

# Using Vegetation Sampling Protocol for invasive species monitoring in two woodlots: Thompson Tract and the Hogsback

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## Acknowledgements

I thank Danijela Puric-Mladenovic, Katherine Baird, and Rebecca Barakat for their insight and collaborative efforts in helping to establish VSP at *rare*, as well as for lending us all of the equipment necessary for field work; the VSP field teams at the City of Kitchener who allowed us to borrow the GPS; Wasyl Bakowsky and other staff members at the OMNRF who assisted with plant identification; Jenna Quinn for her continued support in implementing new sampling protocols at *rare*; Tom Woodcock for assisting with GIS; Employment Ontario and Colleges and Institutes Canada CI Clean Tech Internship program for providing essential funding to support this role; and all of the dedicated volunteers and staff members who assisted with field sampling: Sama Al Maarofi, Mat Farrow, Joey Harris, Owen Lucas, Logan Mercier, and Aqua Rempel.

The *rare* Charitable Research Reserve acknowledges and is grateful to all of the original stewards of the land in which *rare* resides, within the Haldimand Tract, spanning six miles on either side of the Grand River from source to mouth. Understanding that this land has been rich in diverse Indigenous presence since time immemorial there are several Indigenous Nations that we would like to mention. We would like to honor and respect the sovereignty of both First Nations in our area; the Haudenosaunee Peoples of Six Nations of the Grand River and the Anishinaabe Peoples of Mississaugas of the New Credit First Nation. Nia:wen and Miigwech to these Nations who share their lands with us. We'd also like to acknowledge the Neutral Peoples (and their ancestors) and the Indigenous Paleo hunters that we have archeological evidence for dating back 1,200 and 10, 500 years, respectively. Lastly, we'd like to acknowledge those Indigenous Peoples who currently live, work and learn in the urban landscape around us such as other self-identified and status First Nations, Métis, and Inuit.

Cover Photography by Megan Rowcliffe. Clockwise from top: yellow birch organic deciduous swamp in the Hogsback, coniferous plantation with little vegetation in Thompson Tract, dense buckthorn shrub layer in yellow birch mineral deciduous swamp in Thompson Tract.

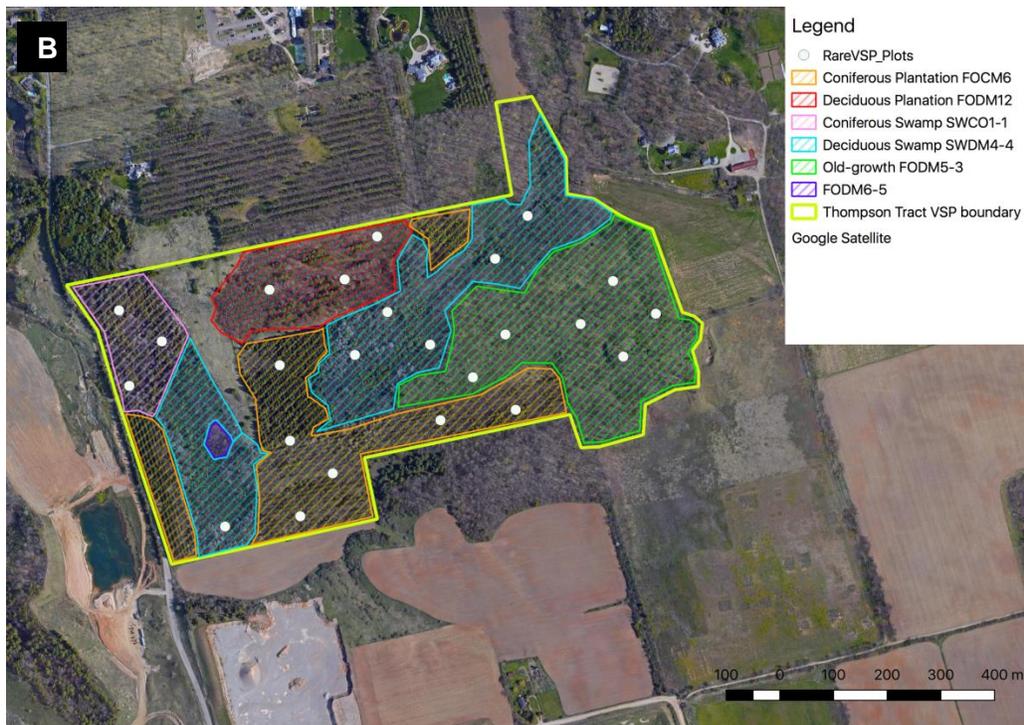
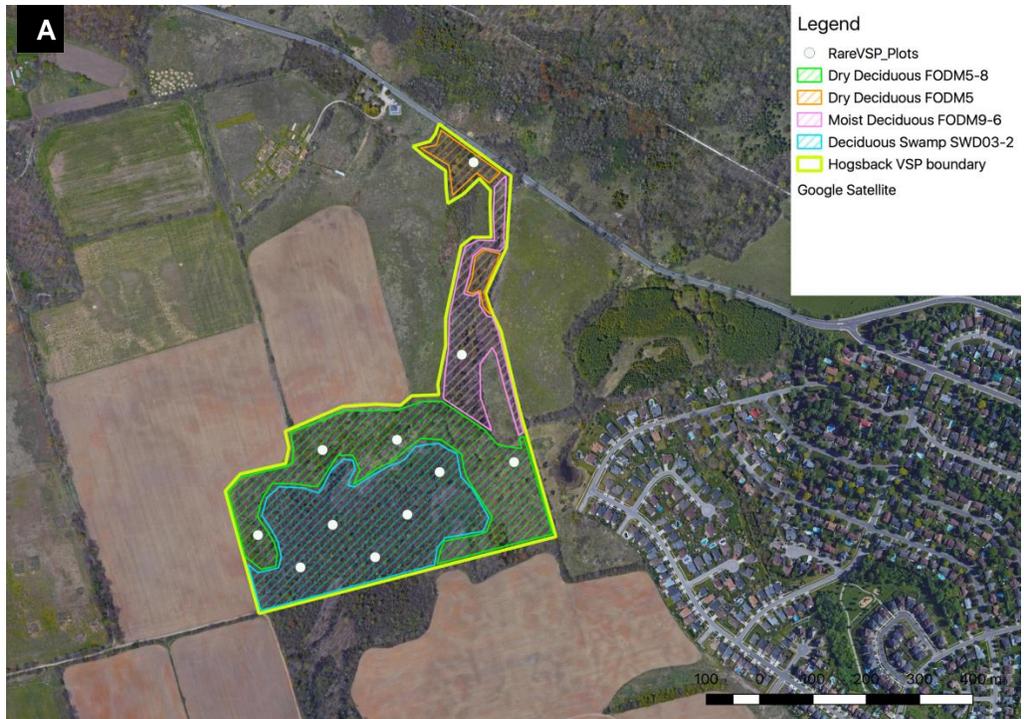
## Executive Summary

With the help of 99 volunteer hours committed to the Vegetation Sampling Protocol (VSP), a total of 304 different species of vascular flora were observed during the course of the 2018 vegetation sampling initiatives. One aster species, three grasses/sedges, seven species of ground vegetation, and one shrub has been added to **rare's** species list all from VSP efforts (Appendix D). Two forests on **rare's** property were sampled this year: the Hogsback (N=11) and Thompson Tract (N=24).

As expected, VSP reiterated that the Hogsback is an extremely high-quality site. It had noticeably fewer invasive species and a higher percent of native woody seedling regeneration than Thompson Tract. Additionally, numerous species were observed in the Hogsback that indicate high-quality wetlands. These species include brome-like sedge (*Carex bromoides*), cinnamon fern (*Osmunda cinnamomea*), tufted loosestrife (*Lysimachia thrysiflora*), swamp candles (*Lysimachia terrestris*), northern long-awned wood grass (*Brachyelytrum erectum* var. *glabratum*), and Chinese hemlock parsley (*Conioselinum chinese*; Appendix A-1). Sampling also revealed parts of the yellow birch mineral deciduous swamps in Thompson Tract to have some high-quality indicators, including species like low-sweet blueberry (*Vaccinium angustifolium*), swamp fly honeysuckle (*Lonicera oblongifolia*), in addition to cinnamon fern (*Osmunda cinnamomea*), northern long-awned wood grass (*Brachyelytrum erectum* var. *glabratum*), and Chinese hemlock parsley (*Conioselinum chinese*; Appendix A-1). However, areas near the coniferous plantation in Thompson Tract were noticeably poorer, likely caused by the heavily shaded understory created by dense stands of buckthorn.

