to minimize damage to the blacktop.

• All things being equal, the backwoods salvage logging is an income-generating logging project. Oak, particularly red oak, is normally one of the most valuable timber species in our area. At this time, the market value of oak has been weakened by current international trade relations (e.g. trade war with China) and by a significant increase in the amount of oak being cut due to recent strong prices and most recently by efforts to salvage oak trees impacted by gypsy moths. At this time, some mills are not taking oak, and others have reduced their prices, which often goes hand in hand with being tougher on log grading and restrictive on how much oak a logger can sell. On the other hand, the value of oak declines quickly once the tree is dead or nearly dead. SWSC is in the position of having to quickly sell a significant amount of oak into a weak market. In informal conversations with a number of loggers over the past few weeks, it still seems to me to be possible to conduct a sale of oak at this time. The ability to break the large project down into a number of separate projects – some of them large in their own right - may help ensure that SWSC can bring in the loggers and value that the market can bear at this time.

• Going forward with the backwoods logging, next steps would be to further develop silvicultural concepts and prepare CH 132 Forest Cutting Permits (submitting these to DCR, the Ludlow Conservation Commission, and presumably DFW for review) and to start developing logging specs and bidder lists. Known infestations of non-native invasive plants would ideally be addressed in the most immediate and aggressive way permissible. Some roadwork would need to be done (e.g. culverts checked and gravel/stone brought in to some truck roads). The use of the

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pathway for trucking would need to be verified. Public outreach would be initiated and a safety policy for path use would be developed.

• Early in the process, a decision would need to be made about the use of the paved path. Will log trucks be allowed to drive on the path? Will rubber-tired logging equipment be allowed to operate on the path? A "no" to either of these questions would place significant restrictions on the ability of SWSC to accomplish the logging.

• The recommended level of cutting would be intermediate salvage (cf. Table 3). In this scenario, oaks with a 75% live crown or greater would be retained. It is important to note that even with a crown > 75%, there is a possibility that some or many of these trees will not survive.

• Subsequent steps would include marking timber to cut, preparing bidding materials and putting projects out to bid. The objective would be to be able to start logging this winter (2018-2019). Public outreach would continue.

• Further subsequent steps would include supervision of logging and bringing each project to a satisfactory close.

• Meanwhile, hazard reduction along the path would occur on those areas that cannot be addressed by backwoods logging, probably as a stand-alone project within a special trailside logging zone, or possibly as a large-scale tree service project.

• Further implementation details are being developed and will be included in a forthcoming proposal.

• It is extremely likely that all of the dozen or so SWSC Belchertown properties are undergoing a similar level of gypsy moth infestation, as this is occurring throughout the wider region. These are smaller parcels scattered along a roughly seven-mile north-south axis. I checked one parcel (Asset ID 168 located on Jabish Canal Rd.) and found a level of infestation similar to Ludlow. The scattered Belchertown properties may be effectively a lower priority than the large Ludlow property, and the cost of action (e.g. salvaging oak) may be a greater than the benefit in many or even all cases. This can be assessed.

• This letter did not examine potential impacts of oak mortality on the canals associated with the Ludlow site.

• Looking ahead, it is unknown whether the gypsy moth infestation will expand westward into the Little River Watershed. As with Ludlow and Belchertown, the SWSC properties in the Little River Watershed feature a significant amount of oak. Some gypsy moth was found in Westfield in 2017 (in a pocket along the Mass Pike, not on SWSC property). This does not mean the outbreak is going to continue spreading, but it might, and therefore it is not too early to begin monitoring for egg cases as part of routine watershed inspections.

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• Ultimately, the maintenance of a diverse forest is the best remedy for gypsy moth or for any other type of pest or pathogen. Accomplishing this is a gradual and ongoing process that is built in to the overarching management program. The Forest Stewardship Plan developed for Middle Brook in 2018, which calls both for favoring a more balanced overstory species mix (de-emphasizing oak to some degree) as well as regenerating the full spectrum of species (including, of course, oak), is an example of this approach.

