NOTICE OF PUBLIC HEARING
SUDBURY CONSERVATION COMMISSION

The Sudbury Conservation Commission will hold a public hearing under the Wetlands Protection Act and Wetlands Bylaw to Amend the Order of Conditions for DEP file number 301-1256, to consider the use of an organic herbicide to control invasive species at 39 Griscom Road, Sudbury MA; Steve Garanin, applicant. The hearing will be held on Tuesday, September 15, 6:45 pm via Zoom. Please see the Conservation Commission web page for further information.
https://sudbury.ma.us/conservationcommission/meeting/conservation-commission-meeting-tuesday-september-15-2020/

SUDBURY CONSERVATION COMMISSION
August 25, 2020

WEED ZAP®

A Non-Selective Herbicide For Annual Grasses And Weeds

Product Information

WEED ZAP is a contact, non-selective, broad spectrum, foliar-applied herbicide. This product will only control actively growing emerged green vegetation. It controls both annual and perennial broadleaf and grassy weeds. This product does not translocate. It will affect only those plants that are coated with the spray solution.

ACTIVE INGREDIENTS

Clove Oil 45%
Cinnamon Oil................................. 45%
OTHER INGREDIENTS: 10%
Lactose and Water.
TOTAL 100%

KEEP OUT OF REACH OF CHILDREN

This product ingredients are exempt from registration with the Federal EPA under section 25 (b) of FIFRA. **WEED ZAP** has not been registered with the Environmental Protection Agency. JH Biotech, Inc. represents that this product qualifies for exemption from registration under the Federal Insecticide, Fungicide and Rodenticide Act.

International & United States Patents Pending

SHAKE WELL BEFORE USE

NET CONTENTS: 2.5 Gallons (9.45 liters)
Weight per Gallon: 8.4 lb (3.81 kg) @ 68°F
Lot #:

Directions and General Recommendations

APPLICATION RATE TABLE

Add 5 gallons of **WEED ZAP** concentrate to 100 gallons of spray water. Apply enough **WEED ZAP** to cover the entire surface of the weed. Spray to the point of run off. The use of a spreader/sticker may increase contact and efficacy of treatment.

FINAL MIX VOLUME	FL. OZ.
1 Gallon	6.4
5 Gallons	32
10 Gallons	64
25 Gallons	160

Put water into spray tank first, then add **WEED ZAP**. Use constant, brisk agitation. Repeat application as necessary. Coverage is essential to establish control.

PRECAUTIONARY STATEMENTS

Off target application of **WEED ZAP** will result in damage to growing plants. Do not apply this product through the irrigation system or over the top of crops. If using a plastic measuring cup, rinse immediately after use. **WEED ZAP** can soften polystyrene (PS) plastics.
Avoid contact with skin, eyes or clothing. In case of contact, immediately flush eyes or skin with plenty of water. Get medical attention if irritation persists.

PERSONAL PROTECTIVE WORK CLOTHING: Applicators and other handlers of this product must wear: Long sleeved shirt and pants, shoes and socks, protective eyewear and gloves.

FIRST AID

IF SWALLOWED
► Call a Physician or Poison Control Center.
► Drink one or two glasses of water.
► Do not induce vomiting.
► If person is unconscious, do not give anything by mouth or induce vomiting.

IF IN EYES
► Hold eyelids open and flush with a steady, gentle stream of water for 15 minutes.
► Get medical attention if irritation persists.

IF ON SKIN
►Wash with plenty of soap and water.
►Get medical attention if irritation persists.

LIMITED WARRANTY

Manufacturer or seller makes no warranty, whether expressed or implied, concerning the use of this product other than for the purposes indicated on the label. Neither manufacturer nor seller shall be liable for any injury or damage caused by this product due to misuse, mishandling or any application not specifically described on the label.

JH Biotech, Inc.

0239-D-B-1

MANUFACTURED BY: JH BIOTECH, INC. P.O. Box 3538 , Ventura, CA 93006 U.S.A. Phone: 805-650-8933 Website: www.jhbiotech.com

Abutters List
Date: August 19, 2020

print this list

Subject Property Address: 39 GRISCOM RD Sudbury, MA
Subject Property ID: L11-0109

Search Distance: 100 Feet

Prop ID: L11-0023
Prop Location: GRISCOM RD Sudbury, MA
Owner: USA - DEPT OF INTERIOR
Co-Owner: TRACT #267A
Mailing Address:

300 WESTGATE CENTER DR
HADLEY, MA

Prop ID: L11-0024
Prop Location: VICTORIA RD Sudbury, MA
Owner: USA - DEPT OF INTERIOR
Co-Owner: TRACT #442
Mailing Address:
300 WESTGATE CENTER DR
HADLEY, MA

Prop ID: L11-0108
Prop Location: 27 GRISCOM RD Sudbury, MA
Owner: MACKENZIE BRENDAN R & LESLIE A
Co-Owner:
Mailing Address:
27 GRISCOM RD
SUDBURY, MA 01776

Prop ID: L11-0110
Prop Location: GRISCOM RD Sudbury, MA
Owner: PENG FEI & TAIE WANG

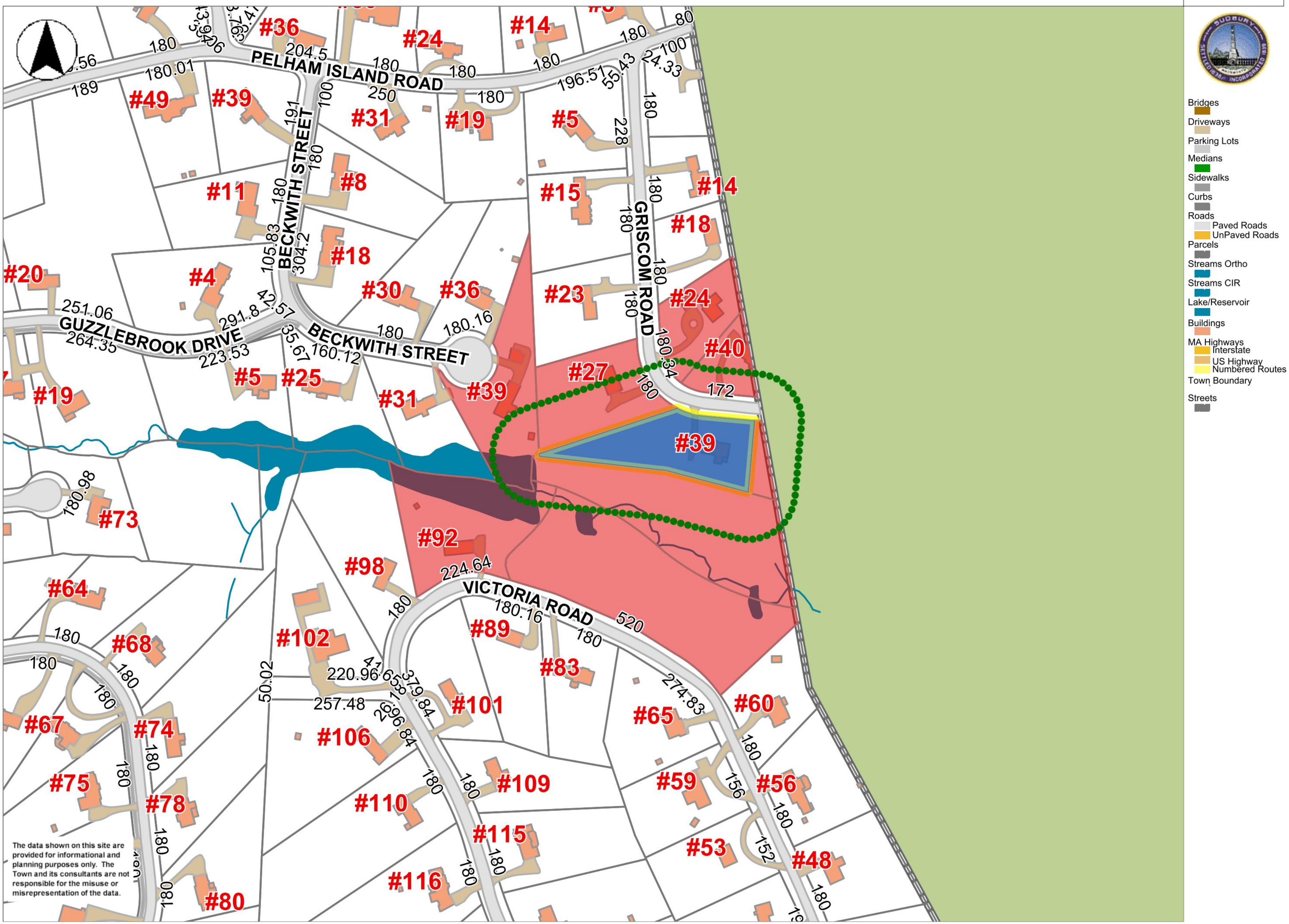
Co-Owner:
Mailing Address:
43 GRISCOM ROAD
WAYLAND, MA 01778

Prop ID: L11-0114
Prop Location: 40 GRISCOM RD Sudbury, MA
Owner: MELNICK SEAN W & SARAH P
Co-Owner:
Mailing Address:
40 GRISCOM RD
WAYLAND, MA 01778

Prop ID: L11-0115
Prop Location: 24 GRISCOM RD Sudbury, MA
Owner: SWIRSKY GERALD R TRUSTEE &
Co-Owner: SWIRSKY GABRIELLE ELLEN MANDEL
Mailing Address:
24 GRISCOM RD
SUDBURY, MA 01776

Prop ID: L11-0308
Prop Location: 92 VICTORIA RD Sudbury, MA
Owner: MORRISSEY JANE K
Co-Owner:
Mailing Address:
92 VICTORIA RD
SUDBURY, MA 01776

Prop ID: L11-0607
Prop Location: 39 BECKWITH ST Sudbury, MA
Owner: NOCE LEONARD & LOUISE
Co-Owner:
Mailing Address:
39 BECKWITH ST
SUDBURY, MA 01776



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Printed on 08/19/2020 at 12:07 PM

Abutters Map

Efficacy and Nontarget Effects of Glyphosate and Two Organic Herbicides for Invasive Woody Vine Control

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Research Article

Efficacy and Nontarget Effects of Glyphosate and Two Organic Herbicides for Invasive Woody Vine Control

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Associate Editor: Chris Evans

ABSTRACT

Mat-forming vines constitute half of invasive plant cover in eastern United States forests. Although glyphosate provides effective control, it has been garnering waning public acceptance due to its potential for harming human health and nontarget organisms, and due to the evolution of plant resistance. Since 67% of eastern Unites States forests are owned by private individuals, finding more acceptable chemical controls for invasive plants is important. Organic herbicides have been used for herbaceous weed control in agriculture. However, there have been no published studies of their efficacy in controlling woody plants or of their potential nontarget effects in natural areas. We compared the ability of two commercially available, organic herbicide formulations (pelargonic acid and cinnamon plus clove oils) against glyphosate to suppress growth of four woody vines, *Akebia quinata*, *Euonymus fortunei*, *Hedera helix*, and *Vinca minor*, in an urban woodland. We also tested whether these herbicides affected soil nematodes and the germination of moss and fern spores from soil. We found that glyphosate killed these vines after two spray treatments, but that a third treatment was needed the next year for the organic herbicides to kill or reduce vines. This reduction lasted into a third summer. We detected no herbicide effects on nematode densities and functional feeding groups, nor on abundance and species richness of moss and fern germinants. Although these organic herbicides cost 5–6.5 times more than glyphosate at dosages used, they greatly reduced these woody vines and can expand choices for chemical plant control for natural areas managers.

Index terms: forest management; glyphosate; invasive vines; moss and fern spore bank; nematodes

INTRODUCTION

Forest fragmentation in the United States has created greater opportunities for being colonized by nonnative plants originating from surrounding agricultural, urban, and other land uses (With 2002; Allen et al. 2013). Using data from the Forest Inventory and Analysis (FIA) plots established by the USDA Forest Service, Oswalt et al. (2015) found that 46% of forest plots in eastern states were invaded by at least one nonnative plant of concern. This disturbing condition was brought into starker relief when actual areal coverage of forests by invasive plants was extrapolated from these FIA plots. In a study of 12 southern states, Miller et al. (2008) calculated that over 7.5 million ha (9%) of forest land was colonized by invasive plants.

Forest fragmentation and invasive plants interact to threaten native biodiversity (With 2002; Pauchard and Shea 2006; Stireman et al. 2014). Once established in forests, invasive plants can alter many ecosystem attributes that can be costly ecologically and economically. These include nutrient cycles (Ehrenfeld 2003; Trammell et al. 2012), forest stand hydrology (Stromberg et al. 2007; Cavaleri et al. 2014), species community composition (Martin 1999; Watling et al. 2011; Rusterholz et al. 2018), and even three-dimensional forest structure (McNab and Meeker 1987; Gorchov and Trisel 2003; Asner et al. 2008).