Many of the naturalized plantations contained large numbers of invasive species and had low native tree regeneration. This was especially true in the south west coniferous plantation. The south east naturalized coniferous plantations were an exception, with greater native woody seedling regeneration and considerably fewer invasive species. The old-growth, dry sugar maple-oak deciduous forests of Thompson Tract had relatively few invasive species and high native woody seedling regeneration despite being in close proximity to some of these highly invaded plots (Figure 1B). One exception was a plot that had the historic remnants of a deer enclosure (see Bubenik and Schams, 1986; and other work by Bubenik), which had considerably higher percent covers of the invasive garlic mustard (*Alliaria petiolata*) and the potentially invasive nipplewort (*Lapsana communis*).

The eastern white cedar organic coniferous swamps of Thompson Tract were the most species rich plots (maximum of 105 species in the ground layer in plot 300; Figure 1B and Appendix B-2). Despite high species diversity, these coniferous swamps also had some of the highest percent cover of buckthorn from the ground to sub-canopy layers.

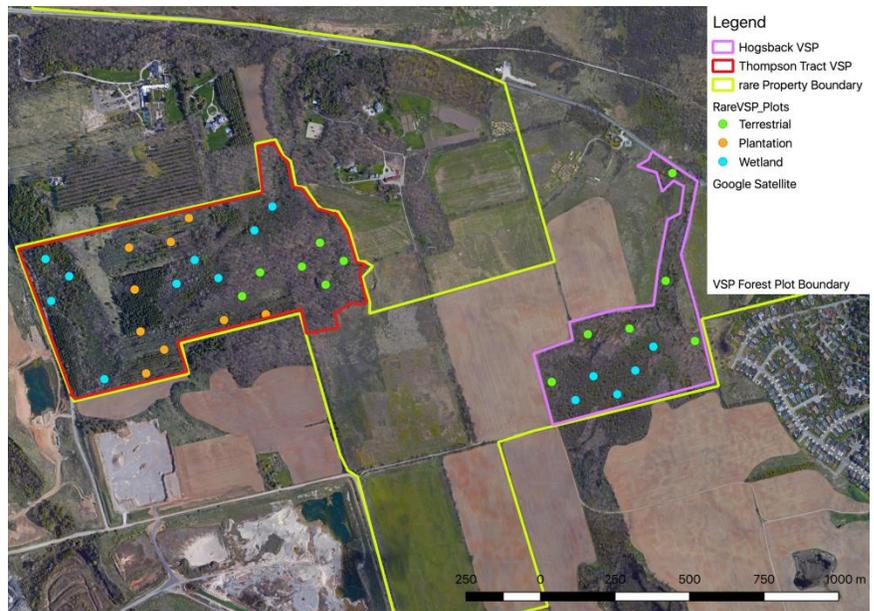


**Figure 1:** Map of the Hogsback (A; N=11) and Thompson Tract (B; N=24), two forest tracts sampled from June-September 2018 following the Vegetation Sampling Protocol at **rare Charitable Research Reserve** in Cambridge; where white markers indicate randomly generated VSP plots (11.28m radius) and coloured polygons indicate the Ecological Land Classification (ELC). Yellow lines indicate established sampling boundaries for each forest following **rare's** property boundaries and eliminating meadows or agricultural fields.

## Methods

### Study sites

Samples were collected from June to September, 2018, from two woodlots within **rare Charitable Research Reserve's** property: The Hogsback (N=11) and Thompson Tract (N=24; Figure 2). Plots were randomly assigned in GIS. The number of plots were proportionate to the size of each forest and the number of different land classifications –Thompson Tract is comprised of five different Ecological Land Classification (ELC) codes (eastern white cedar coniferous organic swamp, naturalized coniferous plantation, naturalized deciduous plantation, yellow birch mineral deciduous swamp, and dry-fresh sugar maple-oak deciduous forest) compared to the Hogsback which only had three ELC codes (yellow birch organic deciduous swamp, dry-fresh sugar maple-white ash deciduous forest, and fresh-moist oak-hardwood deciduous forest). Following the Vegetation Sampling Protocol (VSP) outlined by Puric-Mladenovic and Keeney (2015), each plot was circular in size with an 11.28 m radius. Future study sites and plots for the remainder of **rare's** property have also been randomly generated in GIS and can be found on **rare's** server.



**Figure 2:** Map of Thompson Tract (left, red; N=24) and the Hogsback (right, pink; N=11), two forest tracts sampled from June-September 2018 following the Vegetation Sampling Protocol at **rare Charitable Research Reserve** in Cambridge; where green indicates terrestrial plots (N=13), blue indicates wetlands (N=13), and orange indicates plantation (N=9). Yellow line indicates **rare's** property boundaries.

### Vegetation sampling

Plot sampling adhered to the Vegetation Sampling Protocol (Puric-Mladenovic & Keeney, 2015). The presence and abundance (percent cover estimated as 0.01 or increments of 5%) of all vascular flora were recorded amongst the four designated vertical strata within each plot (<0.5m, 0.5-2m, 2-10m, and >10m). Sampling was separated into four quadrats following the main cardinal directions (N, S, E, W), with one metre by one metre subplots falling on the middle of each cardinal direction and one at the centre of the plot circle. Subplots quantified the presence and abundance of all vascular flora less than or equal to 0.5 meters in height, as well as seedling and sapling regeneration. For seedling regeneration, the number of seedlings were counted for each species and categorized by height (2.5-15cm, 15-30cm, 30-90cm, 150-200cm, >200cm) while also taking into account the number of seedlings browsed. Saplings with diameters at breast height (dbh, measured 1.3m from the ground) between 2.5 cm and less than 5 cm were sampled, recording their dbh with a caliper and if they experienced any level of browsing.

Any tree that fell 50% or more within the plot boundaries with a dbh greater than 5 cm would be measured to one decimal place. Other indices, such as species name, canopy dieback (on a scale of 0-3; where 0 = no dieback, 1 = up to 25%, 2 = up to 50%, 3 >50% dieback), and presence of pests/disease and overall health were recorded for all measured trees. Plot descriptions, such as ELC, canopy closure, age class, topographical characteristics, slope position, hydrological characteristics, evidence of anthropogenic and environmental disturbances were also included. Soil characteristics, coarse woody debris, and tree heights of three representative trees were not sampled during this study, although they are other components of VSP.

When sampling, it is important that you do so in the correct order, to minimize excessive trampling of the vegetation prior to sampling. Subplots should be done first, starting with the centre. When sampling the entire plot, you should sample the ground layer first, and work your way up the strata (shrub, sub-canopy, and canopy). Only after this, should you measure dbh and assess tree health.

For a comprehensive explanation of the methods, refer to the “VSP field inventory and monitoring pocket guide” produced by Puric-Mladenovic and Keeney (2015). For additional information on VSP and all of the sampling occurring in southern Ontario, refer to [www.forests-settled-urban-landscapes.org](http://www.forests-settled-urban-landscapes.org).

### *Data analysis*

Data entry was done in Microsoft Access to reduce typos and maintain accuracy and consistency of species' names throughout the years. Spatial analyses of invasive flora, significant or rare species, buckthorn basal area, and seedling regeneration were done using qGIS (version 3.2). One-way ANOVAs were done using R (version 3.4.2).

## **Results**

### *Seedling regeneration and buckthorn basal area*

Thirteen out of 35 plots in two forests, Thompson Tract and the Hogsback, contained at least one buckthorn with a diameter greater than 5 cm. Plot 286 had the greatest basal area of 5.21 m<sup>2</sup>/ha with a total of 43 stem within a plot, followed by plot 274, with a basal area of 3.60 m<sup>2</sup>/ha and 15 stems, and plot 299 with a basal area of 1.58 m<sup>2</sup>/ha and 16 stems (Appendix A-2). Conspecific seedling regeneration of buckthorn increased significantly with increasing buckthorn basal area ( $p < 0.001$ ), where some plots had greater than 100 seedlings per square meter subplot. These findings complement the available literature (Converse, 1984; Frappier, Eckert, & Lee, 2003).

The Hogsback typically had low non-native woody seedling regeneration, with 0-28% of all seedlings counted in one by one metre plots being non-native. The old-growth, dry sugar maple-oak deciduous forests of Thompson Tract also contained low non-native woody seedling regeneration, with 0-20% of seedlings being non-native. On the contrary, the swamps of Thompson Tract typically contained high percentages of non-native seedling regeneration, with 36-98% of seedlings being non-native. The plantations of Thompson Tract varied greatly between plots, ranging from 0-88% of seedlings being non-native (Appendix A-3).

### *Invasive grasses and monocots*

Invasive grasses and monocots were found primarily in Thompson Tract, while the Hogsback remained relatively free from these invaders. Common reed, subsequently referred to as phragmites (*Phragmites australis*), was recorded in a single plot in a yellow birch mineral deciduous swamp in the south western end of Thompson Tract (Appendix A-4). As an effort to remove all phragmites from the plot, it was spaded on August 29, 2018. Regrowth was observed on October 9, however, no additional stands of phragmites were observed after walking transects in and around this plot.