• In summary, due to the sustained gypsy moth infestation, the condition of the forest at Ludlow is taking a marked turn for the worse. Significant damage has been done, primarily to oak trees, which are very abundant at the Ludlow site. Recent damage cannot be reversed, and, barring an extraordinary spray program or a natural end to the infestation, the latter of which has been expected but has not occurred, SWSC is not able to prevent future further damage to oaks. Eventually, other trees may be impacted. SWSC is not unique in this region-wide situation. A primary response SWSC can take at this time is to salvage-harvest a significant amount of the dead, nearly-dead, or very unhealthy oak, *but only in those areas of the forest that are suitable*. A salvage harvest would have the multiple purposes of removing hazardous and unsightly trees, capturing the timber value contained within those trees, and actively promoting (through the effects of silviculturally-designed logging) greater species diversity in the future forest at the Ludlow site. The 3.2-mile paved path presents a unique challenge within this larger framework because it involves direct interaction between tree cutting and public recreation, and because it involves key infrastructure that was not designed for use in logging operations. A general plan of action is outlined in some of the bullet items above and a more detailed plan will be presented in a forthcoming proposal. The tree health situation in the scattered Belchertown parcels is similar, but actions by SWSC in those may be less practical and/or a lower priority.

I am happy to meet with you and walk through this with you at your convenience.

Sincerely,

Michael Mauri

Picture 1: General view of the canopy showing severe defoliation typical at this time (pic 8-8-2018), as seen from the paved path. Normally at this time of year, the canopy would be dark with foliage. Instead, there are significant gaps. The gaps are oak trees with little or no foliage. Most green foliage is on other hardwoods (hickory, maple, ash, cherry), and on white pine and hemlock.

Picture 2: View up at defoliated oaks surrounded by red maple and other hardwoods, as seen in the forest interior. Despite having a few leaves and technically still alive, these oaks are unlikely to leaf out again next year. In effect, trees such as this are all but dead.

Picture 3: Typical view of a concentrated area of defoliated oaks as seen from the paved path, August 8, 2018. The 2018 defoliation follows a severe defoliation in 2017. This consecutive defoliation has placed oaks under extreme stress. Trees with no foliage or minimal foliage at this juncture are likely to be dead or to die imminently. (Broken branches on some trees most likely stemming from the 2011 Halloween snowstorm are evident on some trees).

Picture 4: Concentrated area of defoliated oaks next to the paved trail/road. Most oaks observed on 8-8-2018 had little or no foliage. This was still true on 8-20-2018. Normally, the paved path would be in dense shade at this time of year.

Picture 5: Another concentrated area of defoliated oaks next to the paved trail/road, as viewed on 8-20-2018. Normally, the sky would not be visible through the trees at this time of year.

Picture 6: Gypsy moth egg cases (8-20-2018) on oak tree on SWSC property boundary (blue paint). Markings from older egg cases are visible above. The tree and its neighbor (to the left) have almost no live foliage.

Picture 7: Concentrated area young white pine that is dead. While overstory white pine have survived recent years of defoliation by a set of needle fungi, many of the young white pine trees have succumbed to a combination of needle fungi, a stem fungus, and drought. As a result, the amount of white pine ready to be recruited into the overstory has been greatly reduced. Also, there is very little hemlock available to be recruited. The future forest is likely to be dominated by hardwoods (e.g. oaks, maples, birches, cherry, poplar). Actions that can be taken by SWSC at this time can enhance the diversity of the future hardwood mix and are discussed in the letter.

Picture 8: An example of a nearly 3’-thick layer of hayscented fern, which blankets some but not all areas of the Ludlow forest (8-20-18). Hayscented fern is a native interfering plant that can prevent the establishment and survival of tree and shrub seedlings as well as herbaceous vegetation, greatly reducing diversity. Hayscented fern seems to be thriving and spreading with the increases in filtered light caused by the gypsy moth defoliation. Heavy disturbance that causes a flush of blackberries can ultimately shade out hayscented fern and later give way to tree seedlings. If deer browse is heavy, the blackberries will be eliminated before the fern is shaded out. If all else fails, a glyphosate treatment in August is known to be very effective at killing hayscented fern.