As invasive plant impacts have grown, so too has the urgency to develop cost-effective control strategies. While colonization prevention and monitoring are the best strategies, once these plants have become established various combinations of physical/mechanical, biological, and chemical methods are needed to remove them (Webster et al. 2006; Miller et al. 2015). In forests owned by corporations, nongovernmental organizations, and government, trained managers use all of these methods. However, forests owned by private landowners may more likely become invasive plant hotspots even if forestry education and training programs are available. For example, in Kentucky, 78% of forest land is owned by individuals, 56% of whom state they take a "hands off" approach to managing their forests (Kentucky Energy and Environment Cabinet 2010). Invasive plant management choices made by private forest owners are not well known. However, if chemical control is their choice, it is probable that glyphosate is used. Glyphosate, marketed in formulations such as Roundup, is well advertised, readily available, and inexpensive. It is also the most commonly recommended and widely applied herbicide for controlling weeds in agriculture and forestry (Andrea et al. 2003; Miller et al. 2015; Benbrook 2016).

Although glyphosate has been an effective herbicide for over 40 y, it is not without its controversies. Three major areas of concern have been raised due to repeated use of glyphosate. These are (1) potential for negatively affecting nontarget organisms, (2) the evolution of plant resistance, and (3) harm to human health. Glyphosate has been used to remove invasive plants successfully (Love and Anderson 2009; Bohn et al. 2011; Schultz et al. 2012) without detectable long-term negative effects on native plant communities in forests (Miller et al. 1999; Carlson and Gorchov 2004; Miller and Miller 2004). However, both direct and indirect effects of glyphosate have been observed on seed germination and seedling root growth of agricultural crops (Hassan 1988; Piotrowicz-Cieślak et al. 2010; Chauhan and De Leon 2014). Glyphosate has been found to completely suppress spore germination in three species of ferns (Aguilar-Dorantes et al. 2015) and to negatively affect growth of fern gametophytes, and young and mature sporophytes. Long-lasting depression of moss and lichen species richness and large changes in their subsequent community compositions were found in an aggrading Ontario forest after a single glyphosate application (Newmaster et al. 1999). It is therefore possible that repeated glyphosate applications can have cumulative negative effects on herbaceous and woody seedling transplantation success (Cornish and Bergen 2005), seed germination, seedling growth and nutrition, and moss and fern community abundance and composition.

Whenever repeated applications of any chemical treatment are needed for weed control, consideration of unwanted side effects on a system's soil species and processes should also be considered as part of the cost–benefit analysis of using the chemical. While herbicides like glyphosate are not normally applied directly to soil, large amounts may reach the soil, especially if sprayers and spray volumes are not strictly controlled (Cornish and Bergen 2005). While the typically reported half-life of glyphosate in soils varies from a few days to 3 mo (Giesy et al. 2000), some studies have shown that glyphosate's soil residence time, and hence some of its residual toxicity, can be 6 mo to more than a year (Heinonen-Tanski 1989; Feng and Thompson 1990; Winton and Weber 1996; Aparicio et al. 2013) depending on soil type, temperature, pH, soil phosphorus, and the soil microbial communities that degrade it (Cornish and Bergen 2005; Zhang et al. 2015).

Therefore, organisms that are part of the soil food web, including bacteria, fungi, earthworms, and nematode worms, can also be affected by glyphosate. Effects on populations and biomass of these organisms have been variable (stimulatory, suppressive, negligible) depending on dosage and whether the study was conducted in the field or in laboratory microcosms (Manachine 2001; Morjan et al. 2002; Liphadzi et al. 2005; Meriles et al. 2006; Ratcliff et al. 2006; Sheng et al. 2012). Due to their intermediate feeding position in soil food webs, nematodes play an important role in channeling energy to organisms at higher trophic levels. Nematodes can also affect the abundances of bacteria, fungi, and other soil organisms by feeding on them. Different species of free-living nematodes tend to be food specialists, eating bacteria, fungi, or other nematodes. As a result, changes in the relative abundance of these different "functional feeding groups" of nematodes and their rapid life cycles make them useful indicators of changes in underlying microbial populations. Nematodes also respond to changes in abiotic soil conditions, such as those caused by pesticide applications. Although herbicide effects on soil fauna have appeared to be transient, most investigations (cited above) have occurred in agricultural systems, not forests, so broader taxonomic and habitat evaluation is warranted.

A second concern over repeated and widespread use of glyphosate is the evolution of plant resistance (GR). Between 1997 (when naturally evolved GR was first discovered) and 2013, 24 plant species throughout the world have naturally developed GR (Shaner 2009; Heap 2014). This includes horseweed (*Conyza canadensis*), a native US species widely distributed in fields and forest perimeters (Shaner et al. 2012). If invasive plants develop resistance, increasing concentrations of glyphosate may become necessary to control them. The probability of undesirable nontarget effects would consequently increase. Over time, glyphosate may have to be retired as a means of invasive plant control, which would greatly diminish our ability to control unwanted plants.

A third reason for concern regarding glyphosate use is the possibility of health risks for people who have applied this herbicide for years. Findings at the epidemiological level have not been consistent (Mink et al. 2011; Alavanja and Bonner 2012; Mink et al. 2012; Schinasi and Leon 2014) and therefore the issue remains controversial and confusing to the public. Guyton et al. (2015) summarized the findings of an international panel (International Research Agency on Cancer, World Health Organization) by stating that although epidemiological studies were inconsistent, animal model studies did show links with cancer. Therefore, the panel concluded that glyphosate was a probable human carcinogen. Subsequently, a number of countries and many cities and counties in 18 US states have either restricted or banned glyphosate use, especially in municipal and public settings (Baum and Hedlund 2018). This negative perception culminated in two trials where California juries found Monsanto (the producer of Roundup) responsible for a municipal worker and an elderly couple developing non-Hodgkin's lymphoma after glyphosate use and awarded them $289 million and $2 billion, respectively, in damages (Charuchandra 2018; Offord 2019). Given that public acceptance of glyphosate may be waning and that so much forested land in many eastern states is privately owned by individuals, less controversial chemical substitutes for glyphosate need to be developed and evaluated for their ability to control invasive plants.

Indeed, a surge in development of more "natural" chemical controls for invasive weeds has occurred recently, largely due to the rise of the organic crop market for which glyphosate is not a sanctioned herbicide. Among these chemical herbicides are those formulations that use naturally occurring plant oils or fatty acids having allelopathic properties (Dudai et al. 1999). Unlike the "systemic" glyphosate, these compounds do not kill plants via metabolic interference, but instead damage foliage by removing the waxy cuticle, causing cellular electrolyte leakage (Tworkoski 2002), desiccation, and "burning." Repeated applications are therefore needed to kill target plants, especially if they are perennial weeds, so that reemerging foliage can be killed again and again until root and stem carbohydrate reserves become depleted and the plant dies. Few factorial studies exist that assess the weed control efficacy and nontarget effects of these organic herbicides under lab or field conditions. The preponderance of existing studies involves annual herbaceous weeds as target plants. So effective dosage concentrations, field volumes, and reapplication recommendations for perennial woody plants, which most often invade forests (Miller et al. 2008), are not well established. The earliest studies used essential oils extracted mostly from culinary herbs and spices that were applied on plant leaf tissues to test if they caused cell death, or if they suppressed seed germination and seedling growth (Dudai et al. 1999; Tworkoski 2002). The oils or fatty acids that have subsequently become formulated and sold commercially include GreenMatch (d-limonene extracted from orange oil as the active ingredient), GreenMatch Ex (lemon grass oil), Matran (clove oil), Weed Zap (clove oil and cinnamon oil), and Scythe (pelargonic acid, also known as nonanoic acid). However, GreenMatch products and Matran are no longer commercially available. Therefore, the efficacy of organic herbicide alternatives to glyphosate have been understudied, particularly in natural areas.

To fill this knowledge gap, the broad goals of this field study were (1) to compare the efficacy of two organic herbicides and glyphosate in controlling the growth of invasive woody plants (specifically woody vines), and (2) to determine if these herbicides affected three nontarget groups of organisms—soil nematodes, mosses, and ferns. The study site was Cherokee Park in Louisville, Kentucky, where successful nonnative honeysuckle (primarily *Lonicera maackii*) eradication has occurred over the last 10 y in its woodlands, but where woody vines appear to have responded positively to invasive shrub removal (Moore 2015). The most problematic vine species there have all been nonnatives, *Akebia quinata* (Houtt.) Dcne. (chocolate vine), *Euonymus fortunei* (Turcz.) Hand.-Maz. (winter creeper), *Hedera helix* L. (English ivy), and *Vinca minor* L. (periwinkle). These temperate woody vines are particularly destructive to forests because collectively they can affect species occupying all vertical strata—the forest floor, sub-canopy, and even tree canopy layers (Miller et al. 2015). All four of these species form dense vine mats on the ground, while all but *V. minor* can climb high enough to strangle and shroud saplings and shrubs. *Hedera helix* may climb as high as 20–30 m to shroud and even topple canopy trees after wind and ice storms. Woody vines are also likely to invade forests from edges caused by forest removal or by aggrading wooded patches, and so are becoming an increasing threat to small forests in the eastern and southern United States, particularly those in urban and urbanizing areas (Matthews et al. 2016). Except for *A. quinata*, the other three vines are evergreen, thus able to photosynthesize all year, and all four are drought- and shade-tolerant and can grow over a wide range of soil types (Miller et al. 2015). Mats of these species depress the abundance and diversity of native plant communities via various mechanisms (Darcy and Burkhart 2002; Biggerstaff and Beck 2007; Bauer and Reynolds 2016; Mattingly et al. 2016; FEIS 2018). In southern US forests, eight species of invasive woody vines have been responsible for over half of the invasive plant coverage estimated and include *E. fortunei*, *H. helix*, and *V. minor* (Miller et al. 2008). Invasion by nonnative woody vines will likely become an increasing threat to forests, especially since many, including the four species in this study, are still sold by the US horticultural trade. Therefore, finding safer and more publicly acceptable chemical controls for these invasive species is timely and important.

The specific aims of this study were (1) to compare the ability of two organic herbicides (pelargonic acid [PA] formulated as Scythe, and cinnamon and clove oils [CC] formulated as Weed Zap) and glyphosate (formulated as Roundup) to reduce the growth of four nonnative, woody vine species (*A. quinata*, *E. fortunei*, *H. helix*, *V. minor*) on the forest floor of an urban park where these species have been established for decades (Slack 1941); and (2) to document the responses to field herbicide applications of three nontarget groups of organisms—soil nematodes, and moss and fern spores in the soil spore bank. As far as we are aware, this study is the first to report responses of woody plants, nematodes, and moss and fern spore banks to organic herbicides in a forest.

METHODS

Experimental Site

This study was conducted in Cherokee Park in Louisville, Kentucky, USA. Louisville (38°15′N, 85°46′W) is located in north-central Kentucky and is a part of the Interior Low Plateau, Bluegrass Section and in the Eastern Broadleaf Forest (Continental) Province biome (USDA Forest Service 2018). Annual mean temperature is 14.6 °C with a mean minimum in January of –2.8 °C and a mean maximum in July of 31.7 °C. Annual precipitation averages 114 cm and ranges from 7.6 to 13.4 cm monthly (US Climate Data 2018). Approximately half of Cherokee Park's 160 ha consists of secondary mixed deciduous forest that exists as patches interspersed with lawns, meadows, and an internal public road system. The woodlands in this park therefore consist almost entirely of edge habitat. Woody nonnative plants were planted from the 1890s to the 1920s (Carreiro and Zipperer 2011), and *A. quinata*, *E. fortunei*, and *V. minor* were listed as present but "infrequent" in a plant species inventory conducted in the late 1930s (Slack 1941). An EF-4 tornado in April 1974 destroyed half the wooded area in the park. Without a substantial tree canopy, exotic woody vines and shrubs came to dominate these woodlands, leaving the native plant community in a depauperate state (Carreiro and Zipperer 2011). In 2006, the Louisville Olmsted Parks Conservancy embarked on an aggressive campaign of exotic vine, shrub, and tree removal and monitoring. While many native plants have been returning, exotic woody vines have been as well, thus prompting this study.