Smooth brome (*Bromus inermis ssp. inermis*) is known to be highly invasive, although dominates only certain niches (Urban Forest Associates Inc., 2002). It was recorded in a single plot in a naturalized deciduous plantation in Thompson Tract (Appendix A- 5). While smooth brome only made up 12.5% of the plot, it was well established outside of plot boundaries forming a dense monoculture in and around that area.

Although trace amounts of invasive blue grasses (Kentucky bluegrass, *Poa pratensis ssp. pratensis*, and Canada bluegrass, *Poa compressa*) were found in three plots within the Hogsback, the naturalized coniferous plantations in Thompson Tract experienced the most impact from these invaders (Appendix A-6). These grasses are considered moderately invasive but can still locally dominate an area (Urban Forest Associates Inc., 2002). The greatest percent cover of invasive bluegrasses within a coniferous plantation plot was 80.05%, allowing very little ground vegetation to grow.

### *Invasive shrubs*

Japanese barberry (*Berberis thunbergii*) was found primarily in the north eastern corner of both Thompson Tract and the Hogsback, with plot 264 in Thompson Tract containing the greatest quantity (1.325%; Appendix A-7). Five out of the eight plots with Japanese barberry contained individuals that reached the shrub layer. Additionally, common barberry (*Berberis vulgaris*) was found scattered near the edges of both forests, with a maximum percent cover of 2.5% (Appendix A-8). Three out of five plots contained common barberry that reached the shrub layer. Both of these non-native barberries are considered moderately invasive (Urban Forest Associates Inc., 2002).

Invasive bush honeysuckles (tartarian honeysuckle, *Lonicera tatarica*; and Morrow's honeysuckle, *Lonicera morrowii*) were found in eleven plots throughout both forests –although no individuals were observed in the old-growth section of Thompson Tract (Appendix A-9). Seven out of the eleven plots contained invasive bush honeysuckles that reached the shrub layer. No individuals exceeded 1.25% of the plot. Both of these non-native bush honeysuckles are considered highly invasive and transformers on the landscape (Urban Forest Associates Inc., 2002).

Common privet (*Ligustrum vulgare*) was only observed in Thompson Tract (Appendix A-10), with half (three) of the observations clustered in the old-growth section of the forest. Of the six occurrences of common privet, three individuals reached shrub level, two of which were in the old-growth forest. Percent cover of common privet never exceeded 1.25%. This shrub is considered to be moderately invasive, with the possibility of dominating locally only under certain conditions (Urban Forest Associates Inc., 2002).

Multiflora rose (*Rosa multiflora*) was scattered in nine out of 35 plots (Appendix A-11). The largest percent cover of multiflora rose (10%) was in plot 72, in the fragmented riparian zone of Cruickston Creek connecting to the Hogsback. Additionally, plot 295 also had a large multiflora rose which was not entirely represented in the data as it occurred on the edge of the plot. Multiflora rose is considered highly invasive in certain niches (Urban Forest Associates Inc., 2002).

#### *Invasive trees*

European mountain ash (*Sorbus aucuparia*) had one occurrence in the Hogsback, with the remaining five occurrences in Thompson Tract (Appendix A-12). All observations were trace counts of seedlings, found in plots clustering in the eastern white cedar organic coniferous swamp of Thompson Tract, most likely due to adult European mountain ashes being observed by the road adjacent to *rare's* property.

Manitoba maple (*Acer negundo*) was observed in four plots (Appendix A-13). Unsurprisingly, seedlings were found in the fragmented riparian zone of the Hogsback and in the forested edge of the eastern white cedar organic deciduous swamp near Langdon Drive, where many established trees were found adjacent to the property. Similarly, a mature Manitoba maple, cut at breast height (dbh of 36.0 cm), was observed in plot 287 (naturalized deciduous planation) with many new epicormics shoots. This likely explains the additional seedlings found in the interior of Thompson Tract. Manitoba maple is considered highly invasive with the potential to transform a site indefinitely (Urban Forest Associates Inc., 2002).

Autumn olive (*Elaeagnus umbellatas*) had a large percent cover (up to 12.5% of the plot in sub-canopy) in the south western corner of the naturalized coniferous planation reaching up to the sub-canopy layer (Plot 258 and 259; Appendix A-14). Most observations of autumn olive were in the naturalized plantations, although trace amounts of seedlings were also found in plots within the yellow birch mineral deciduous swamp, adjacent to the plantations. Autumn olive is considered highly invasive within certain niches (Urban Forest Associates Inc., 2002).

All plots contained either common buckthorn (*Rhamnus cathartica*) or glossy buckthorn (*Rhamnus frangula*). The eastern white cedar organic coniferous swamps of Thompson Tract contained some of the highest percent cover of buckthorn (Appendix A-15, A-16, and A-17). The greatest percent cover of buckthorn observed in a single plot in the sub-canopy was 78.75%, while the shrub layer had a maximum percent cover of 96.25% and the ground layer of 48.75%. Plots in close proximity to Bauman Creek also had considerable amounts of buckthorn. A single plot in the Hogsback (plot 45) and four plots in Thompson Tract (Plots 299, 300, 274 and 306 – in increasing order), contained a shrub layer with more than 50% buckthorn. Three plots (299, 274, and 306) in Thompson Tract contained more than 50% buckthorn in the sub-canopy layer. No plots exceeded 50% buckthorn in the ground cover. The old-growth, dry sugar maple-oak deciduous forest surprisingly had very little buckthorn cover in all layers. Trace amounts of alder-leaved buckthorn (*Rhmanus alnifolia*) was only observed in a single plot in Thompson Tract (Appendix A-18). Although alder-leaved buckthorn was also observed in the south western part of the yellow birch mineral deciduous swamps of the Thompson Tract, outside of the defined VSP plots.

Although the native range of black locust (*Robina pseudoacacia*) is just south of Ontario, it is highly invasive in certain niches here (Urban Forest Associates Inc., 2002). Known to invade primarily in oak, beech-maple, and aspen forests, it may be important to consider managing black locust as the high valued, old-growth dry sugar maple-oak deciduous forest is

nearby (Warne, 2016). Large black locusts were observed solely in the naturalized deciduous plantations, although seedlings were found in the yellow birch mineral deciduous swamps, the eastern white cedar organic coniferous swamps, and the sugar maple-oak deciduous forests plots (Appendix A-19).

### *Invasive ground vegetation*

Six plots (one in the Hogsback, five in Thompson Tract) contained garlic mustard (*Alliaria petiolate*) with a ground cover of 5% or greater (Appendix A-20). Two plots in a naturalized deciduous plantation contained 17.5% and 11.25% garlic mustard. Additionally, a plot in the old-growth dry sugar maple-oak deciduous forest, where half of the plot contained the historic remnants of the deer enclosure fence, had 13.75% garlic mustard. The remaining plots with high levels of garlic mustard were found in two naturalized coniferous plantations in Thompson Tract and one dry sugar maple-white ash in the Hogsback, close to the forest edge.

The presence and gradients of other invasive ground vegetation were also mapped (in order of most invasive to potentially invasive): purple loosestrife (*Lythrum salicaria*), dame's rocket (*Hesperis matronalis*), Canada thistle (*Cirsium arvense*), lily of the valley (*Convallaria majalis*), forget-me-nots (*Myosotis sp*), common St. John's-wort (*Hypericum perforatum*), butter-and-eggs (*Linaria vulgaris*), coltsfoot (*Tussilago farfar*), nipplewort (*Lapsana communis*), birds-eye speedwell (*Veronica chamaedrys*) and greater celandine (*Chelidonium majus*; Appendix A-21 through A-31).