Picture 9: In other areas the understory is in a more neutral (mostly bare leaf litter) or even positive condition, with desirable native plants such as huckleberry and lowbush blueberry (left) (note some hayscented fern) and prickly dewberry, or oak and hickory seedlings (right) that could be released. The presence of these oak seedlings offers a window of opportunity: attempting to release these at a large

enough scale is the best chance of securing these for a future overstory before they succumb to browse, interfering vegetation, and shading.

Picture 10: Invasive plants are a serious concern in Ludlow. These non-native plants interfere with the normal functioning of the forest. Fortunately, at the Ludlow site, most of the invasive plants seem to be concentrated along existing roadways (including the paved path), and are not widespread in the woods. The picture above shows Japanese knotweed on the old log landing in the northwest part of the site.

Picture 12: This pic taken along the old truck road to the landing shown in the previous picture shows hayscented fern in the foreground and a thick, dark green midstory of burning bush (winged euonymous), a non-native invasive shrub, underneath the tall trees. It is not readily perceptible, but stems of burning bush are sticking up through the hayscented fern in what is a roadside strip maintained by brush hogging. Without a decisive intervention to eliminate the fern in non-native invasive from a site such as this, an area such as this will not be able to grow trees and effectively will not be functioning as a forest. Other invasives noted include bittersweet, honeysuckle, barberry, autumn olive, and multiflora rose.

## Table 1a: Forest Composition Ludlow
## All Live Trees ≥ 1"Diameter (Dbh.)

SWSC Ludlow Compartment, Ludlow MA, August, 2018, 9 plots

**Species Listed from Highest to Lowest % Basal Area**

| Species | Basal Area | | | Trees per acre | | | 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** | **47** | **34%** | **34%** | **40** | **40** | **22.1%** | **14.6** | **14.6** |
| **Oak scarlet** | **24** | **18%** | **18%** | **20** | **20** | **11.0%** | **14.9** | **14.9** |
| Hemlock | 13 | 10% | | 31 | | | 8.9 | |
| Pine WHITE | 11 | 8% | | 5 | | | 20.9 | |
| **Oak white** | **7** | **5%** | **5%** | **4** | **4** | **2.4%** | **16.7** | **16.7** |
| Maple red | 7 | 5% | | 7 | | | 13.4 | |
| Birch yellow | 4 | 3% | | 12 | | | 8.2 | |
| Ash white | 4 | 3% | | 4 | | | 14.5 | |
| Hickory pignut | 4 | 3% | | 33 | | | 5.0 | |
| **Oak black** | **4** | **3%** | **3%** | **5** | **5** | **2.8%** | **12.6** | **12.6** |
| Birch paper | 4 | 3% | | 14 | | | 7.6 | |
| Maple sugar | 2 | 2% | | 2 | | | 15.0 | |
| Birch black | 2 | 2% | | 6 | | | 8.0 | |
| Totals | 136 | 100% | **61%** | 183 | **70** | 38% | 11.7 | **14.7** |