Plot Establishment, Experimental Design, and Herbicide Treatments

We established 14 sites across the park woodlands for this experiment. Each site was dominated by one of the following target woody vine species, *A. quinata*, *E. fortunei*, *H. helix*, and *V. minor*. The experiment constituted a randomized block design. At each site, four 3×3 m plots were established with a minimum 1-m buffer separation. Sites for any one woody vine species were chosen based on their ability to accommodate the four 3×3 m plots and be distributed as far apart as possible. The Euclidean distance measured for closest and farthest plot pairs, respectively, for sites by species were *A. quinata* 349 m and 792 m, *E. fortunei* 92 m and 1477 m, *H. helix* 71 m and 843 m, and *V. minor* 15 m and 482 m. The group of four plots at each site comprised a single experimental block. Three of the plots at each site received one of the herbicides with adjuvant added, and the fourth received water plus the adjuvant, thus serving as a control. Plot treatment was randomly determined. Herbicide efficacy in reducing cover of the target vines was measured for all

Table 1.—Concentration and doses of herbicides used in this study. Volume applied was 1 L of diluted solution per 9-m^2 plot. ai = active ingredient; ae = acid equivalent. The g ai per L of Weed Zap was estimated as a mass per volume since ai was not on label and J.H. Biotech company representative could not clarify whether percentage was on a mass or volume per volume basis when contacted.

Herbicide	Full-strength commercial formulation	Concentration of commercial formulation applied	Dose equivalent applied in 1 L to each 9 m^2 plot
Roundup Custom (Monsanto Co.)	53.8% glyphosate 648 g ai L^{-1}	6% 38.88 g ai L^{-1}	43.2 kg ai ha^{-1} or 32.4 ae ha^{-1}
Scythe (Mycogen Corp)	57% pelargonic acid 503 g ai L^{-1}	15% 75.45 g ai L^{-1}	83.8 kg ai ha^{-1}
Weed Zap (J.H. Biotech)	45% cinnamon oil 45% clove oil 450 g ai L^{-1} of each oil	15% 67.5 g ai L^{-1} of each oil	Best estimate: 75 kg ha^{-1} of each oil

four vine species. However, the nontarget effects (soil nematodes, moss and fern spore bank responses) were determined only in the *E. fortunei* sites, because this was the most abundant of the four species. As a result, three blocks were established for *A. quinata*, *H. helix*, and *V. minor* and five blocks for *E. fortunei*.

The two organic herbicide formulations that were tested against Roundup Custom (active ingredient 53.8% glyphosate; Monsanto, St. Louis, Missouri, USA) were Scythe (active ingredients 57% pelargonic acid and 3% other related fatty acids; Mycogen, San Diego, California, USA) and Weed Zap (active ingredients 45% cinnamon oil, 45% clove oil; J.H. Biotech, Ventura, California, USA). The concentrations of these herbicides and the active ingredient doses applied appear in Table 1. A total of 1 L of either 6% Roundup Custom, 15% Scythe, 15% Weed Zap, or the water control was sprayed evenly over each 9-m^2 plot. The adjuvant, methylated seed oil (MES; Drexel Chemical, Memphis, Tennessee, USA), was added to the herbicide solutions and to the water controls (4.7 mL MES per L of final solution) to improve herbicide permeability through waxy foliar cuticles. The first treatment occurred on 21 July 2016, the second on 20 August 2016, and the third on 9 July 2017. No rainfall events occurred for at least 48 hr after each of the treatments.

Soil and Other Plot-Level Environmental Variables

In late June before herbicide treatments began, we measured environmental variables (% tree canopy density, % soil organic matter [SOM], soil pH) that could potentially influence the responses of the vines, soil nematodes, or moss and fern spores in the spore bank. Tree canopy density was determined across all plots by averaging four values per plot using a densiometer (Lemmon 1956). Soil pH and % SOM were only measured in the *E. fortunei* plots and came from the same samples collected for estimating nematode abundance (details in the nematode section). After the first herbicide application, soil pH was again measured, because we were not sure if PA could alter microbial and nematode abundance by directly changing soil acidity. SOM was also measured before and after the first treatment (4 wk apart), because we thought foliar and root death due to herbicide application may cause a short-term change in organic matter to which microbes, and hence nematodes that feed on microbes or living roots, might respond. Soil pH was determined with an Orion #420 pH meter using soil–water solutions containing 25 g fresh mass soil stirred in 25 mL deionized water (1:1 mixture). SOM content was determined by loss-on-ignition after combusting 10 g oven dry mass soils in a Box muffle furnace (Asheville, North Carolina, USA) at 500 °C for 6 hr, reweighing and calculating the % ash-free dry mass (AFDM), which is equivalent to SOM in the soils of this park (unpublished data).

Vine Cover Estimation

Before the first herbicide application, percent cover of the target vines was estimated on 21 June 2016 in each 9-m^2 plot using a 25 × 25 cm template held above the plot for continuous reference as the entire plot was scanned visually. To capture the fact that forest floor vine cover in many plots often consisted of more than one foliar layer, percent cover could sometimes be greater than 100%. In 2016, vine cover was again estimated on 8 and 18 August (18 and 28 d after the first treatment), and on 20 October (61 d after the second treatment). Overwinter survival and growth were evaluated by measuring vine cover on 21 April 2017. The third and last treatment occurred on 9 July 2017 and percent vine cover was measured on 8 August 2017. A final vine cover estimation was made on 5 June 2018, which allowed the vines ample time to potentially grow through the spring, and therefore allowed evaluation of vine recuperation after the previous years' treatments.

Soil Nematodes

Only *E. fortunei* plots ($n = 5$ blocks) were used to evaluate potential nontarget effects of treatments on soil nematode abundance and nematode feeding groups, as this was the most abundant vine found as a monoculture in these woodlands. Pretreatment soil samples were collected on 29 and 30 June 2016 to determine if nematodes in the plots within a block or between blocks varied initially, and if differences might be related to any underlying environmental variability in site and soil factors that could potentially affect nematodes. These variables were soil pH, SOM, tree canopy density, and vine cover. Soils were resampled on 29 and 30 July, which was a week after the first herbicide treatment. Eight cores (2.5 cm diameter) were randomly removed from the upper 10 cm of soil for each 9-m^2 plot and pooled. Bags of soil were stored in a cooler in the field and refrigerated until extracted within 2 d of collection. A 100-cm^3 soil sample from each bag was extracted for nematodes using the sieving and sucrose centrifugation-flotation method of Jenkins (1964). The resulting extracts were preserved in 3% formalin (final concentration) and refrigerated until examined under a microscope.

To quantify the nematodes in each sample, the entire contents of each extract were emptied into an 85 mm diameter Petri dish. Then nematode counts were made in 43 stratified-random fields across the entire Petri dish under 40× magnification, which represented 15% (851 mm^2) of the dish area. These values were then extrapolated to estimate nematode abundance in the entire dish, which in turn represented the amount extracted from 100 cm^3 of soil. Nematode abundance was also expressed on a per gram oven dry mass (ODM) soil and on a per gram ash-free dry mass (AFDM) basis, after additional 100 cm^3 subsamples of soil were oven dried at 105 °C and then combusted in a muffle furnace at 500 °C for 6 hr to obtain the conversion factors. To estimate the relative abundance of nematode feeding groups, all nematodes from random 40× microscope fields were removed until a total of 20 nematodes were obtained. These nematodes were placed in PVLG (polyvinyl alcohol, lactic acid, and glycerol) mounting medium (Koske and Tessier 1983) on microscope slides, viewed at 200× or 400× magnification, and identified as belonging to one of the following three feeding groups based on mouthparts: bacterivore, fungivore-herbivore, predator. Since both fungivores and root herbivores have similar mouthparts (styluses or spears for piercing), they cannot be separated without making genus-level taxonomic identifications, which we did not have the expertise to accomplish. However, members of the Criconematidae (a root-feeding herbivore family) were separately tracked due to the morphological distinctiveness of their annular rings.

Moss and Fern Spore Bank

Effects of herbicides on moss and fern spore banks were determined only in the *E. fortunei* plots. Soils for this study were collected on 6 and 7 July 2016 before the first herbicide treatments and again in early November 2016. Our methods of soil collection and rearing of bryophytes and ferns is similar to that of Ross-Davis and Frego (2004). After surface litter removal, three 7.2 cm diameter cores for each plot were removed from the upper 5 cm of soil and pooled by plot. Soils were placed in a drying oven at 30 °C for at least 24 hr or until dry enough to sieve through a 1.5–2 mm mesh screen. Sieves were sterilized with 0.8% bleach solution between each use to prevent cross-contamination.

On 8 July, the soils from each plot were planted into their respective small pots (16.5 cm × 10.2 cm × 5 cm high) with drainage perforations. Before adding soil, capillary matting strips were placed on the bottom of each pot such that two ends threaded out of the pot and into a filtered water reservoir below to maintain even moisture in the soils. Perlite (2 cm) was added on top of the capillary matting, then 2 cm of the field soil was added on top of the perlite, and gently pressed to form a smooth surface. Room control pots were also prepared with the same materials using autoclave-sterilized soil. These controls determine if any of the moss or ferns growing in pots originated from sources other than plot soils.

Five of these pots were placed into a tray with one pot being a room control plot. The other four pots contained soil from the plots and were randomly assigned to each of five trays. The five trays were then randomly assigned positions in the lighted shelving to reduce the possibility of microenvironmental variation in the room or shelves biasing the results from the field herbicide treatment. Clear domes were placed on the trays to conserve moisture and T4 fluorescent lights were set to a 12:12 hr day:night cycle. Position of the trays on the light racks was changed every 10 d such that each tray experienced all microhabitats created on the light stand. Any angiosperm and gymnosperm seedlings that may have germinated in the pots were counted and then removed so as not to affect moss and fern spore germination.

We waited until fall to collect soils after the second herbicide application because bryophyte and fern spore bank diversity below *E. fortunei* vine cover in the initial pretreatment soils was very low. We suspect one reason may be that these vines block spore entry into the soil. Once vine foliage had been killed by herbicides, we hypothesized that allowing greater time for spore rain entry may increase the ability to detect whether vine cover may also play a role in suppressing bryophyte and fern community development by comparing results in treated plots with the vine-covered control plots. Soils were collected at the same sites using the same protocols described above. Soils were placed in the lab on 2 November 2016 using the same techniques and conditions as used for the pretreatment samples. Both pre- and post-treatment samples were incubated in the lab under the same conditions for 1 yr before counting and identifying mosses and ferns.

Bryophytes (mosses, liverworts, and hornworts) were identified to species where possible using keys and nomenclature from Flora of North America, volumes 27 and 28 (2007, 2014). For ferns, Weakley (2015) and Flora of North America (1993) were used. Species were recorded as 1/0 for present/absent for each pot at the end of 1 yr. Trays were checked approximately every 10 d after 1 mo of incubation to detect early emerging ephemeral species. When mosses produced sporophytes, samples of the gametophyte and sporophyte were collected, used for identification, and preserved as voucher specimens. Moss sporophytes were regularly removed from trays to prevent spore dispersal and among-tray contamination. Many moss species are not identifiable to species without sporophytes (e.g., species of *Pohlia*); thus, several mosses are identified only to genus. Fern gametophytes are notoriously difficult to identify. Fern gametophytes were counted periodically as they appeared in the first few months of the experiment and then fern sporophytes were counted. We did a final count of fern sporophytes at the end of the year and identified ferns to species if possible. In most cases, if sori were not present, it was not possible to identify beyond genus with confidence. The same is true for lack of sporophytes in mosses. Pots were labeled with codes and the researcher who identified the plants was blind to the treatment.

Statistical Procedures

For each vine species, percent cover data were recalculated and expressed as absolute coverage in m^2 (e.g., 100% cover equals 9 m^2). To determine whether there were any potential differences in pretreatment vine cover by plot within a block of a single vine species, we used a mixed model (planned herbicide treatment as a fixed main effect and block as a random effect) with the *glmer* function in the *lme4* package in R (R Core Team 2016). The model residuals were found to be normally distributed and homoscedastic using histograms and plots of fitted values vs. residuals. Post hoc comparisons were made using Tukey's HSD in the *multcomp* package in R. For post-treatment data, we restricted our interest to determining the main effect of herbicides on each vine species singly and not on whether vine species responded differently than another to herbicides or whether there were any species-by-herbicide interactions. Therefore, separate models were run for each vine species. Because overwinter responses to a previous year's treatment by different herbicides would be of major management interest, we performed repeated measures analysis on vine cover data from three dates: the pre-treatment date (21 June 2016) and two post-treatment dates (21 April 2017 and 5 June 2018). Repeated measures mixed models were run separately for each species using *lme* from the *nlme* package in R. To compare the effect of the herbicide treatments to the control and to each other, linear contrasts were performed using *glht* from the *multcomp* package in R. Separate contrasts were run for the 21 April 2017 and 5 June 2018 cover data. *P* values were adjusted for multiple testing using the single-step method.