## **Conclusions & Recommendations**

Twelve new species were added to **rare's** species list from VSP in 2018 (Appendix D). The following invasive species observed during the 2018 vegetation sampling are listed as priorities at **rare** (Pope, 2014): common reed, autumn olive, multiflora rose, common buckthorn, glossy buckthorn, invasive bush honeysuckles, common barberry, and Japanese barberry. Figure 3 depicts the total percent covers of all priority species at **rare**. Both common and glossy buckthorn have been excluded from this map since their numbers are so high it inflated the total percent cover values and minimized the visibility of the other priority species. Refer to Appendix A-15 through A-17 for information on where high levels of buckthorn exist on the property. Based on mapping **rare's** invasive species priorities, sites for removal and restoration action can also be prioritized (Figure 3), and are listed below:

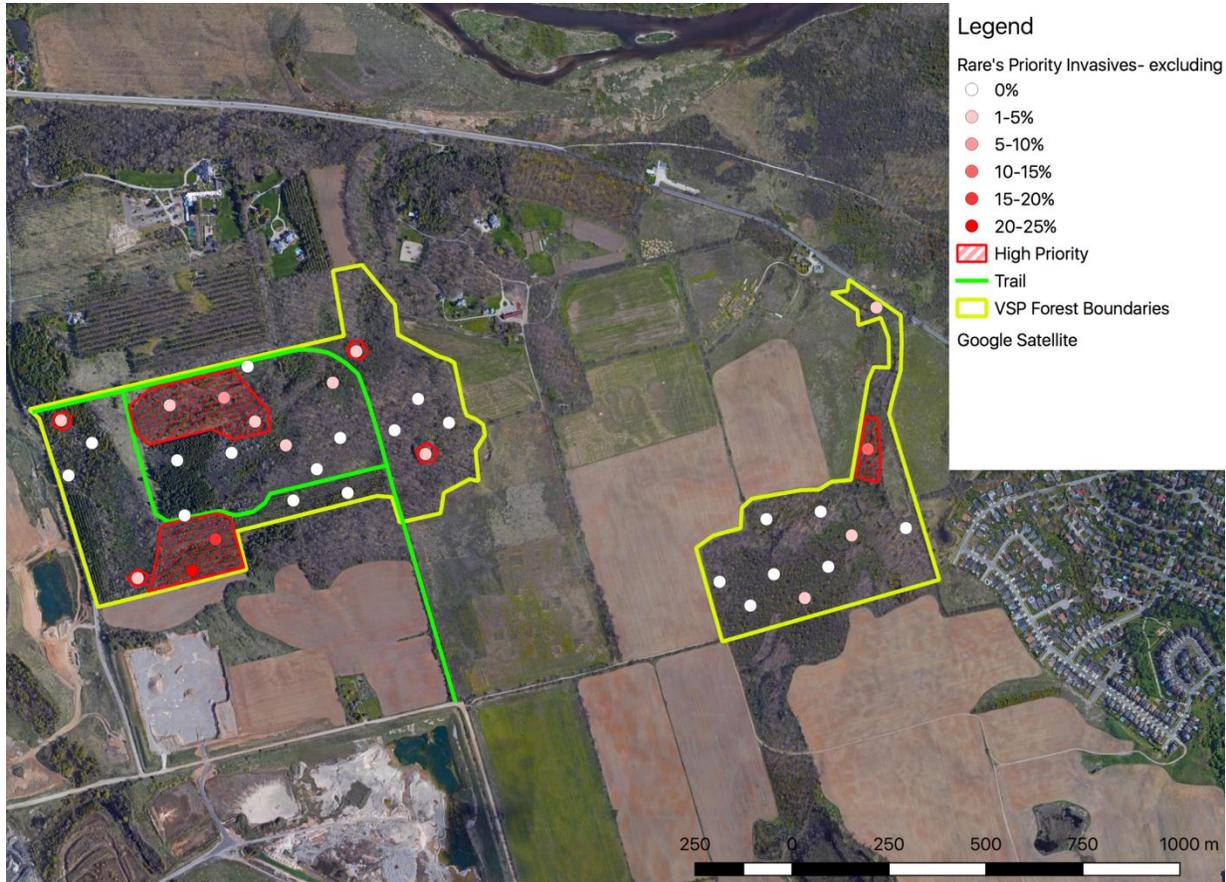
### *The Hogsback:*

- Riparian zone along Cruickston Creek north of the Hogsback proper due to high levels of **rare's** top invasive species priorities and close proximity to the Hogsback, a high quality site at **rare**.

### *Thompson Tract:*

- South western naturalized coniferous plantations and naturalized deciduous plantations and boarding area of the yellow birch mineral deciduous swamp due to the high levels of **rare's** top invasive species priorities.
- South western yellow birch mineral deciduous swamp as that is the only surveyed plot where phragmites was observed.
- Southern region of the old-growth forest as it was the only plot in the old-growth area to have fairly high levels of **rare's** invasive species priorities. This should occur quickly and cautiously so that invasive species do not move into the rest of the old-growth forest

- North eastern yellow birch mineral deciduous swamp and the northern part of the eastern white cedar coniferous swamp. Both of these plots were in close proximity to rare species (Chinese hemlock parsley) and high quality, species rich sites. Care should be taken to reduce the spread of invasive to these areas.



**Figure 3:** Map of Thompson Tract (left) and the Hogsback (right) depicting total percent cover of *rare's* top invasive species priorities: common reed, autumn olive, multiflora rose, invasive bush honeysuckles, common barberry, and Japanese barberry. Common and glossy buckthorn have been excluded. Total percent cover is expressed on a gradient, where plots that did not contain any priority species are depicted in white, lower percent cover of priority species are depicted in light red, increasing in colour intensity with increasing percent cover. Red polygons depict the areas of recommended restoration action priorities. Yellow lines indicate the boundaries of each VSP forest plots; green lines indicate trails. Total percent covers of invasive species priorities were obtained during vegetation sampling following the Vegetation Sampling Protocol, from June-September 2018 at the *rare* Charitable Research Reserve in Cambridge, Ontario.

In the future, it is recommended that *rare* scales up the measurements taken during VSP to include tree height (Puric-Mladenovic, personal communication). Additionally, in five years when 2018 plots are resampled, tree height measurements can also be obtained for these current plots. There are many benefits to obtaining tree height data. Reliable tree height in conjunction with basal area can give information on stand volume, carbon stocks, biomass, and site productivity. Tree height can also give information on crown length within a plot or forest (Juknys & Augustaitis, 1998). Tree height in conjunction with age can also be used as an index of forest site quality (Schreuder *et al.*, 1993; Andersen *et al.*, 2006). As long as the surveyor is

following sampling rules, traditional methods in measuring tree height can be accurate, estimated to be  $-0.27 \pm 0.27$ m in some studies (Andersen *et al.*, 2006; Puric-Mladenovic, personal communication). Nonetheless, the challenges that **rare** has experienced in the past with measuring tree heights within established EMAN (Environmental Monitoring and Assessment Network) plots should be noted. In 2017, tree heights were measured in EMAN plots as a means to revise the protocols used in 2016 which gave inaccurate results; however, the 2017 efforts continued to reveal inconsistencies in the data. Since the establishment of EMAN protocols at **rare**, unrealistic changes in tree heights have been documented across the monitoring years (Abram, 2017). Fortunately, there are key differences in protocols between VSP and EMAN which may yield more accurate tree height measurements. The Vegetation Sampling Protocol only measures three representative tree heights within a plot every five years, whereas EMAN measures the heights of every tree within a plot each year. These differences may make measuring tree heights more accessible to the surveyor, as easier –yet still representative trees –can be measured to increase accuracy. These trees may be on flat ground, as opposed to a slope, with a visible canopy.

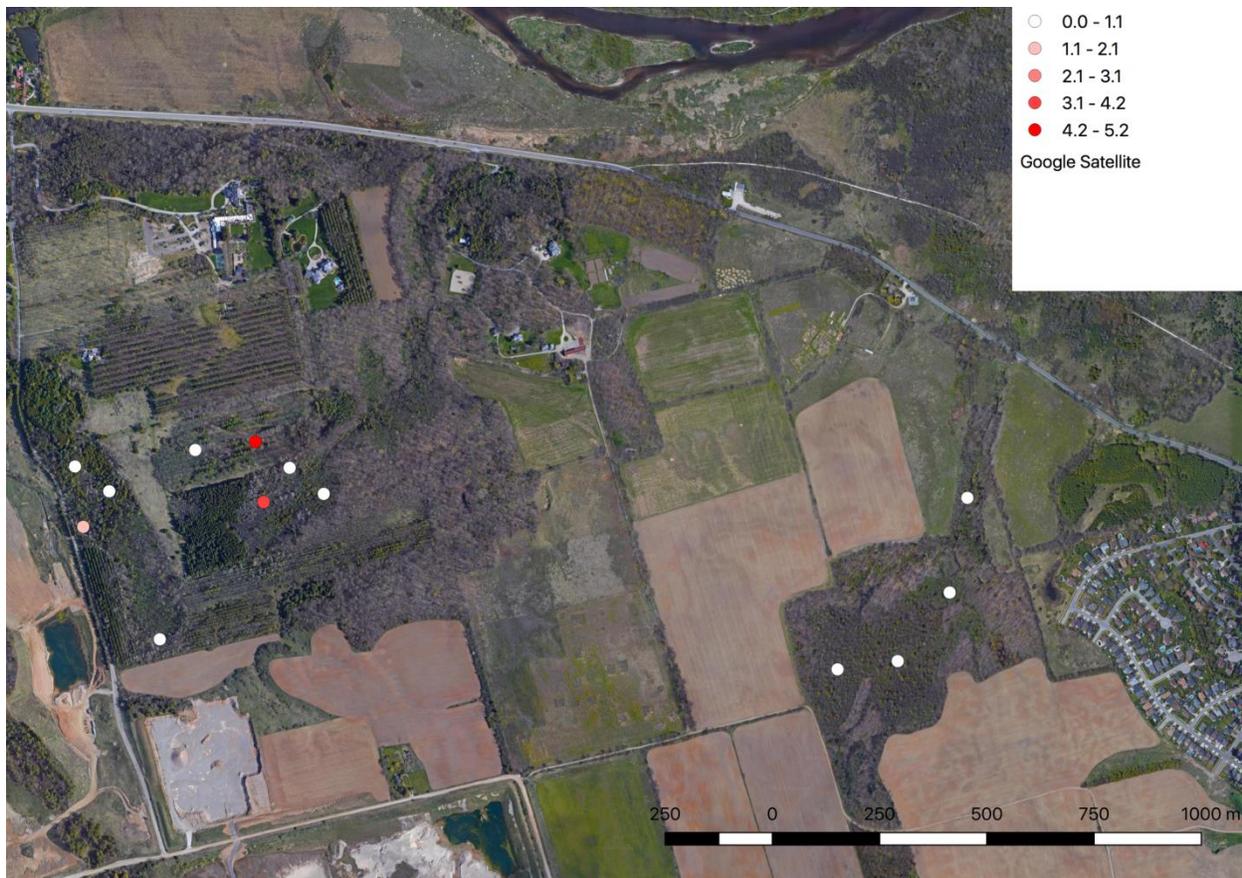
Using rebar to permanently mark plot centres is also highly recommended to ensure accurate comparisons when plots are resampled every five years. Although rebar was not in **rare's** budget for this year's sampling efforts, we plan to stake the plots as soon as possible.