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

SWSC Ludlow Compartment, Ludlow MA, August, 2018, 9 plots

**Species Listed from Highest to Lowest % Basal Area**

| Species | Timber Volume | | | Timber Value | | |
|---|---|---|---|---|---|---|
| | Timber per acre (bf) | Timber Oak Only Per Acre (bf) | **Oak as % of total timber** | Est. Value per Mbf | Est. Value per Acre | Oak as % of total timber |
| **Oak RED** | **4,493** | **4,493** | **39%** | $225 | $1,011 | 53% |
| **Oak scarlet** | **2,055** | **2,055** | **18%** | $150 | $308 | 16% |
| Hemlock | 601 | | | $50 | $30 | |
| Pine WHITE | 2,676 | | | $120 | $321 | |
| **Oak white** | **706** | **706** | **6%** | $150 | $106 | 6% |
| Maple red | 360 | | | $50 | $18 | |
| Birch yellow | 0 | | | $0 | $0 | |
| Ash white | 267 | | | $150 | $40 | |
| Hickory pignut | 0 | | | $50 | $0 | |
| **Oak black** | **241** | **241** | **2%** | $125 | $30 | 2% |
| Birch paper | 0 | | | $25 | $0 | |
| Maple sugar | 228 | | | $200 | $46 | |
| Birch black | 0 | | | $75 | $0 | |
| Totals | 11,627 | 7,495 | **64%** | | $1,910 | 76% |

## Table 2: Apparent Health of Oak Trees (All Species), Ludlow Forest
## All Live Trees ≥ 1"Diameter (Dbh.)

SWSC Ludlow Compartment, Ludlow MA, August, 2018, 9 plots

**Species Listed from Best to Worst Health**

| Crown Condition of Oaks | Basal Area of Oaks | Percent of Oak Basal Area | Oak trees per acre | Percent of oak trees per acre |
|---|---|---|---|---|
| 100% live crown (more or less normal vigor) | 2.2 | 2.7% | 5.0 | 7.1% |
| >75% live crown (health is compromised but may survive) | 4.4 | 5.4% | 7.4 | 10.5% |
| 25%-75% live crown (poor health, many unlikely to survive) | 28.9 | 35.2% | 20.4 | 29.0% |
| <25% live crown (very poor health, may be dead next year) | 22.2 | 27.0% | 14.4 | 20.5% |
| 0%-1% live crown (probably will die this year) | 8.9 | 10.8% | 10.0 | 14.2% |
| Leaves totally brown (tree just died) | 2.2 | 2.7% | 2.0 | 2.8% |
| Snag 2018 (died this year, leafless but with fine branches) | 8.9 | 10.8% | 6.2 | 8.9% |
| Snag pre-2018 (died before this year, no fine branches) | 4.4 | 5.4% | 4.9 | 7.0% |
| Totals | 82.1 | 100% | 70.3 | 100% |
| Range: Dead to very poor health (< 25% live crown) | 47 | 57% | 38 | 53% |

## Table 3a & 3b: Salvage-Harvest Scenarios, Ludlow Forest
## All Live Trees ≥ 1"Diameter (Dbh.)

| Table 3a | 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 | Volume (bf/ac) to cut |
| 100% live crown | | | | | |
| >75% live crown | | | | | |
| 25%-75% live crown | | | | | |
| <25% live crown | 22.2 | 27.0% | 14.4 | 20.5% | 2,020 |
| 0%-1% live crown | 8.9 | 10.8% | 10.0 | 14.2% | 810 |
| Leaves totally brown | 2.2 | 2.7% | 2.0 | 2.8% | 200 |
| Snag 2018 (fine branches) | 8.9 | 10.8% | 6.2 | 8.9% | 809 |
| Snag pre-2018 (no fine branches)* | NA | NA | NA | NA | NA |
| Totals | 42.2 | 51% | 32.6 | 46% | 3,839 |

| Table 3b | Intermediate 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 | Volume (bf/ac) to cut |
| 100% live crown | | | | | |
| >75% live crown | | | | | |
| 25%-75% live crown | 28.9 | 35.2% | 20.4 | 29.0% | 2,630 |
| <25% live crown | 22.2 | 27.0% | 14.4 | 20.5% | 2,020 |
| 0%-1% live crown | 8.9 | 10.8% | 10.0 | 14.2% | 810 |
| Leaves totally brown | 2.2 | 2.7% | 2.0 | 2.8% | 200 |
| Snag 2018 (fine branches) | 8.9 | 10.8% | 6.2 | 8.9% | 809 |
| Snag pre-2018 (no fine branches)* | NA | NA | NA | NA | NA |
| Totals | 71.1 | 87% | 53.0 | 75% | 6,469 |

* Some may be cut, others may be left.