Statistical analyses on soil pH, AFDM, and nematode data from the *E. fortunei* plots were performed using mixed models (herbicide treatment as a fixed main effect and block as a random effect) with the *glmer* function in the *lme4* package in R. While data for soil pH did not need to be transformed, that for AFDM was arcsine-square root transformed before analysis. Nematode densities expressed on a per 100 cm^3 basis were square-root transformed to fit assumptions of normality and variance stability. Nematode densities expressed on a g ODM or g AFDM soil basis did not require transformation. Data on the proportions of functional feeding groups were arcsine-square root transformed after the constant of 0.05 was added to all data because the predator data contained some zero values. No statistics linking vine cover and nematode abundance with tree cover density were performed because variation in tree cover density was low across the *E. fortunei* plots.

In the moss and fern spore bank experiment, because sample sizes were small, we used permutation tests to examine differences among treatments for number of species present. Permutation tests use repeated resampling and are not limited by the same assumptions of parametric tests. We used Resampling Stats for Excel and conducted these analyses in Excel using RSXL 4.0 (Resampling Stats, Arlington, Virginia, USA; www.resample.com). To examine variation among treatments, we calculated the difference in number of species between the pre- and post-spray treatment samples and used the absolute sum of the treatment mean deviations from the grand mean in 1000 iterations to determine a probability value.

RESULTS

Environmental Variables

In late June 2016 before treatments, tree canopy density was high across all 14 sites (56 plots) and ranged from 89.5% to 95.6%. Soil pH, which was only measured in the 20 *E. fortunei* plots, ranged from slightly acidic (5.58) to nearly neutral (6.91) and did not differ significantly by treatment categories assigned before the actual treatments ($P = 0.52$). Mean % AFDM across all 20 *E. fortunei* plots ranged from 5.8% to 12.7% and did not differ significantly by assigned treatment categories before the actual treatments ($P = 0.35$). In early August, a week after the first herbicide treatment, no significant differences in pH (range: 5.25–7.15, $n = 20$) were found to be associated with any specific herbicide treatment ($P = 0.18$). After the first herbicide treatment, AFDM content ranged from 4.9% to 10% across 19 plots, with one outlier at 18.9%. While % AFDM in *E. fortunei* plots did decrease on average by 1.8% from late June to early August, no statistically detectable differences were found to be associated with specific herbicide treatments ($P = 0.50$).

Target Vine Responses to Herbicide Treatments

None of the plots within species blocks assigned to different treatments differed significantly in foliar cover before herbicide treatments (*A. quinata*: $P = 0.14$, *E. fortunei*: $P = 0.27$, *H. helix*: $P = 0.22$, *V. minor*: $P = 0.08$). Within 18 d after the first treatment, the two organic herbicides caused almost total defoliation of each of the four vine species (Figure 1 A–D). However, the time-course for near-total defoliation by a single Roundup application varied from 18 d for *A. quinata* (Figure 1A) to 28 d for *H. helix* (Figure 1C) and *V. minor* (Figure 1D). Two Roundup applications, a month apart, were required before near-total defoliation of *E. fortunei* was observed (Figure 1B). Repeated measures analysis showed that vine cover decreased significantly over time for all four species (*A. quinata*: $P = 0.001$; *E. fortunei*: $P < 0.0001$; *H. helix*: $P = 0.0003$; *V. minor:* $P < 0.0001$) in the herbicide-treated plots relative to the controls. In the Roundup plots, there was no regrowth of *A. quinata* in April 2017 (after two 2016 treatments). *Akebia quinata* cover in both the Scythe and Weed Zap plots was reduced from pretreatment levels by 75% (difference from controls: Roundup $P < 0.0001$; Scythe $P = 0.01$; Weed Zap $P = 0.009$). However, none of the herbicide treatments differed statistically from each other. After two 2016 treatments, *E. fortunei* cover the following April was reduced by 98%, 87%, and 83% in Roundup, Scythe, and Weed Zap plots, respectively. All differed significantly from the control plots ($P < 0.00001$), but not from each other. *Hedera helix* cover in the Roundup and Scythe plots was reduced by 99% and in Weed Zap plots by 84%, with all statistically differing from the control plots (Roundup $P = 0.001$; Scythe $P = 0.002$; Weed Zap $P = 0.03$), but not from each other. Cover in Roundup-treated *V. minor* plots was reduced 100%, whereas cover in Scythe and Weed Zap plots was reduced by 82% and 88%, respectively. All herbicide-treated *V. minor* plots differed from controls ($P < 0.0001$), but not from each other.

Despite the fact that in April 2017 the effects of the three herbicides were not statistically distinguishable from each other, enough foliar regrowth had recurred in the organic herbicide plots for all the woody vine species that a third treatment in July 2017 was deemed necessary for continued control (Figure 1). Although there was no vine regrowth in the Roundup plots, a third Roundup treatment was also applied to maintain experimental symmetry. A month after this third treatment, the organic herbicides caused near-total reductions in vine cover across all species. By June 2018, a year after the third treatment, cover of all the woody vine species treated with Roundup remained at zero. For *A. quinata*, cover was reduced by 80% and

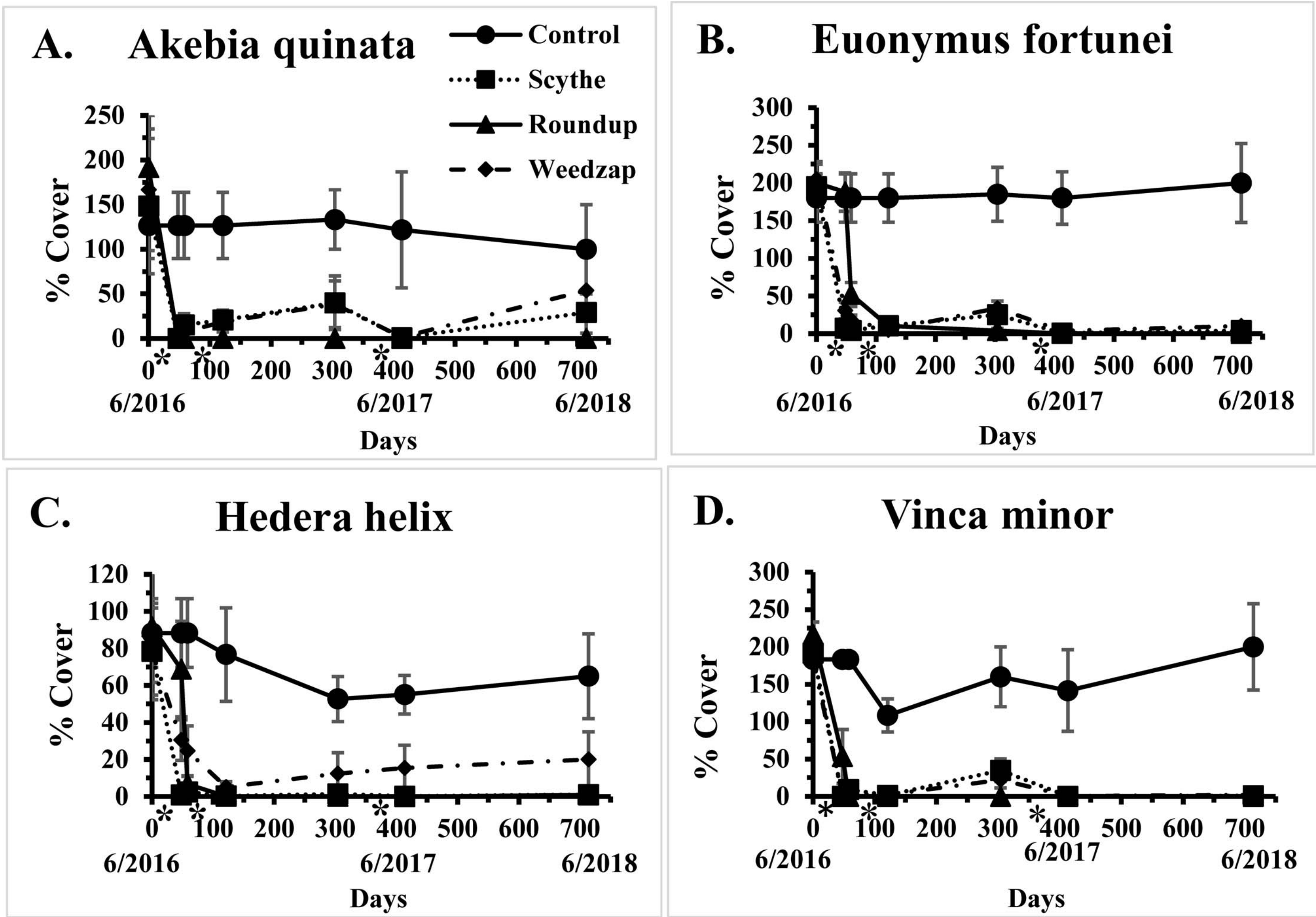

Figure 1.—Foliar cover responses (means ±1 SE) of four invasive woody vine species (A. *Akebia quinata*, B. *Euonymus fortunei*, C. *Hedera helix*, and D. *Vinca minor*) to three applications of either Roundup, Scythe, or Weed Zap (active herbicidal ingredients: glyphosate, pelargonic acid, clove and cinnamon oils, respectively). All treatments, including the water Control, contained methylated seed oil as an adjuvant. Day 0 provides foliar cover data before herbicide applications. The treatment dates are marked with asterisks on the *x*-axis and occurred on 21 July and 20 August 2016 and 9 July 2017. For details, see Methods. $N = 3$ plots per treatment for all but *E. fortunei* where $N = 5$ plots per treatment. Various statistical analyses, reported in the Results section, were performed using data collected on Day 0, Day 304, and Day 714.

68% in Scythe and Weed Zap plots, respectively; for *E. fortunei* by 98% and 95%; for *H. helix* by 99% and 75%; and for *V. minor* by 99% for both organic herbicides. Vine cover in all herbicide-treated plots differed statistically from controls for three of the species (*E. fortunei*: $P < 0.00001$ for all herbicides; *H. helix*: $P < 0.0001$ for Roundup and Scythe, $P = 0.009$ for Weed Zap; *V. minor*: $P < 0.0001$ for all herbicides). The exception was *A. quinata* where only Roundup-treated plots differed significantly in cover from the control (*A. quinata*: Roundup $P < 0.005$; Scythe $P = 0.1$; Weed Zap $P = 0.6$). None of the herbicide treatments differed statistically from each other in June 2018 for any of the species.

In summary, based on zero foliar cover in April 2017, glyphosate in Roundup appeared to have killed the vine mass of these four species after only two treatments the previous year. While there was no statistical difference between the organic herbicide and Roundup plots in vine cover in April 2017, there had been enough foliar regrowth that a third treatment in year 2 was deemed necessary to assure continued vine cover control. By June 2018, the organic herbicides appeared to have done nearly as well at suppressing vine cover as glyphosate with the exception of *A. quinata*. Although not statistically different, the PA in Scythe reduced vine cover more so than the CC in Weed Zap for *A. quinata* and *H. helix*. Even in the cases where vine cover had been reduced by more than 98%, however, concluding that these organic herbicides actually killed these woody vines can be stated with less confidence than for glyphosate where the lethal mode of action has been well studied. Nonetheless, the cover reductions by the organic herbicides were large and would provide a sufficient time window for replanting an area with native species, if desired.

Soil Nematode Responses to Herbicide Treatments

Before herbicide treatment, nematode densities across all 20 *E. fortunei* plots ranged from 87 to 980 per 100 cm^3 soil (1.1–10.5 per g ODM soil; 10–61 per g AFDM soil). We did not find a trend in pretreatment plot assignment that could explain pretreatment nematode densities ($P = 0.44$, $P = 0.47$, and $P = 0.17$ on a per soil volume, g ODM, and g AFDM basis, respectively). While the range in total nematode abundance did not correlate significantly with AFDM before herbicide treatment, it was significantly and negatively correlated with soil pH ($P = 0.01$). After the first herbicide application, nematode abundances (on a per volume, g ODM, or g AFDM soil basis) increased 3- to 10-fold across all plots and treatments. Across all 20 plots, nematode abundance ranged from 647 to 3033 per 100 cm^3 soil (7.2–31.7 per g ODM soil; 91–595 per g AFDM soil). However, no effects of herbicide treatment on nematode abundance were detected when expressed on a per volume ($P = 0.56$), g ODM ($P = 0.57$), or g AFDM ($P = 0.17$) soil basis.

Across all 20 plots, the pretreatment means (± 1 SD) of percent distribution of nematodes across feeding groups were: bacterivores 17% (± 7.0%), combined fungivores and herbivores 77% (± 9.0%), and predators 6% (± 7.0%), with no statistically detectable differences observed in these functional feeding groups among plots assigned to different treatments ($P = 0.76$, $P = 0.90$, $P = 0.86$ for bacterivores, fungivore-herbivores, and predators, respectively). One week after the first herbicide treatments, the percentages (±1 SD) of different feeding groups across all 20 plots were bacterivores 28.0% (±12.4%), combined fungivores and herbivores 69.0% (±12.6%), predators 3.0% (±3.4%), and no statistical differences were found among the groups associated with treatment ($P = 0.21$, $P = 0.20$, $P = 0.98$ for bacterivores, fungivores and herbivores, and predators, respectively). The percent of total nematodes consisting of individuals in the root-parasitizing Criconematidae was 12.3% (±13.6) before treatment and 7.3% (±7.5) after treatment.