In this pilot year, VSP has already proven to be an extremely valuable protocol to add to **rare's** long-term monitoring program. This in-depth method of vegetation sampling has not only added new species to our property list, but has also provided high-quality data to support Land Management work and prioritize sites for invasive species removal and restoration action. With plans to resample these plots in the Hogsback and Thompson Tract in five years, VSP will also provide valuable insight on any spatial or temporal shifts in vegetation on the property. With so many uses and benefits that can be applied to the data gathered through VSP, in future years **rare** should consider expanding its VSP efforts to include Cliffs and Alvars forest in addition to the many open habitats across the property.

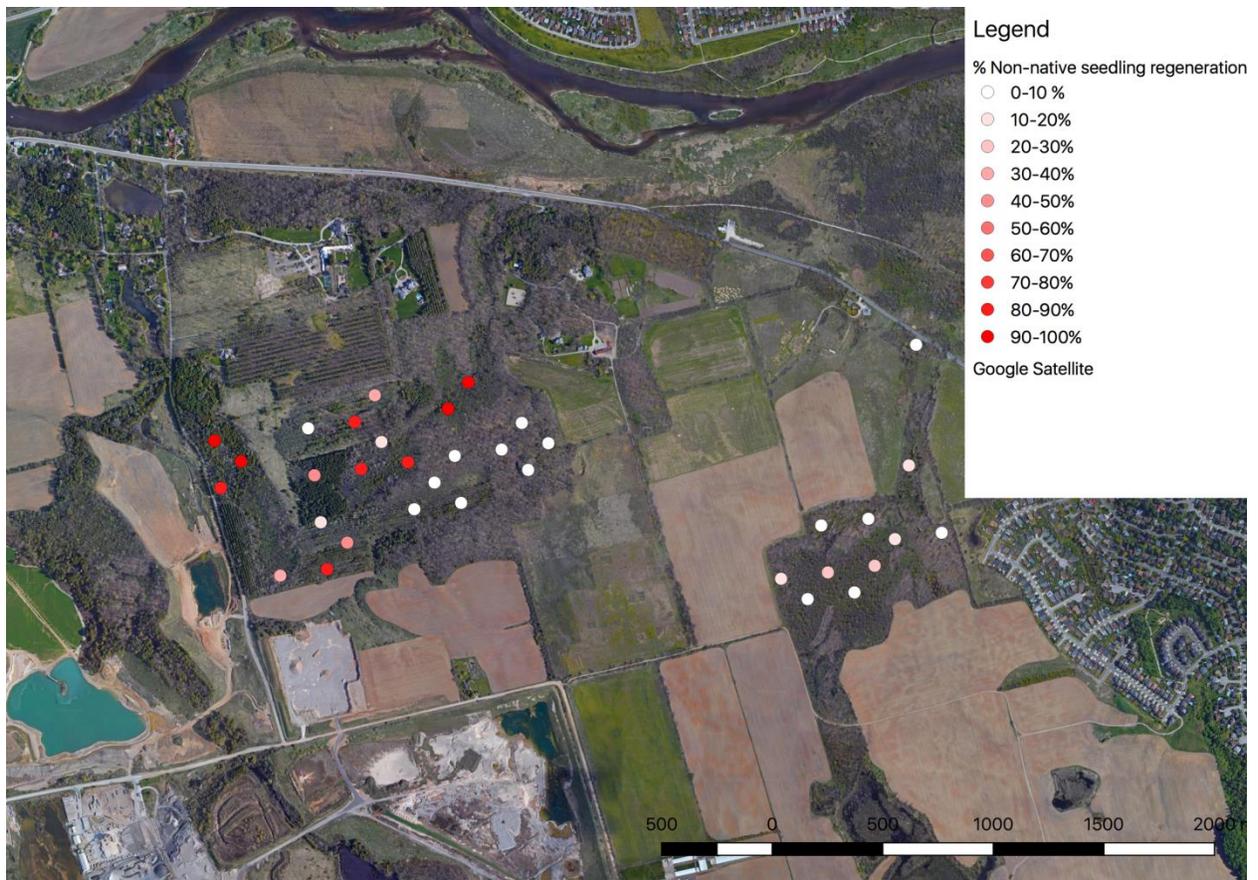
## Appendix A



**Figure A-1:** Map of the *rare* Charitable Research Reserve depicting presence of Chinese hemlock parsley (*Conioselinum Chinese*; S3 rank) in two forests, Thompson Tract and the Hogsback. Most locations of species presence were obtained from randomly regenerated plots sampled during June-September, 2018 in Cambridge, Ontario (all points in the Hogsback), in addition to other GPS locations observed near established plots (both plots in Thompson Tract).