## Table 4: Approximate Acreages, Ludlow Forest

| Acres | Feature |
|---|---|
| 1,807.0 | Total Ludlow property not including canals |
| -402.7 | Springfield Reservoir |
| 1,404.3 | Ludlow land area |
| -80.6 | 100'-buffer around reservoir |
| -393.6 | Combined wet soils plus streams, wetlands and 100' filter strip buffer |
| -57.0 | Steep areas |
| -10.2 | Operations facilities including filters and ponds |
| -48.0 | 100-foot path buffer that is not included in other buffers |
| 589.4 | Area not suitable for normal logging |
| 814.9 | Area potentially available for logging |
| -62.0 | Gunnery |
| 752.9 | Area *potentially* available for logging after deducting Gunnery |

## Table 5: Possible Stands (Harvest Areas), Ludlow Forest

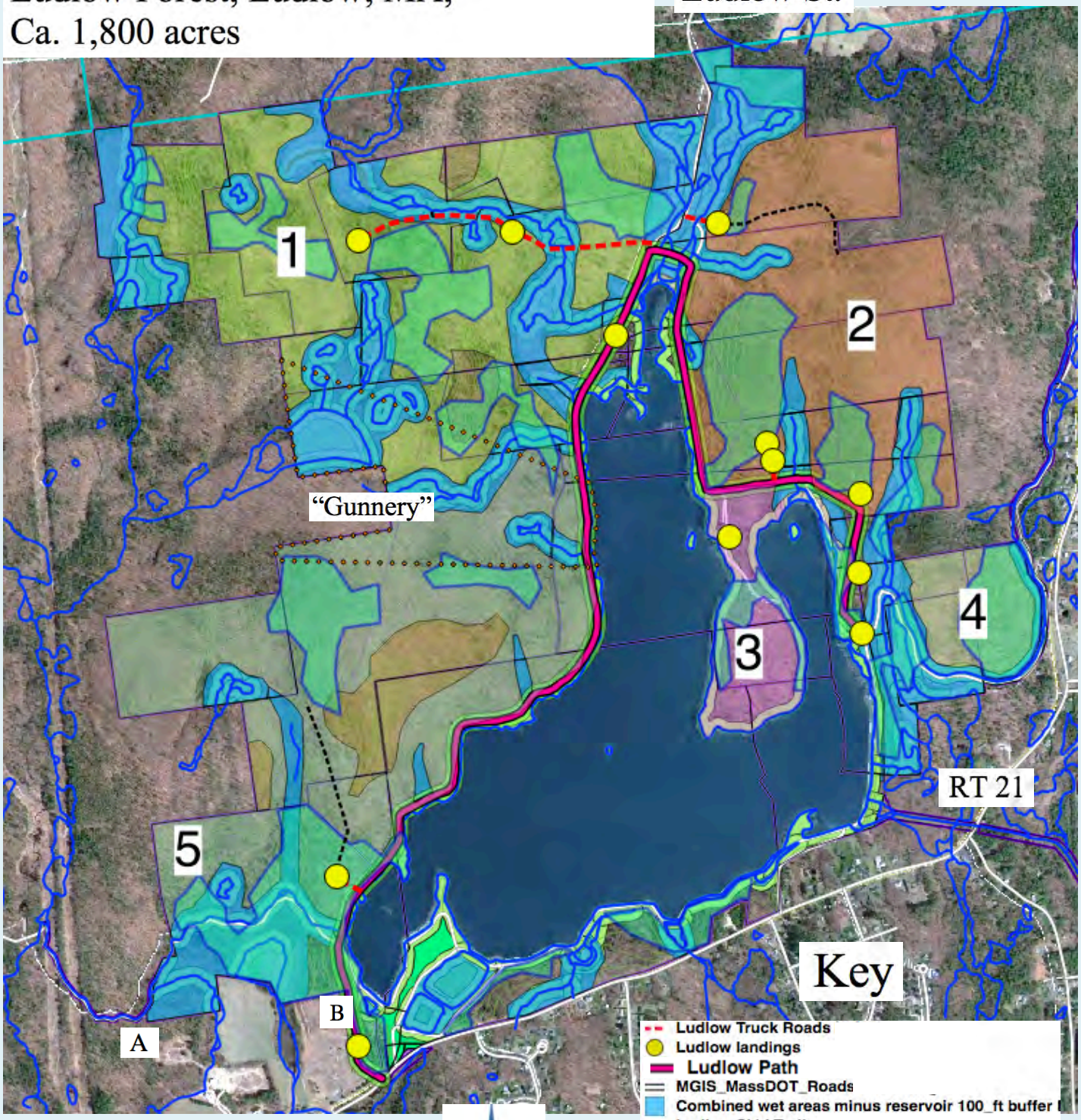
| Section | Acres | Acres minus estimated gunnery range | Most-Likely Harvest Acres (cf. Table 6 subsections) |
|---|---|---|---|
| 1 | 256 | 239 | 87.6 |
| 2 | 209 | 209 | 155.2 |
| 3 | 49 | 49 | 29.7 |
| 4 | 37 | 37 | 42.3 |
| 5 | 277 | 235 | 147.2 |
| Total | 828 | 769 | 462 |