Moss and Fern Spore Bank Responses to Herbicide Treatments

The mosses that emerged from soil samples were widespread, weedy colonizers typical of disturbed soils in the region (Table 2). *Physcomitrium pyriforme* Hedwig was the most common species found in every soil sample, followed by *Pohlia* spp. We found 20 moss species before treatment and 16 after treatment (these numbers consider *Pohlia* as a single species, so estimates are conservative). In pretreatment samples, there were 7 pleurocarpous and 13 acrocarpous mosses and in treated samples, 4 pleurocarpous and 12 acrocarpous species. All species in the treated samples were found in the pretreatment samples. Three pleurocarpous mosses not found in treated samples were *Anomodon rostratus* Hedwig, *Homomallium adnatum* Hedwig, and *Plagiomnium cuspidatum* Hedwig. These species were not abundant in the pretreatment soils, each occurring in only one of the samples. Three species (*Weissia muhlenbergiana* Swartz, *Weissia controversa* Hedwig, and *Pseudotaxiphyllum elegans* Bridel) occurred in one more sample in treated soils vs. soils before treatment. All soils, including the control, had on average fewer species after treatment than before. The control pots containing soils treated with water-and-adjuvant exhibited the largest difference before and after treatment (3.4 fewer species emerged from treated soils), whereas the average decrease in species emerging from herbicide-treated soils was 1.5. This indicates that none of the herbicide treatments had an impact on number of moss species emerging from the soils. Permutation tests revealed no difference among treatments in the change in moss species before and after treatment ($P = 0.790$).

Table 2.—Moss species that germinated from the soil spore bank beneath *Euonymus fortunei* vine mats before and after herbicide treatments. Values are number of plots in which they were present out of a maximum of 20 plots sampled. There were no statistically detectable differences due to type of herbicide treatment, so data are pooled by before and after spraying. Species with asterisk (*) are pleurocarpous; others are acrocarpous.

Species	Presence before spraying	Presence after spraying
Amblestegium serpens *	2	1
Anomodon rostratus *	1	0
Brachythecium acuminatum *	7	2
Campylopus tallulensis	8	1
Ceratodon purpureus	9	9
Dicranella heteromalla	4	1
Ditrichum pallidum	1	0
Fissidens taxifolius	8	2
Funaria hygrometrica	7	7
Gemmabryum klinggraeffii	7	5
Homomallium adnatum *	1	0
*Leskea gracilescens**	3	3
Physcomitrium pyriforme	20	20
Plagiomnium cuspidatum *	1	0
Pohlia spp.	20	20
Pseudotaxiphyllum elegans *	2	3
Trematodon longicollis	15	6
Trichostomum tenuirostre	12	4
Weissia controversa	15	16
Weissia muhlenbergiana	1	2

The final counts of fern sporophytes and gametophytes emerging from incubated soils before and after treatment were made on 6 October 2017 and 16 January 2018, respectively. Only three fern species were identified from the soil spore bank: *Asplenium platyneuron* (L.) Britton, Sterns & Poggenb., *Cyrtomium falcatum* (L.f.) C. Presl, and *Polystichum acrostichoides* (Michx.) Schott. All three species grew from soils before treatment and two from treated soils. *Cyrtomium falcatum*, found in one soil from one site in the pretreatment samples, is a nonnative species commonly used in landscaping. The other species, *Asplenium platyneuron* and *Polystichum acrostichoides*, are common in the park and surrounding region (Slack 1941; Haragan 2014). *Asplenium platyneuron* was the most plentiful fern sporophyte in both pre- and post-treatment samples. There was high variation among treatments in the numbers of fern sporophytes and gametophytes emerging from soil samples. Overall, ferns exhibited the same pattern as mosses; there were more total gametophytes and sporophytes emerging from soils before treatment than from the treated soils. That was true for all treatments, including the control. The change in total number of fern individuals (gametophytes and sporophytes) from pre- to post-treated soils did not differ among treatments ($P = 0.790$). However, among treatments the difference in number of sporophytes developing from soils before vs. after treatment was statistically significant ($P = 0.02$). For both control and Scythe treatments an average of 1.2 more sporophytes developed from soils before treatment than after. The Roundup-treated soils exhibited the largest difference (1.4 more fern sporophytes in the pretreated soils), but there were slightly more sporophytes (0.2) germinating from soils after Weed Zap treatment than before.

DISCUSSION

Vine Control Effectiveness

This experiment provided several clear-cut results about the comparative effectiveness of two organic herbicides and glyphosate in reducing growth of these four woody vine species. As expected, two summer applications in 2016 of 6% glyphosate (32.4 kg acid equivalent ha^{-1}) as Roundup reduced woody vine cover to zero and killed all four woody vine species. This effect lasted through July 2017 when a third application was administered only to retain experimental treatment symmetry. No vine species in the Roundup plots recovered as of June 2018. Bauer and Reynolds (2016) observed only 4% cover regrowth of *E. fortunei* in a hardwood forest 3 yr after applying a 2% solution of glyphosate, while Mattingly et al. (2016) found that two applications of a 1.6% glyphosate solution together with pre-mowing kept this vine species below 20% cover in a hardwood forest for 3 yr. Yang et al. (2013) cite a study by Soll (2005; no longer available online) as finding that glyphosate, applied twice at amounts of 4.5 kg ae ha^{-1} for each application, controlled *H. helix* in forests of the Pacific Northwest. Schulz and Thelan (2000) achieved a 50% reduction in *V. minor* cover in a temperate forest after spraying 5% glyphosate on cut vines. After spraying *V. minor* with 2% glyphosate, Tatina (2015) measured 0–25% recovery of this vine a year later. We could find no published studies in the peer-reviewed literature that described the response of *A. quinata* to glyphosate either in a greenhouse or field setting and this study may represent the first factorial experiment reporting the response of this species in the peer-reviewed literature.

More interestingly, we determined that the two organic herbicides (PA in Scythe, CC in Weed Zap) were able to defoliate dense well-established mats of woody vines in a forest and that this foliar reduction occurred more quickly than in glyphosate-treated vines. While foliar recovery was low after treatments, second and third applications of organic herbicides were needed to deal with regrowth, showing that the vines had not been killed and still retained enough carbohydrate reserve to support foliar reemergence in that first full year of treatment. By June 2018, a year after the third application, foliar regrowth in plots treated with organic herbicides was statistically indistinguishable from that of glyphosate for all species. Both of these organic herbicides fully suppressed foliar regrowth of *E. fortunei* and *V. minor* a year after the third treatment, and Scythe (PA) suppressed regrowth of *H. helix*. However, regrowth of *A. quinata* did occur in plots treated with both organic herbicides, more so in Weed Zap plots, and *H. helix* regrowth occurred in Weed Zap plots as well. We suspect that this may have been due to the active ingredients (CC) in Weed Zap being oils with lower water solubility than the fatty acid (PA) in Scythe. We observed partitioning of the CC oils from aqueous solution in the spray tanks soon after mixing, so tanks were shaken as often as possible during spraying. This partitioning may, however, explain the occasional patchiness in foliar survival we saw in the Weed Zap plots. Small patches that might have escaped the full CC treatment for this reason would then have provided nuclei for regrowth. This likely explains greater regrowth of *A. quinata* and *H. helix* in Weed Zap than in Scythe plots by the end of this study. This patchiness in foliar survival was not observed with Scythe or Roundup, indicating that the people applying the treatments did take care to provide even coverage across each 9-m^2 plot using the pump-and-tank applicators.

Few factorial studies exist that assess the weed control efficacy of these organic herbicides under lab or field conditions. In fact, we could find no experiments in either the "gray" or peer-reviewed literature that used either PA or CC to control invasive woody plants. Therefore, we believe this is the first such study to describe their use on woody vines in forests. Ward and Mervosh (2012), however, did use PA (as Scythe) among several chemical and nonchemical treatments to determine its effectiveness in reducing Japanese stiltgrass (*Microstegium vimineum*) in a wooded floodplain. Unlike our results, they found that PA was among the least effective in reducing cover of that invasive grass 2 yr after application; however, subsequent seed rain from that grass imported into the plots could partially have explained those results. The preponderance of studies using organic herbicides involve annual weeds as target plants in agricultural fields, lawns, or greenhouse trials (Lemke 2005; Kornecki and Price 2010; Lanini 2011; Rowley et al. 2011). Therefore, effective dosage concentrations, field volumes, and reapplication recommendations for perennial woody plants, such as woody vines, are not well established. This study shows that 15% concentrations of the commercial formulations of PA and CC can be effective at reducing foliar cover of these four woody vines to levels achieved by 6% glyphosate. Indeed, three applications of either PA or CC a year apart may have been enough to kill *E. fortunei* and *V. major* via attrition of stored carbohydrate reserve or some other yet unknown mechanism, since there was no regrowth measured a year after the third application. PA but not CC may also have killed *H. helix*. Why *A. quinata* recovered after three organic herbicide treatments may be explained by the fact that cover in one of the blocks was triple that of the other two. Defoliation days after treatment was total in this block as well as the others, indicating that the spray reached all the foliage. This suggests that the carbohydrate reserve in stems and roots was higher in the vine mass in this block and was not depleted after three treatments.

One reason for determining in future experiments if lower concentrations of PA and CC may suffice for controlling invasive woody plants is the cost of using them instead of glyphosate. This is probably the strongest disadvantage to their use. At the concentrations and dose levels used in their study, Rowley et al. (2011) calculated that use of organic herbicides was 100 times more expensive than Roundup ($4.80/ha), with Scythe being the least expensive ($344/ha) of several organic herbicides evaluated. Lemke (2005) found that Scythe cost three times more than Roundup ($6880 per year) for controlling weeds for the entire public school system in Howard County, Maryland. Lanini (2011) calculated that the cost of using Weed Zap at 15% of full strength (the same used in this study) would range $1482–2223/ha at the dose levels they used. We calculated that the cost of using a 6% solution of Roundup Custom at a dose amount of 43.2 kg active ingredient (ai) ha^{-1} would be $600 ha^{-1}. The cost for Scythe (15% solution, 83.8 kg ai ha^{-1}) in this experiment was five times greater and for Weed Zap (15% solution, 150 kg ai ha^{-1}) 6.5 times greater than Roundup Custom. Therefore, use of organic herbicides instead of Roundup or other glyphosate-containing herbicide has generally been restricted to weed suppression in organic farms with high-value crops (e.g., fruits). More experimentation to test the effectiveness of organic herbicides in reducing the abundance of different invasive plants in natural areas and to determine their nontarget effects is warranted so their costs can be weighed against their benefits in restoration efforts.

Nontarget Effects

In this study we chose to focus on soil nematodes as indicators of herbicide disturbance to soil food webs. We also chose to study potential effects on moss and fern spore banks, since moss and fern life cycles involve haploid as well as diploid generations that may be differentially vulnerable to herbicides and for which research is thin. As far as we could detect within a week after one application, none of these herbicides had any detectable effect on nematode abundance or on the proportions of nematode functional groups. Nonetheless, because these organisms respond quickly to disturbance (Yeates et al. 1993), we think it unlikely that direct effects occurred on the nematodes themselves or that herbicides caused major perturbations in nematode food items, or perturbations in the populations of predators that consume nematodes.

More studies of effects of repeated herbicide applications on forest soils would be needed to evaluate the possibility of longer-term impacts on soil food webs. However, there is not much published research available with which to compare the effects of glyphosate and organic herbicides on nontarget food web organisms like nematodes in natural areas. In large part that reflects the fact that herbicide usage has occurred mostly in farms or along urban paved areas where maintaining other valued species (biodiversity) is not a high priority. Nontarget impact assessments of herbicides have focused on soil organisms involved in crop plant disease, microbes and invertebrates involved in nutrient cycling, or on soil nutrient status in agricultural land. Liphadzi et al. (2005) concluded in a greenhouse study that glyphosate doses as high as 4.48 kg ai ha^{-1} did not have a direct toxic effect on nematode densities and trophic groups. We found no studies that investigated the potential effects of PA or CC on nematode communities. However, in a study conducted in a Washington apple orchard, Hoagland et al. (2008) concluded that clove oil (formulated as Matran) had no detectable effect on total nematode abundance or soil biological activity compared with control plots.