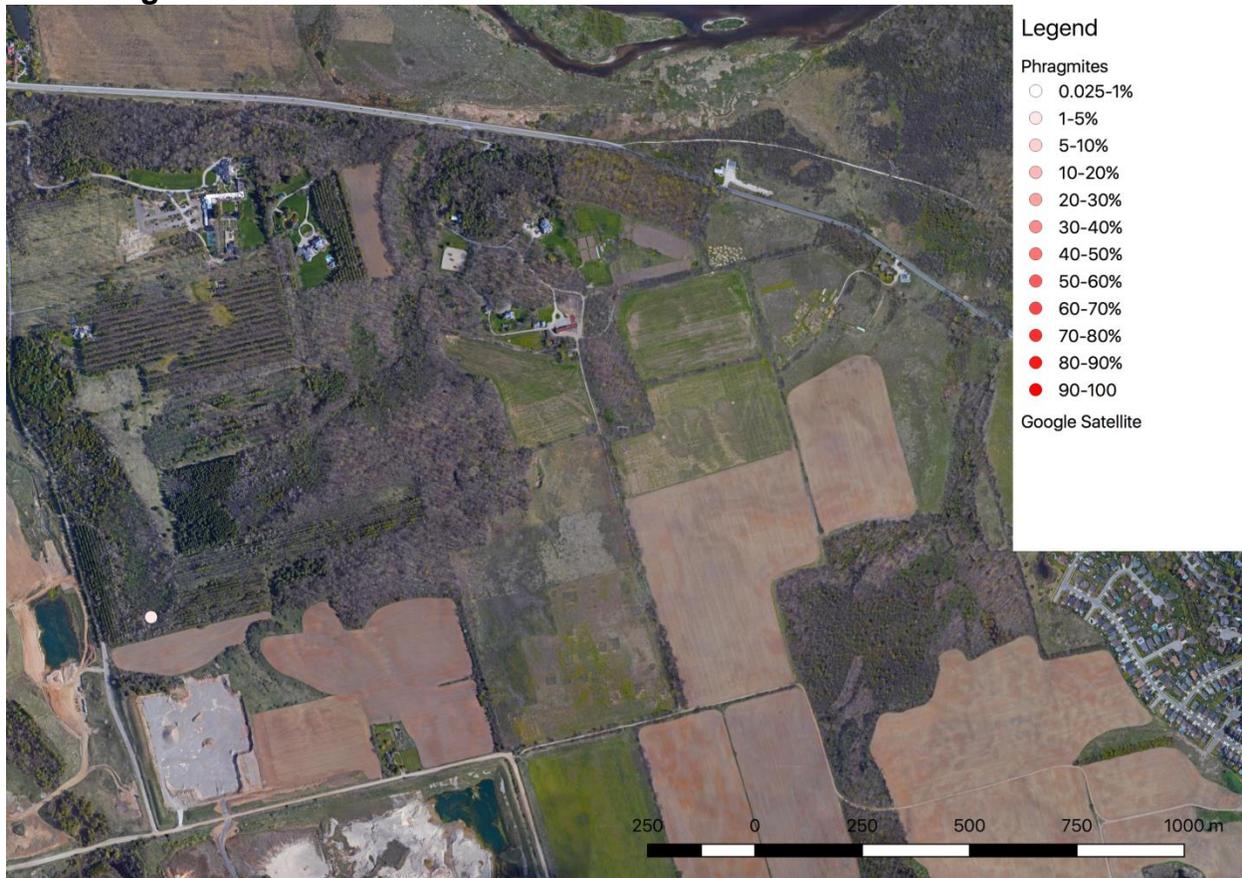


**Figure A-2:** Map of the *rare Charitable Research Reserve* depicting total basal area ( $m^2/ha$ ) of common and glossy buckthorn, *Rhamnus cathartica* and *Rhmanus fragula*, within a plot based on diameter measurements at breast height of all buckthorn with a dbh greater than or equal to 5cm. Thirteen out of 35 plots in two forests, Thompson Tract and the Hogsback, contained at least one buckthorn with a diameter greater than 5cm. Plot 286 had the greatest basal area of  $5.21 m^2/ha$  with a total of 43 stem; followed by plot 274, with a basal area of  $3.60 m^2/ha$  and 15 stems; and plot 299 with a basal area of  $1.58 m^2/ha$  and 16 stems. Basal area is expressed on a gradient, with lower basal area being white to light red, increasing in colour intensity with increasing basal area. Values were obtained from randomly regenerated plots sampled during June-September, 2018 in Cambridge, Ontario.

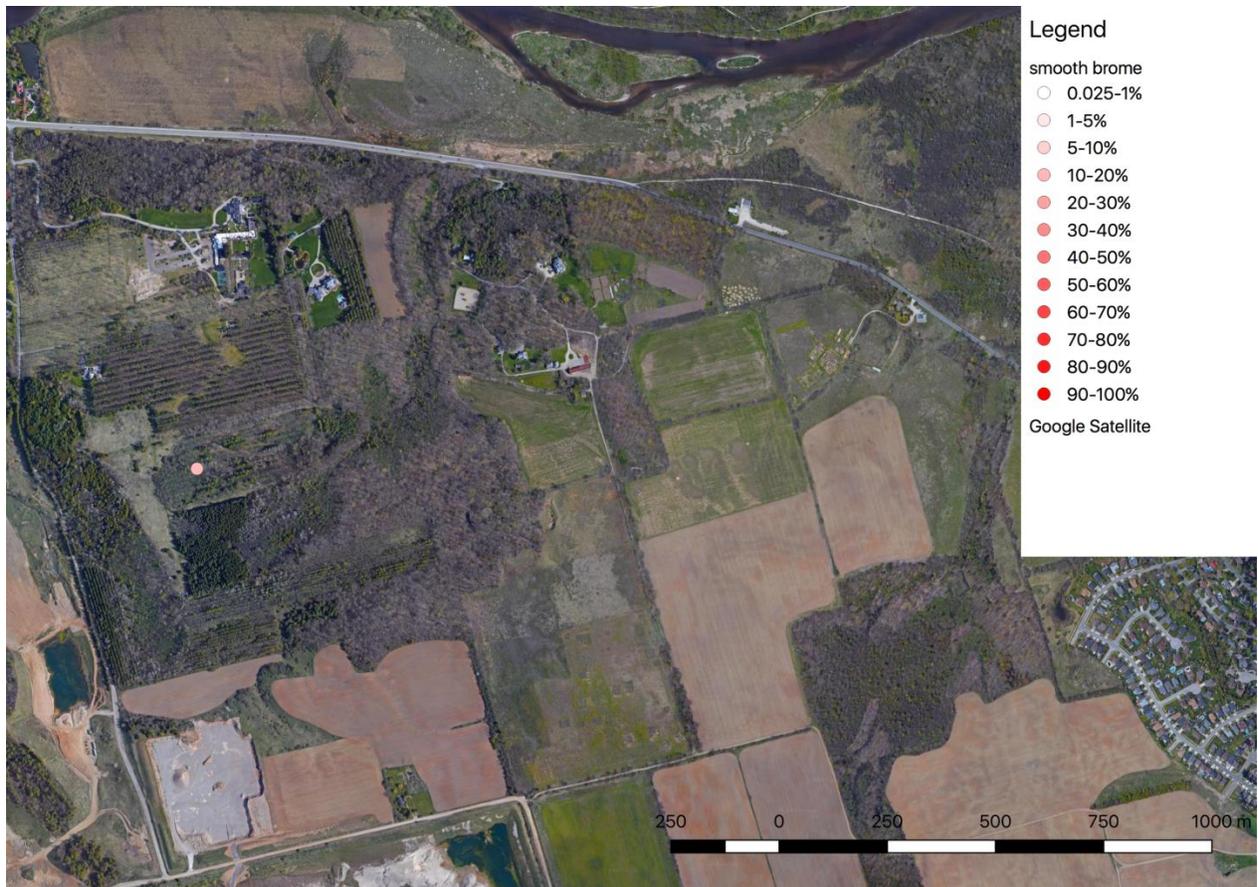


**Figure A-3:** Map of the *rare Charitable Research Reserve* depicting percent non-native seedling regeneration in two forests, Thompson Tract and the Hogsback. Percent non-native seedling regeneration is expressed on a gradient, with lower percent non-native seedling regeneration being white to light red, increasing in colour intensity with increasing percent of non-native seedling regeneration. Values were obtained from randomly regenerated plots sampled during June-September, 2018 in Cambridge, Ontario.

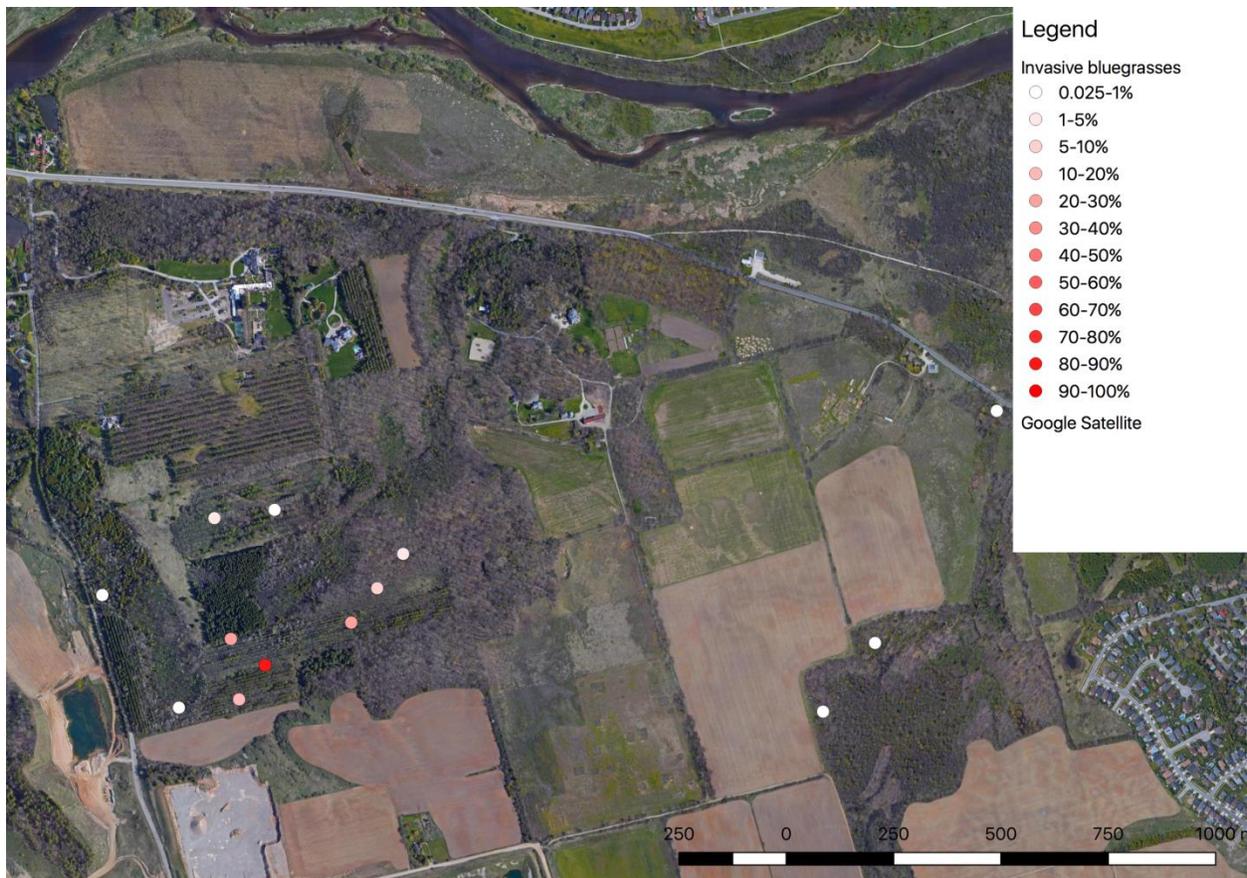
## Invasive grasses and monocots



**Figure A-4:** Map of the *rare* Charitable Research Reserve depicting total percent cover of common reed/phragmites, *Phragmites australis*, in ground (0-0.5m) layer within a 400m<sup>2</sup> plot (11.28 m radius). One out of 35 plots in two forests, Thompson Tract and the Hogsback, contained phragmites, comprising of 2.525% of the plot. Percent cover is expressed on a gradient, with lower percent cover being white to light red, increasing in colour intensity with increasing percent cover. Values were obtained from randomly regenerated plots sampled during June-September, 2018 in Cambridge, Ontario.