Note: the discrepancy between the total acreage in Tables 4 & 5 can be resolved with further refinement of mapping as needed.

## Table 6: Subsections Most Likely to be Logged, Ludlow Forest

| STAND | Subsection | Acres |
|---|---|---|
| 1 | 1.1 | 45.5 |
| 1 | 1.2 | 6.3 |
| 1 | 1.3 | 22.3 |
| 1 | 1.4 | 13.5 |
| 2 | 2.1 | 23.3 |
| 2 | 2.2 | 10.1 |
| 2 | 2.3 | 73.7 |
| 2 | 2.4 | 43.1 |
| 2 | 2.5 | 4.2 |
| 2 | 2.6 | 0.8 |
| 3 | 3.1 | 29.7 |
| 4 | 4.1 | 20.9 |
| 4 | 4.2 | 21.4 |
| 5 | 5.1 | 111.2 |
| 5 | 5.2 | 36 |
| | Total | 462.0 |

# Potential Salvage Logging Areas
# Springfield Water and Sewer Commission
# Ludlow Forest, Ludlow, MA,
# Ca. 1,800 acres




| Section | Acres |
|---|---|
| 1 | 239 |
| 2 | 209 |
| 3 | 49 |
| 4 | 37 |
| 5 | 235 |
| Total | 769 |

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 Google Earth photo,
GIS layers from SWSC and MA GIS,
and fieldwork with GPS
by M.M., August-September, 2018

# Subsections Most Likely to be Logged
# Springfield Water and Sewer Commission
# Ludlow Forest, Ludlow, MA,
# Ca. 1,800 acres

Ludlow St.