In our study, there were also no discernable impacts of the herbicide treatments on moss species emerging from the spore bank. It is more likely that seasonal variation impacted the number of species that germinated from pre- and post-treated soil samples. This was shown in a study of bryophytes in Maine where the composition of the aerial diaspore bank showed significant differences among seasons, and the relationship between the composition of the aerial and buried diaspore banks also changed depending on season (Ross-Davis and Frego 2004).

The mosses that grew under laboratory conditions in our study were ruderal species that readily invade disturbed sites and are known to be hardy colonizers. Spore banks tend to house asexual or sexually produced spores and other asexual propagules from short-lived species and, to a far lesser extent, fragments of longer-lived pleurocarpous species (During 2001). Pleurocarpous mosses that grow on the forest floor are usually longer-lived, perennial stayers, whereas the small acrocarpous mosses that produce large spores are short-lived, like the moss most common in our samples, *Physcomitrium pyriforme*, which is an annual shuttle species and *Ceratodon purpureus*, which is a colonist (During 1979).

While comparing conditions in a nursery with the field is not the same, Fausey (2003) showed that PA did provide 80% control of two weedy bryophytes, *Marchantia polymorpha* and *Bryum argenteum*, in container-grown plants in nurseries. Formulations of cinnamon oil were less effective. However, this high degree of control was documented for already growing bryophytes, not specifically on the ability of these herbicides to prevent spore germination of these species.

We found only three species of ferns in the spore bank, but in a previous study, Fuselier et al. (2018) identified seven species in the spore bank of this same urban park. There were more species in the spore bank than extant aboveground in the park, so the spore bank in Cherokee Park is an important temporal refuge for ferns. This is consistent with a study in New Zealand that found ferns to be persistent in spore banks even in urban areas (Overdyck and Clarkson 2012).

There is some evidence that glyphosate negatively impacts fern sporophyte emergence from the spore bank. Aguilar-Dorantes et al. (2015) showed that glyphosate suppressed spore germination in three species of ferns in Mexico and growth of fern gametophytes, young sporophytes, and mature sporophytes. Glyphosate (2–4%) has been used successfully to kill invasive ferns in pine forests in Florida (Bohn et al. 2011), with 98% control even 2 yr after application. In our study, soils treated with glyphosate were less likely to produce fern sporophytes, though there was no statistical difference in total gametophyte-plus-sporophyte emergence from soils before and after herbicide treatment. This trend deserves further study, particularly for native ferns in natural areas where glyphosate is being used for invasive plant control.

CONCLUSIONS

As more of our forested lands become reduced to small patches, the potential for invasion by woody plants, such as mat-forming vines, entering from human-dominated land surrounding them will increase. These invasions threaten a forest's ability to regenerate via tree seedling and sapling recruitment, compromise the ability of forests to serve as a reservoir of native biodiversity, and reduce the ability of forests to provide society with many ecosystem services. Even if regulations were in place to ban future sales of invasive plants by the horticultural industry (Reichard and White 2001), coverage of our forests by these exotic plants is already high and self-perpetuating.

Currently, glyphosate in formulations like Roundup is much less expensive than organic herbicides like PA and CC in Scythe and Weed Zap for invasive plant control in natural areas. However, plant resistance to glyphosate is increasing, making the likelihood that increasing concentrations and dosages will be required to maintain invasive plant control. In addition, recent notorious and large court awards to litigants claiming that Roundup use caused their cancers has made more people leery of using glyphosate-containing products. More cities, counties and even countries have banned or are close to banning glyphosate. We need to recognize that the majority of forested lands in the eastern United States are being managed by private, often untrained land owners who may stop using glyphosate for these perceived health reasons. Therefore, it is likely that the current array of chemicals to control invasive plants will need to be expanded.

In addition, untrained land managers may be more likely to overspray plants and soils with herbicides, organic or not, than professionally trained teams. Therefore, we will need more studies to assess not only direct impacts of herbicides on target plants, but the short-term and long-lasting effects of herbicides on nontarget organisms, especially those in the soil. These include soil invertebrates, microbes, mycorrhizae, and the seed and spore banks of native plants, particularly those of high conservation value. Including organic herbicides in the chemical control tool kit for management of invasive woody plants would expand choices for all forest managers, especially if the trends in plant glyphosate resistance and in rejecting glyphosate use continues.

ACKNOWLEDGMENTS

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Margaret Carreiro is Professor Emerita of Biology at the University of Louisville. Her research focused on decomposition, nutrient cycling, and plant and soil ecology in urban and suburban habitats.

Linda Fuselier is an Associate Professor of Biology at University of Louisville with a Ph.D. in Evolutionary Biology. She studies the biology and evolution of bryophytes as well as postsecondary biology education.

Major Waltman is the Project Director for the Olmsted Parks Conservancy in Louisville, Kentucky. He has been managing natural areas restoration projects in Louisville's Olmsted Parks since 2006. He holds Masters' degrees in Environmental Engineering and Ecology from the University of Louisville.

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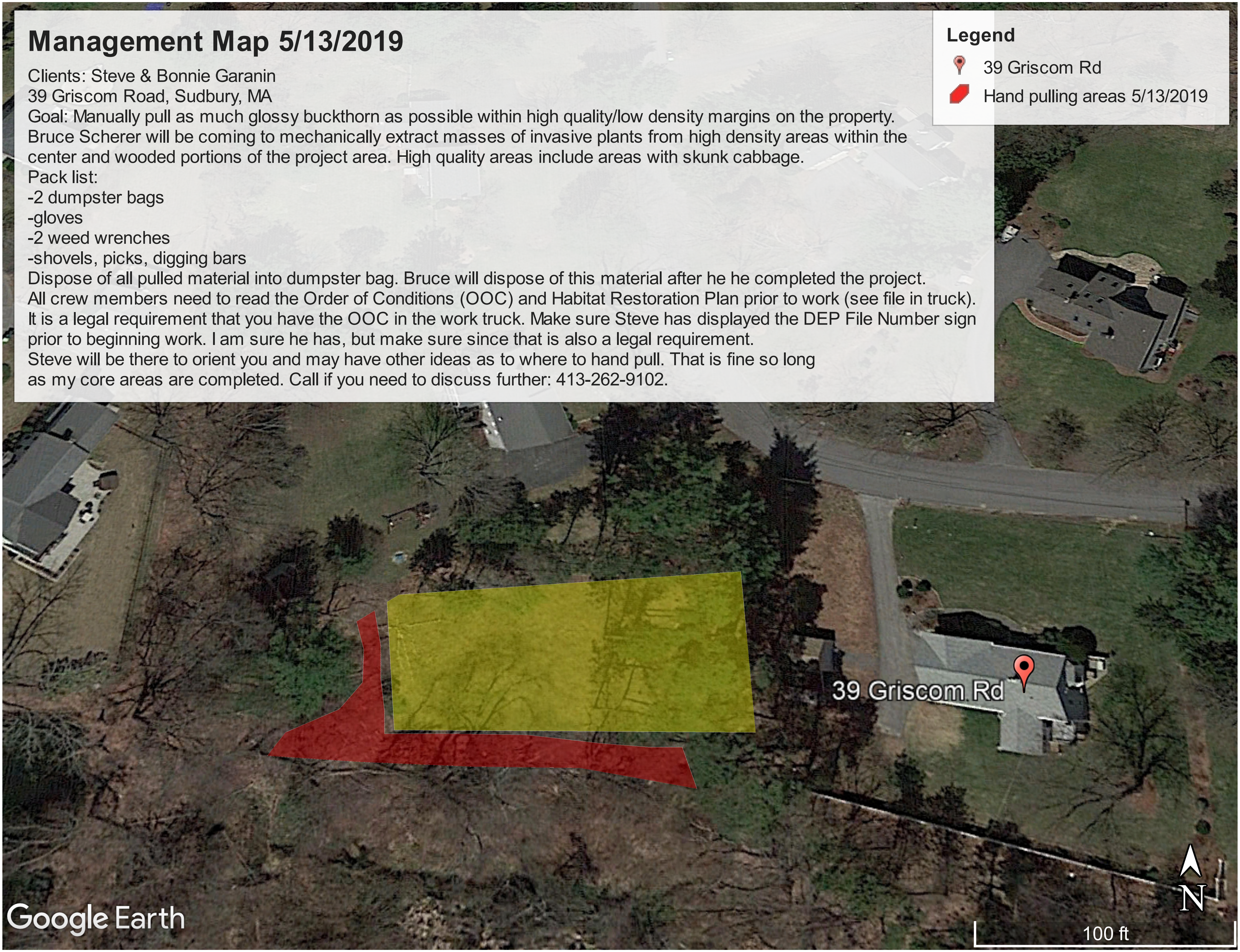
Management Map 5/13/2019

Clients: Steve & Bonnie Garanin
39 Griscom Road, Sudbury, MA
Goal: Manually pull as much glossy buckthorn as possible within high quality/low density margins on the property. Bruce Scherer will be coming to mechanically extract masses of invasive plants from high density areas within the center and wooded portions of the project area. High quality areas include areas with skunk cabbage.
Pack list:
-2 dumpster bags
-gloves
-2 weed wrenches
-shovels, picks, digging bars
Dispose of all pulled material into dumpster bag. Bruce will dispose of this material after he he completed the project.
All crew members need to read the Order of Conditions (OOC) and Habitat Restoration Plan prior to work (see file in truck). It is a legal requirement that you have the OOC in the work truck. Make sure Steve has displayed the DEP File Number sign prior to beginning work. I am sure he has, but make sure since that is also a legal requirement.
Steve will be there to orient you and may have other ideas as to where to hand pull. That is fine so long as my core areas are completed. Call if you need to discuss further: 413-262-9102.



Notice of Request to Amend Oder of Conditions, DEP #301-1256, dated March 28, 2019

To: Mass DEP

From: Stephen A Garanin, 39 Griscom Road, Sudbury, MA 01776

Date: August 25, 2010

To Whom It May Concern:

Please find my request for an amendment to order of condition #301-1256 sent to you at the direction of Lori Capone, Sudbury Conservation Coordinator.

There has been some positive progress in the reduction of invasive species and reestablishment of native trees and shrubs on the subject property. The newly planted native species have taken root and are indeed growing at an appropriate pace. The "new" wetland woods should be well along by the end of the Order, March 2022.

The only issue that has occurred is the overwhelming growth of one of the invasive plants we are trying to control, Celastrus orbiculatus. In the most recent senior wetlands specialist report, it was noted as starting to impact many of the newly planted trees and shrubs as well as the area surrounding them. If left to its own devices, the plantings will be completely overrun with in a year or two, thus slowing their reestablishment.

The request to amend the order of conditions will go far to leveling the growing area relative to keeping the invasive plants in check until the newly planted vegetation can compete successfully on its own. Hand-pulling of this particular invasive is not an option. The proposed use of a spray, Weed Zap, will reduce the abundance of Celastrus. The spray is a 100% natural, non-synthetic product: cinnamon oil and clove oil combination. It must be sprayed on growing plants. It will be applied once this late summer and, if necessary, again in the spring after growth has commenced; by a licensed professional in the field of habitat restoration, Land Stewardship, Inc. Its efficacy in this situation will be evaluated by the senior wetlands biologist and reported on in his June 2021 report.

I am requesting approval of this amendment by the Sudbury Conservation Commission. The request and all attachments sent to the Conservation Commission are enclosed for your files.

Respectfully yours,

Stephen A Garanin

ENCL: 1-8

January 21, 2019

Habitat Restoration Plan

39 Griscom Road
Sudbury, MA

Submitted to:
Sudbury Conservation Commission
Department of Public Works Building
275 Old Lancaster Road
Sudbury, MA 01776

Prepared for:
Stephen Garanin
39 Griscom Road
Sudbury, MA 01776

1. INTRODUCTION

On behalf of the Applicant, Stephen Garanin, Goddard Consulting, LLC is pleased to submit this Habitat Restoration Plan as a component of the Notice of Intent filed for 39 Griscom Road in Sudbury, MA.

Restoration is proposed within an 11,734 sf area, in the western half of the property, in response to a Notice of Violation that was issued to the Applicant on December 17, 2018. See attached Orthophoto for a visual plan of the restoration area.