**Figure A-5:** Map of the *rare* Charitable Research Reserve depicting total percent cover of smooth brome, *Bromus inermis ssp. inermis*, in ground (0-0.5m) layer within a 400m<sup>2</sup> plot (11.28 m radius). One out of 35 plots in two forests, Thompson Tract and the Hogsback, contained smooth brome, comprising 12.5% of the plot. Percent cover is expressed on a gradient, with lower percent cover being white to light red, increasing in colour intensity with increasing percent cover. Values were obtained from randomly regenerated plots sampled during June-September, 2018 in Cambridge, Ontario.

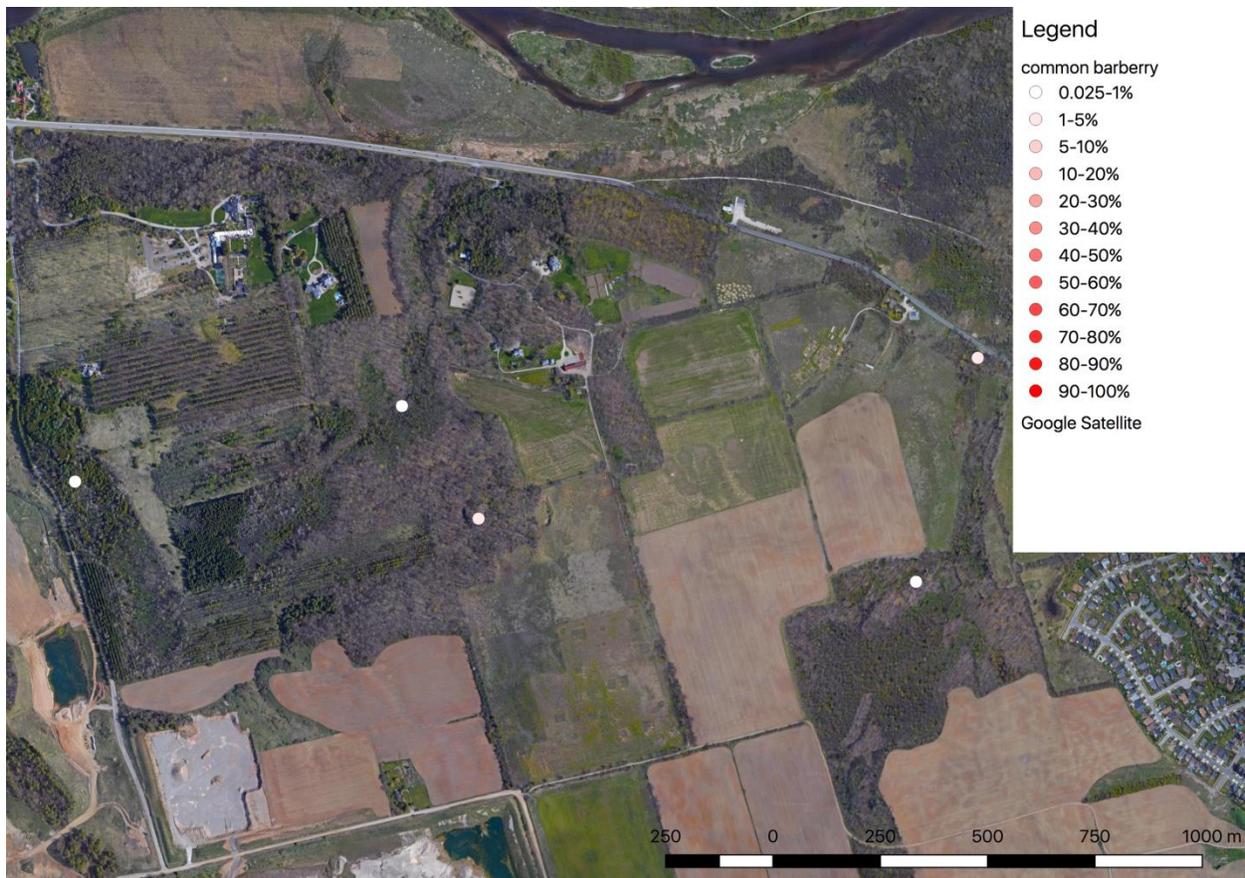


**Figure A-6:** Map of the *rare Charitable Research Reserve* depicting total percent cover of invasive bluegrass, Kentucky bluegrass and Canada bluegrass, *Poa pratensis* ssp. *pratensis* and *Poa compressa*, in ground (0-0.5m) layer within a 400m<sup>2</sup> plot (11.28 m radius). Sixteen out of 35 plots in two forests, Thompson Tract and the Hogsback, contained Kentucky bluegrass and Canada bluegrass, with the lowest being 0.025% and the highest being 80.05%. Percent cover is expressed on a gradient, with lower percent cover being white to light red, increasing in colour intensity with increasing percent cover. Values were obtained from randomly regenerated plots sampled during June-September, 2018 in Cambridge, Ontario.