gate

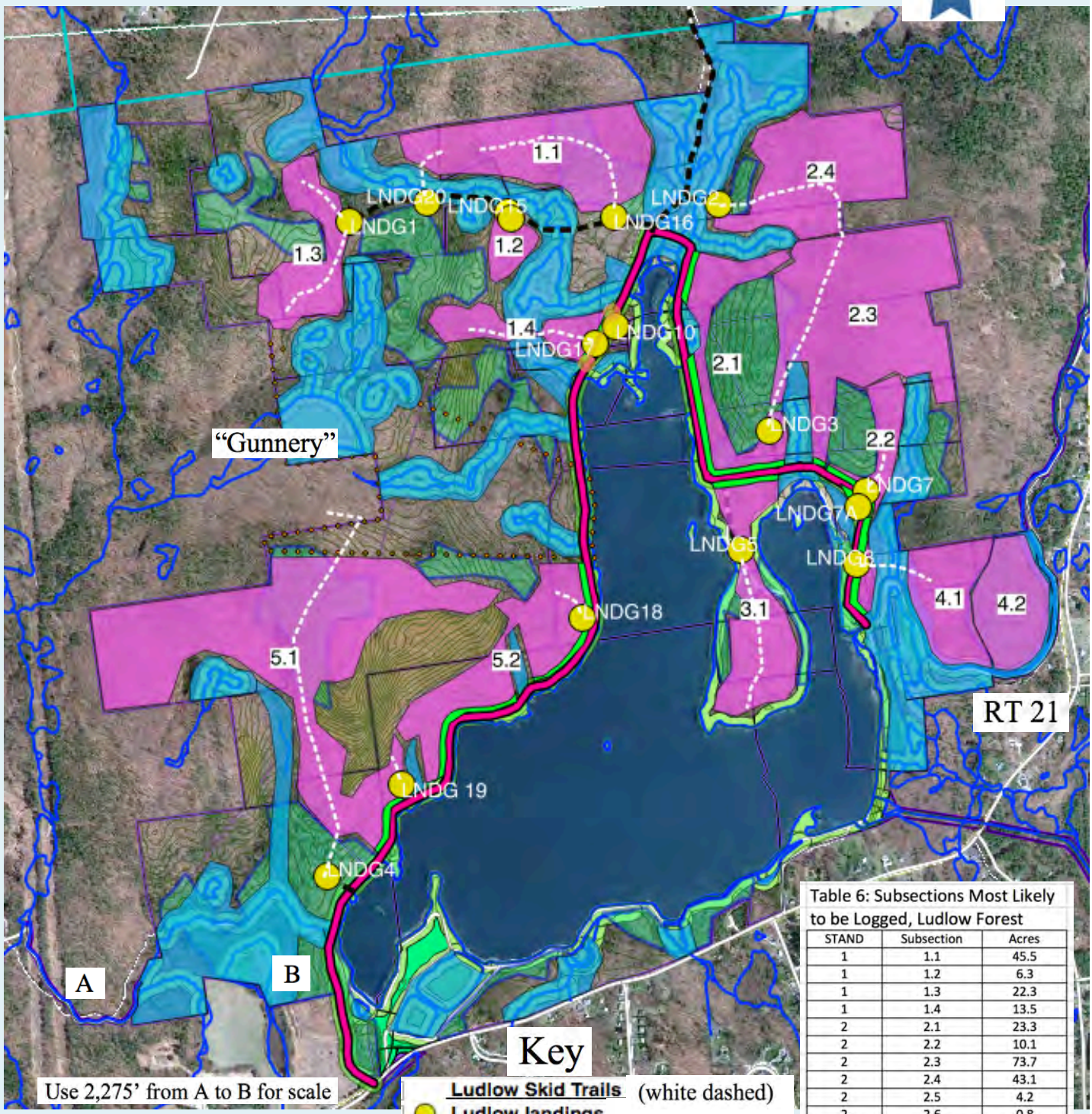



Table 6: Subsections Most Likely to be Logged, Ludlow Forest

| STAND | Subsection | Acres |
|---|---|---|
| 1 | 1.1 | 45.5 |
| 1 | 1.2 | 6.3 |
| 1 | 1.3 | 22.3 |
| 1 | 1.4 | 13.5 |
| 2 | 2.1 | 23.3 |
| 2 | 2.2 | 10.1 |
| 2 | 2.3 | 73.7 |
| 2 | 2.4 | 43.1 |
| 2 | 2.5 | 4.2 |
| 2 | 2.6 | 0.8 |
| 3 | 3.1 | 29.7 |
| 4 | 4.1 | 20.9 |
| 4 | 4.2 | 21.4 |
| 5 | 5.1 | 111.2 |
| 5 | 5.2 | 36 |
| | Total | 462.0 |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