2. RESTORATION PLAN SUMMARY

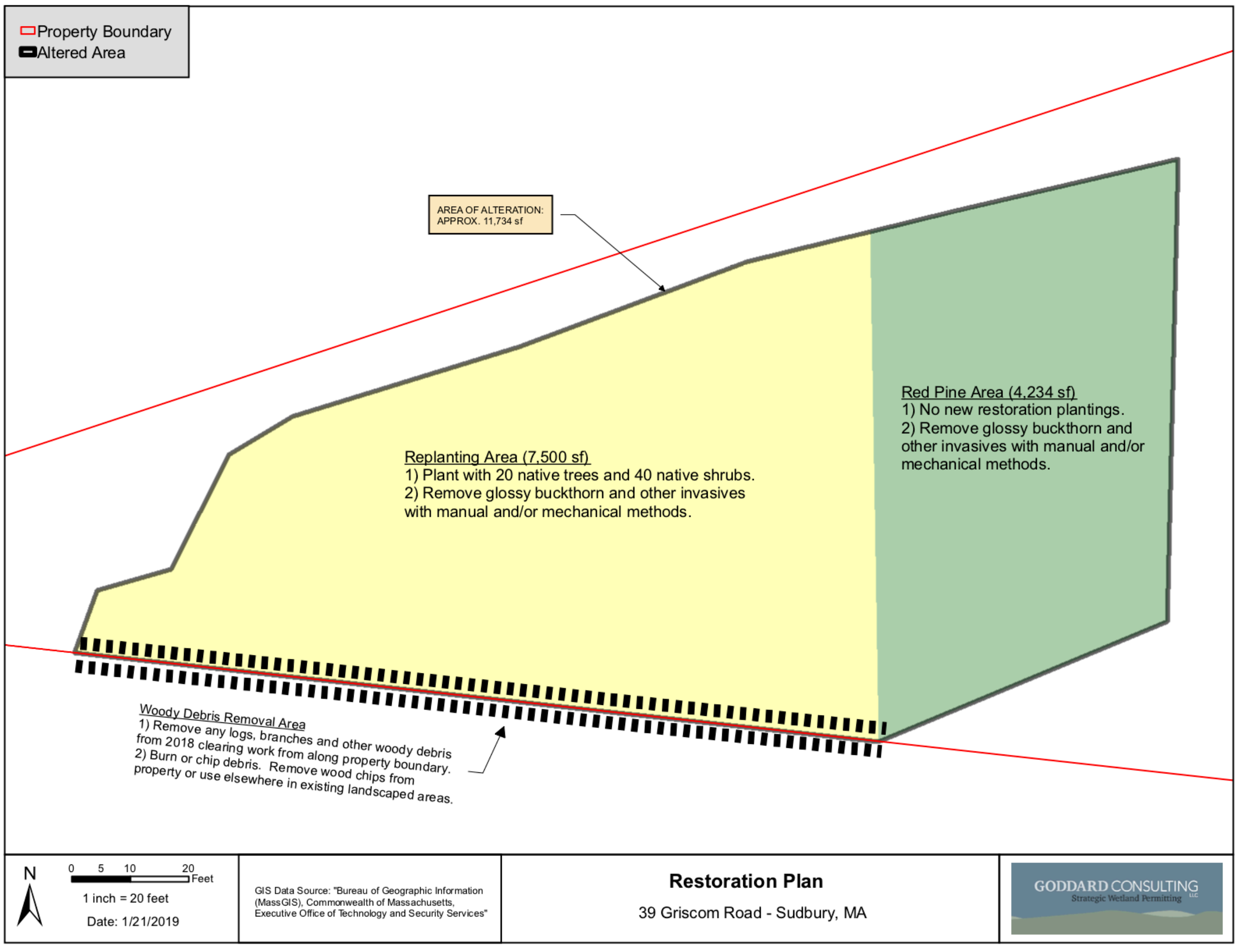
2.1 Habitat Restoration Area Location

This includes an upland area (approximately 11,734 sf in extent) located in the western half of the property. The following is a reduced version of the Orthophoto. A full-size version is attached to this report.

The Restoration has been sub-divided into three separate treatment areas:

Red Pine Area (4,234 square feet)
Replanting Area (7,500 square feet)
Woody Debris Removal Area (select portions of the 140 linear-foot southern property line)

The following is a reduced version of the Restoration Plan. A full-size version is attached to this report.



2.2 Habitat Restoration Plan Components

The plan includes new tree and shrub plantings, invasive species removal and management, and woody debris removal.

3. RESTORATION PLAN DETAILS

3.1 Overview

Supervision: All work within the restoration area shall be supervised by a qualified wetland scientist or biologist with a minimum of five years' experience. The supervisor shall submit monitoring reports to the Conservation Commission as described below. Reports shall contain details of all work performed and photographs of completed conditions.

Timing: Debris removal and invasive species removal shall take place during the late winter and/or early spring of 2019, with the goal of having restoration area plantings installed during the Spring 2019 growing season.

3.2. Sequencing of Procedures

Step 1: Identify Limits of Work
The wetland scientist shall flag out or otherwise clearly identify the limits of work for each treatment area. Erosion control barriers shall not be necessary given the flat nature of the restoration area and the dense vegetation that exists along and south of the southern property line. The supervising wetland scientist shall have authority to require erosion control measures if deemed necessary.

Step 2: Identify invasive species for removal
The wetland scientist shall identify and flag (with pink flagging) any non-native invasive species to be removed prior to the planting activities. Species known to be present include, glossy false buckthorn and Oriental bittersweet. Different treatments shall be utilized for the various species.

Step 3: Remove woody debris from southern property boundary
Any fresh shrub and tree cuttings from the 2018 clearing activity shall be removed from the southern property boundary. The debris should be burned or chipped and removed from the property or used as mulch in existing landscaped areas. The wetland scientist shall identify and flag (with yellow flagging) any notable large woody debris specimens (rotting logs and branches) for stockpiling and subsequent addition to the restoration area.

Step 4: Remove invasive species
All invasive species specimens shall be removed and discarded in accordance with the following species-specific procedures. No herbicides shall be used since the entire restoration area is within Riverfront Area.

Glossy false buckthorn: hand-pull individual plants so that entire root system is removed. Chip or burn, taking care not to spread any berries beyond already-contaminated areas. If roots cannot be removed, cut as close to ground as possible to impede growth of stump sprouts the following growing season, and repeat regularly until the plant ceases to resprout.

Oriental bittersweet: cut vines from living trees, attempt to pull out individual vines at the roots. Chip or burn removed pieces, taking care not to spread berries beyond already-contaminated area.

Step 5: Planting

This will take place within the 7,500 sf Replanting Area. Species and quantity to be planted include:

Trees
- 5 red oak (*Quercus rubra*) (3-4' height or greater)
- 5 red maple (*Acer rubrum*) (3-4' height or greater)
- 5 box elder (*Acer negundo*) (3-4' height or greater)
- 5 sassafras (*Sassafras albidum*) (3-4' height or greater)

Shrubs
- 10 American hazelnut (*Corylus americana*) (18"-24"' height)
- 10 serviceberry *(Amelanchier canadensis/arborea*) (2-3' height)
- 10 alternate-leaf dogwood (*Cornus alternifolia*) (2-3' height)
- 10 highbush blueberry (*Vaccinium angustifolium*) (2-3' height)

Seed Mix
- 6 lbs. New England Wetland Plants New England Conservation/Wildlife Mix or equivalent (25 lbs/acre) applied to newly planted portions

Notes
- Precise citing of plants may be determined by the owner or wetland scientist in the field prior to installation.

- All plantings shall be distributed randomly throughout the area; trees spaced at 15' on center; shrubs spaced at 6-10' on center.

- Each plant will have it roots loosened prior to planting to encourage root growth away from the planting bulb.

- Leaf litter shall be spread throughout area if available. Seed mix shall be scattered evenly by hand throughout the restoration area.

- Plantings shall take place during suitable growing conditions and not before completion of the woody debris and invasive plant species removal.

- All plantings shall be watered appropriately during the first growing season, and shall be monitored by the supervising biologist at the end of the first growing season to assess survival and whether replacement plantings are necessary.

- Any plants that do not survive the first growing season shall be replaced prior to the next growing season.

- Substitutions may be made to the above list upon approval from the Conservation Commission or its agent. Only plants native to Middlesex County shall be used.

Step 7: Monitoring

a. **Seasonal monitoring reports** shall be prepared for the restoration area by a qualified wetland scientist for a period of 2 additional years after installation. This monitoring program will consist of late spring and early fall inspections, and will include photographs and details about the vitality of the restoration area. Monitoring reports shall be submitted to the Commission by November 30th of each year. Monitoring reports shall describe, using narratives, plans, and color photographs, the physical characteristics of the area, survival of vegetation and plant mortality, aerial extent and distribution, species diversity and vertical stratification (i.e. herb, shrub and tree layers). Invasive species will be documented if present.

b. **At least 80% of the surface area** of the restoration area shall be re-established with indigenous plant species within three growing seasons. If the restoration area does not meet the 80% re-vegetation requirement by the end of the second growing season after installation, the Applicant shall submit a remediation plan to the Commission for approval that will achieve, under the supervision of a Wetland Specialist, the desired goals. This plan must include an analysis of why the areas have not successfully re-vegetated and how the Applicant intends to resolve the problem.

c. There should be an intensive effort to prevent the establishment of non-native invasive plant species, and to ensure timely and consistent treatment (e.g., hand pulling, cutting) of invasive plant species that become established within the Restoration Area.

N

0 12.5 25 50 Feet

1 inch = 50 feet

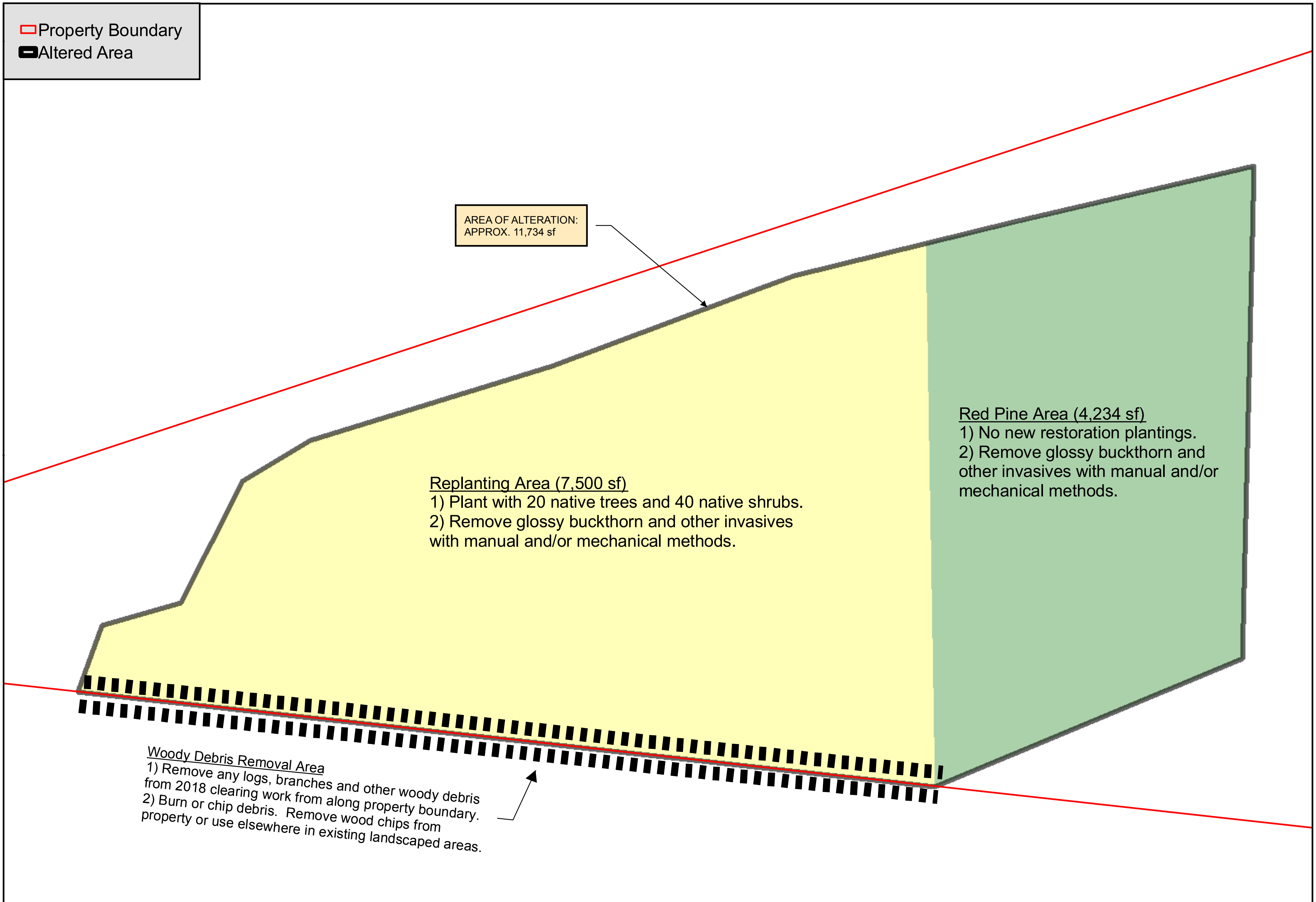
Date: 1/14/2019

GIS Data Source: "Bureau of Geographic Information (MassGIS), Commonwealth of Massachusetts, Executive Office of Technology and Security Services"

Orthophoto View of Site

39 Griscom Road - Sudbury, MA

GODDARD CONSULTING LLC
Strategic Wetland Permitting



N

0 5 10 20 Feet

1 inch = 20 feet

Date: 1/21/2019

GIS Data Source: "Bureau of Geographic Information (MassGIS), Commonwealth of Massachusetts, Executive Office of Technology and Security Services"

Restoration Plan

39 Griscom Road - Sudbury, MA

GODDARD CONSULTING LLC
Strategic Wetland Permitting

July 13, 2020

Sudbury Conservation Commission
Department of Public Works Building
275 Old Lancaster Road
Sudbury, MA 01776

Re: Spring 2020 Monitoring Report
39 Griscom Road, Sudbury, MA
DEP File #301-1256

1. Introduction

Goddard Consulting, LLC (GC) is pleased to submit this report detailing the monitoring activities performed at the 39 Griscom Road project site in Spring of 2020. The monitoring was conducted for the property owner and permit holder, Steve Garanin.

2. Summary of Plantings

The following plants were installed within the 7,500 sf Replanting Area in spring of 2019. Species and quantity planted include:

Trees
- 5 red oak (*Quercus rubra*) (3-4' height)
- 5 red maple (*Acer rubrum*) (3-4' height)
- 5 box elder (*Acer negundo*) (3-4' height)
- 5 moosewood (*Acer pensylvaticum*) (3-4' height)

Shrubs
- 5 Highbush cranberry (*Viburnum trilobum*)
- 5 Black chokeberry (*Aronia melanocarpa*)
- 10 serviceberry *(Amelanchier canadensis*)
- 10 Red-osier dogwood (*Cornus sericea*)
- 10 highbush blueberry (*Vaccinium angustifolium*)

Seed Mix
- 6 lbs. New England Wetland Plants New England Conservation/Wildlife Mix

3. Monitoring

On June 19, 2020, I inspected the restoration area. The majority of the trees and shrubs survived the first growing season, but Oriental bittersweet has regrown vigorously in. many parts of the restoration area, despite active management by the

The following photos show the conditions present on the 6/19 inspection.

Photo 1 - Main portion of restoration area, facing west.

Photo 2 - Facing east toward residence from center of restoration area.

Photo 3 - Healthy box elder tree.

Photo 4 - Healty highbush blueberry shrub.

Photo 5 - Oriental bittersweet climbing up red pine trunk.


Photo 6 - Oriental bittersweet invading planted red maple.

4. Conclusions

I conclude that there is a high level of plant survivorship after the first 1.5 growing seasons, however the regrowth of Oriental bittersweet is substantial and problematic for Mr. Garanin. The area will be monitored in Fall of 2020 to ensure continued success.

Please feel free to contact me if you have any questions.

Very truly yours,

Dan Wells
Senior Wetland Scientist and Wildlife Biologist

Notification to Abutters
Under the Massachusetts Wetlands Protection Act
and the Sudbury Wetlands Administrative Bylaw

In accordance with the second paragraph of Massachusetts General Laws Chapter 131, Section 40, you are hereby notified of the following:

A. The name of the **Applicant** is ____

B. The Applicant has filed a Notice of Intent with the Sudbury Conservation Commission seeking permission to work in an Area Subject to Protection (Wetland Resource Area and/or Buffer Zone) under the Massachusetts Wetlands Protection Act (General Laws Chapter 131, Sec.40) and the Town of Sudbury Wetlands Administrative Bylaw.

C. The **address** of the lot where the activity is proposed: _____________________________

D. The **proposed activity** is: ____

____

____

E. A **Public Hearing** regarding this Notice of Intent will be held on:
Tuesday, September 15, 2020 at 6:45 PM.

F. **Public Participation will be via Virtual Means Only** - In light of the ongoing COVID-19 coronavirus outbreak, Governor Baker issued an emergency Order on March 12, 2020, allowing public bodies greater flexibility in utilizing technology in the conduct of meetings under the Open Meeting Law. The Town of Sudbury Conservation Commission greatly values the participation of its citizens in the public meeting process, but given the current circumstances and recommendations at both the state and federal levels to limit or avoid public gatherings, including Governor Baker's ban on gatherings of more than 10 people, together with the present closure of Sudbury Town Hall and other public buildings to the public, the Town has decided to implement the "remote participation" procedures allowed under Governor Baker's emergency Order for all boards, committees, and commissions.

G **The public may participate in this meeting via Remote Participation.**
You can access this meeting using the link on the Conservation Commission website at: https://sudbury.ma.us/conservationcommission/meeting/conservation-commission-meeting-tuesday-september-15-2020/

H Copies of the Notice of Intent may be examined by visiting this Website:
https://sudbury.ma.us/conservationcommission/meeting/conservation-commission-meeting-tuesday-september-15-2020/

I. Copies of the Notice of Intent may be obtained from either The Applicant, or the Applicant's representative ______________________________, by calling this telephone number: __________________ between the hours of ______________________

Note: Public Hearing Notice, including its date, time, and place, will be published at least 5 days in advance in either the Sudbury Crier or MetroWest newspapers (at the applicant's expense).

Request to Amend Order of Conditions #301-1256, dated March 28, 2019

TO: Sudbury Conservation Commission

FROM: Stephen A. Garanin, 39 Griscom Road, Sudbury, AM 01776

DATE: August 20, 2020

A. Background:

In December 2018, I hired a local landscaper to remove 11,734 square feet of very high density Frangula alnus and Celastrus orbiculatus on the subject property. He accomplished this, but someone in the area notified the Conservation Commission of its removal from within a "riverfront" wetland area. Due to this I was served a Notice of Violation (NOV) and required to file a Notice of Intent (NOI); including a Habitat Restoration Plan (January 21, 2019).

In March 2020, I received an Order of Conditions (OOC), MassDEP #301-1256. The salient conditions, relatable to this Amendment request are as follows:

4. Work authorized hereunder shall be completed within three years from the date of this OOC. (March 27, 2022)

13. The work shall conform to the plans and special conditions referenced in this OOC. (Habitat Restoration Plan, January 21, 2019)

14. Any change to the plans identified in Condition #13 shall require the applicant to inquire of the Conservation Commission in writing whether the change is significant enough to require the filing of a new NOI. (It was determined that it did not.)

B. Special Conditions:

I.d. Invasive plants that attempt to recolonize the area may continue to be pulled by hand or mechanical means provided an updated Invasive Species Management Plan is submitted to the Commission for approval following the completion of the planting restoration and achievement of performance standards in this OOC. (Land Stewardship, Inc., three year contract with possibility of ongoing mitigation in out years.)

II.t. The disturbed area shall be monitored for the duration of this three-year OOC by an Environmental Monito (EM)r. (Dan Wells, Senior Wetland Scientist and Wildlife Biologist, Goddard Consulting, llc.) with expertise in native plant and invasive plant identification. The EM shall submit status progress reports on the plant installation and regrowth twice annually. Once in late June/early July and again in late October, for the duration of this OOC.

IV.a. Any modification or revisions to the plans referenced, or by any new plans, must be submitted to the Commission for review and a determination as to whether a new NOI is required. (It is not.) If this procedure is not followed, this OOC may be amended. No additional work not specifically allowed by this OOC shall be accomplished on the site without the approval of the Sudbury Conservation Commission and the appropriate new filings or amendment requests are approved.

B. <u>Narrative:</u>

1. On June 3, 2020, two Land Stewardship, Inc. employees arrived at locus property to accomplish the previously contracted for spring buckthorn and bittersweet hand pulling. While here the two men said they were confident that one more spring pull will reduce the buckthorn to a minor level of growth. However, they both stated that they were only able to pull a limited amount of bittersweet, stating that it was so pervasive and that the roots left behind would continue grow and germinate. They said that the only way to control it was by the use of herbicides, but they knew that they cannot be utilized in Sudbury. They mentioned that they would report what was happening on the property to Chris Polatin, principal at Land Stewardship, Inc. This was their second year of pulling invasives so they are aware of how it is looking and what has been effective.
2. On August 6, 2020, Chris Polatin, Land Stewardship, Inc., sent me an email stating the following: "I'd like to propose we use an organic/non-synthetic product to manage the bittersweet via foliar application. Hand-pulling is not a viable option. I've attached a research paper which compared the use/efficacy of this approach. [It compared two organic products to using Roundup.] I've also attached the label for a product called Weed Zap, which contains clove and cinnamon oils for active ingredients and proved effective on [4] invasive vines in the research paper. If it is acceptable, we can do the application for you."
3. During the third of six site visit reports by Wetland Specialist, Dan Wells, (June 18, 2020), the following was observed, "I conclude that there is a high level of plant survivorship after the first 1.5 growing seasons, however, the regrowth of Oriental bittersweet is substantial and problematic for Mr. Garanin."
4. After the Wetland Specialist's visit, I request a site visit be made by Lori Capone, Sudbury Conservation Specialist. She visited on June 30, 2020. Her observations included concurrence with Dan that the buckthorn is being reduced and managed. Further, the planted trees and shrubs are in good health. The most outstanding issue noted was the exceedingly prolific growth of bittersweet. In several instances, it was using the newly planted trees for support, thus lowly strangling them. Additionally, it was moving into areas previously inhabited by the buckthorn. Her conclusion was that it would not and could not be managed by hand-pulling or mechanical pulling.
5. A scientific study regarding Weed Zap efficacy was reported in the Natural Areas Journal, 40(2): 129-141, 13 April 2020. The following is their conclusion:
   As more of our forested lands become reduced to small patches, the potential for invasion by woody plants, such as malforming vines, entering from human-dominated land surrounding them will increase. These invasions threaten a forest's ability to regenerate via tree seedling and sapling recruitment, compromise the ability of forests to provide society with many ecosystem services. Even if regulations were in place to ban future sales of invasive plants by the horticultural industry, coverage of our forests by exotic plants is already high and self-perpetuating. Currently, glyphosate in formulations like Roundup is much less expensive than organic herbicides like PA (perlagonic acid) and CC (clove and cinnamon oils) in Scythe and Weed Zap, [respectively], for invasive plant control in natural areas. However, plant resistance to glyphosate is increasing, making the likelihood that increasing concentrations and dosages will be required to maintain invasive plant control. In addition, recent notorious and large court awards to litigants claiming that Roundup use

caused their cancers has made more people leery of using glyphosate-containing products. More cities, counties, and even countries have banned or are close to banning glyphosate. We need to recognize that the majority of forested lands in the eastern United States are being managed by private, often untrained owners who may stop using glyphosate for these perceived health reasons. Therefore, it is likely that the current array of chemicals to control invasive plants will need to be expanded."

Notification to Abutters
Under the Massachusetts Wetlands Protection Act
and the Sudbury Wetlands Administrative Bylaw

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A. The name of the **Applicant** is ___Stephen A. Garanin________________________________

B. The Applicant has filed a Notice of Intent with the Sudbury Conservation Commission seeking permission to work in an Area Subject to Protection (Wetland Resource Area and/or Buffer Zone) under the Massachusetts Wetlands Protection Act (General Laws Chapter 131, Sec.40) and the Town of Sudbury Wetlands Administrative Bylaw.

C. The **address** of the lot where the activity is proposed: _39 Griscom Road, Sudbury, MA 01776

D. The **proposed activity** is: Continued habitat restoration i.e. spraying of 100% organic herbicide, Wood Zap (cinnamon and clove oil), broad spectrum, foliar-applied: for the purpose of controlling and/or eliminating invasive herbaceous species: Celastrus orbiculatus and Rhamnus frangula._

E. A **Public Hearing** regarding this Notice of Intent will be held on:
Tuesday, September 15, 2020 at 6:45 PM.

F. **Public Participation will be via Virtual Means Only** - In light of the ongoing COVID-19 coronavirus outbreak, Governor Baker issued an emergency Order on March 12, 2020, allowing public bodies greater flexibility in utilizing technology in the conduct of meetings under the Open Meeting Law. The Town of Sudbury Conservation Commission greatly values the participation of its citizens in the public meeting process, but given the current circumstances and recommendations at both the state and federal levels to limit or avoid public gatherings, including Governor Baker's ban on gatherings of more than 10 people, together with the present closure of Sudbury Town Hall and other public buildings to the public, the Town has decided to implement the "remote participation" procedures allowed under Governor Baker's emergency Order for all boards, committees, and commissions.

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H Copies of the Notice of Intent may be examined by visiting this Website:
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I. Copies of the Notice of Intent may be obtained from either The Applicant, or the Applicant's representative ________________________________, by calling this telephone number: _978-460-4207 _____between the hours of _8:00 am and 6:00 pm.______________________

Note: Public Hearing Notice, including its date, time, and place, will be published at least 5 days in advance in either the Sudbury Crier or MetroWest newspapers (at the applicant's expense).