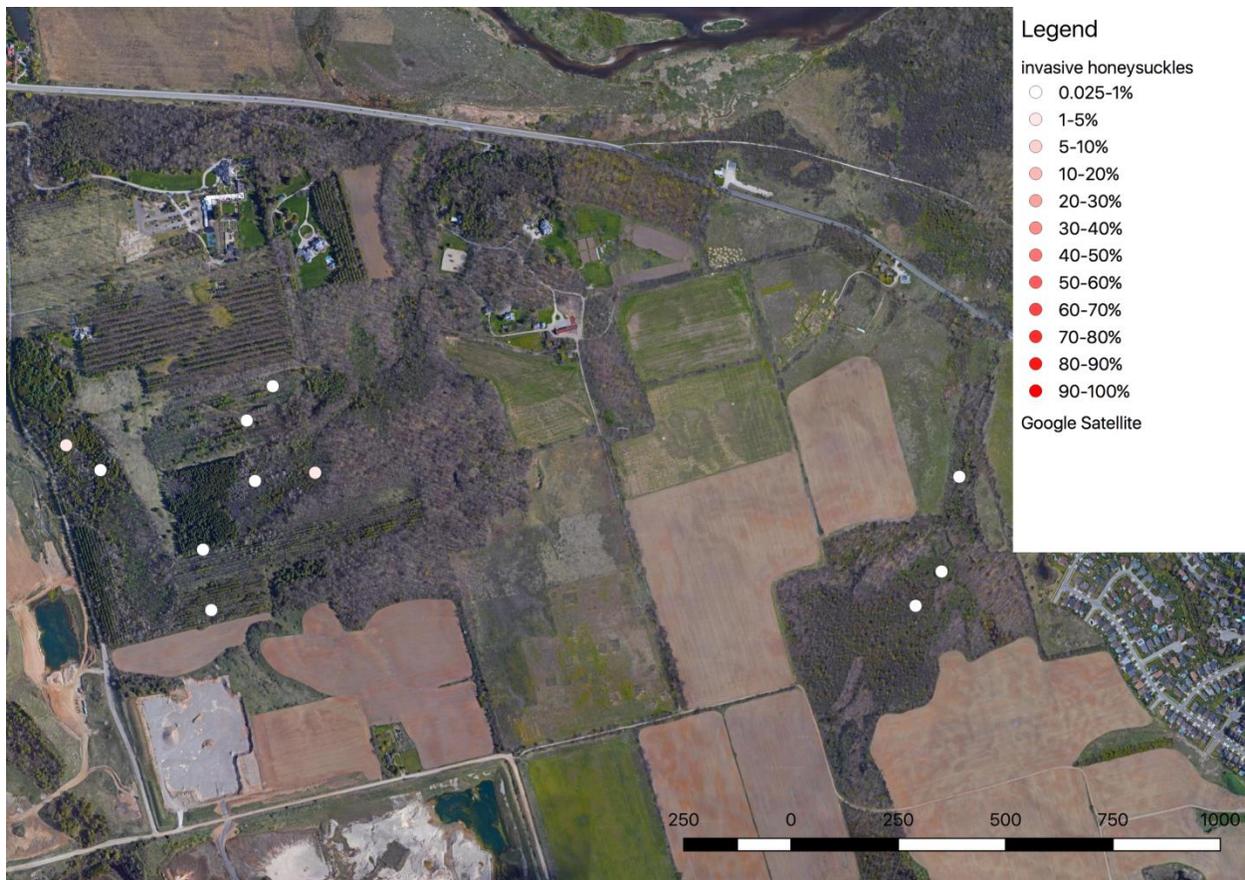
## Invasive trees and shrubs



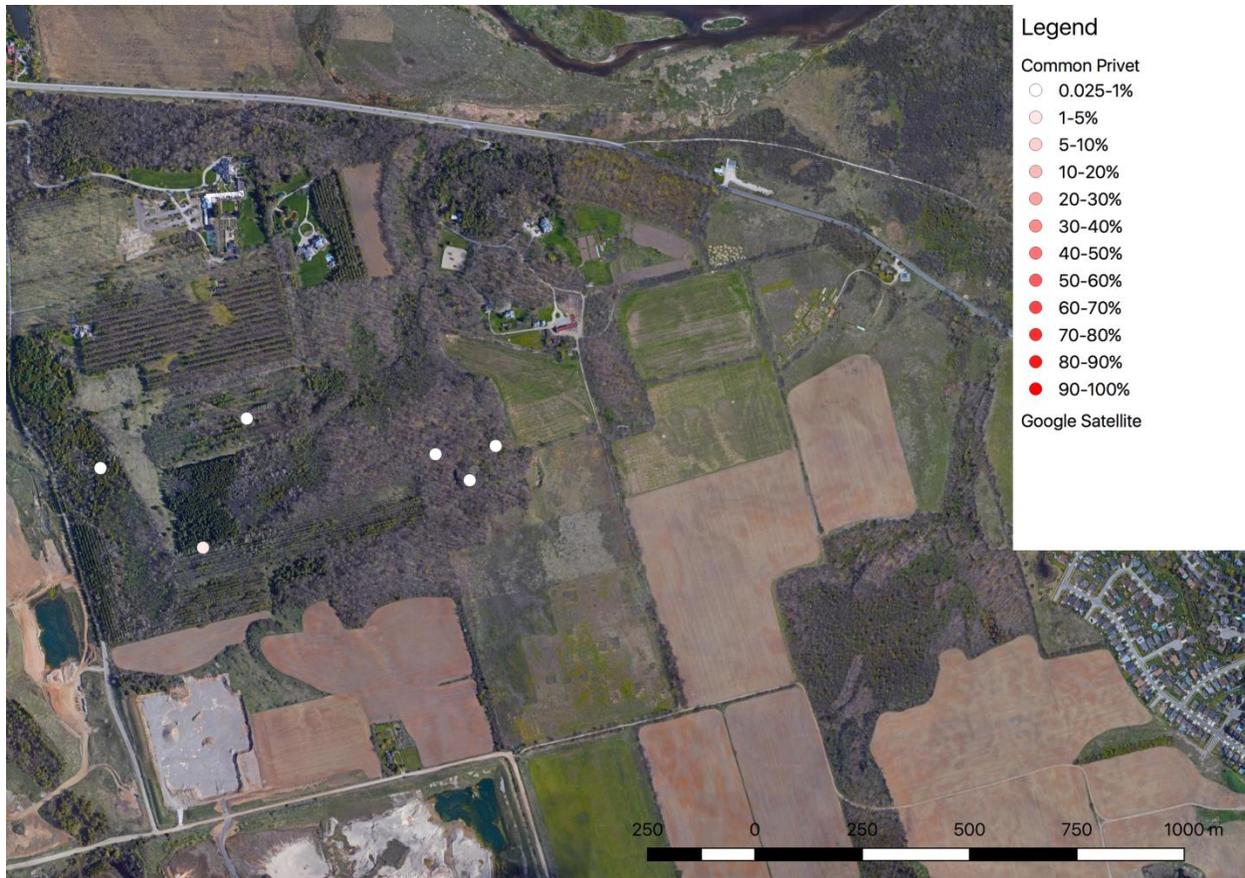
**Figure A-7:** Map of the *rare Charitable Research Reserve* depicting total percent cover of Japanese barberry, *Berberis thunbergii*, in ground (0-0.5m) layer within a 400m<sup>2</sup> plot (11.28 m radius). Eight out of 35 plots in two forests, Thompson Tract and the Hogsback, contained Japanese barberry, with the lowest being 0.025% and the highest being 1.325%. Percent cover is expressed on a gradient, with lower percent cover being white to light red, increasing in colour intensity with increasing percent cover. Values were obtained from randomly regenerated plots sampled during June-September, 2018 in Cambridge, Ontario.



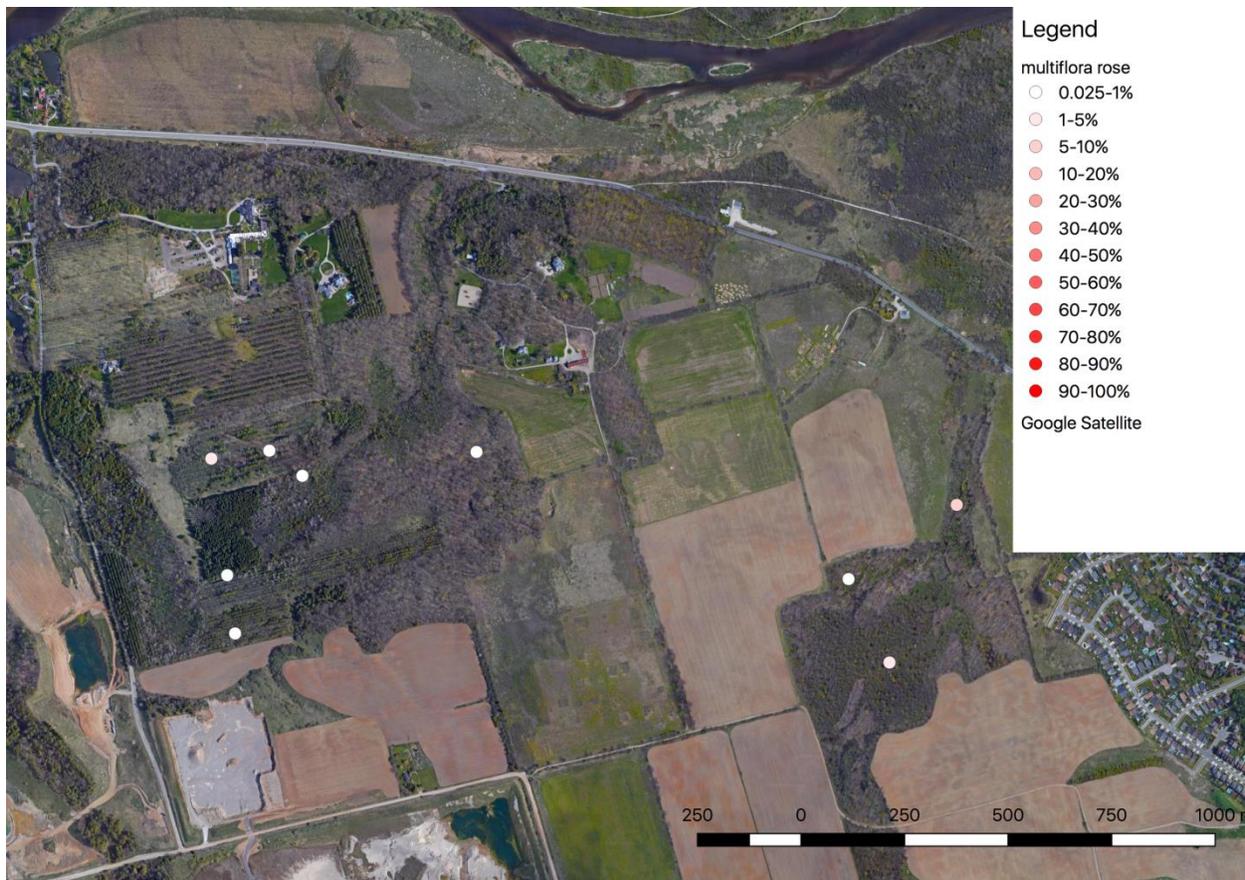
**Figure A-8:** Map of the *rare Charitable Research Reserve* depicting total percent cover of common barberry, *Berberis vulgaris*, in ground (0-0.5m) layer within a 400m<sup>2</sup> plot (11.28 m radius). Five out of 35 plots in two forests, Thompson Tract and the Hogsback, contained common barberry, with the lowest being 0.025% and the highest being 2.5%. Percent cover is expressed on a gradient, with lower percent cover being white to light red, increasing in colour intensity with increasing percent cover. Values were obtained from randomly regenerated plots sampled during June-September, 2018 in Cambridge, Ontario.



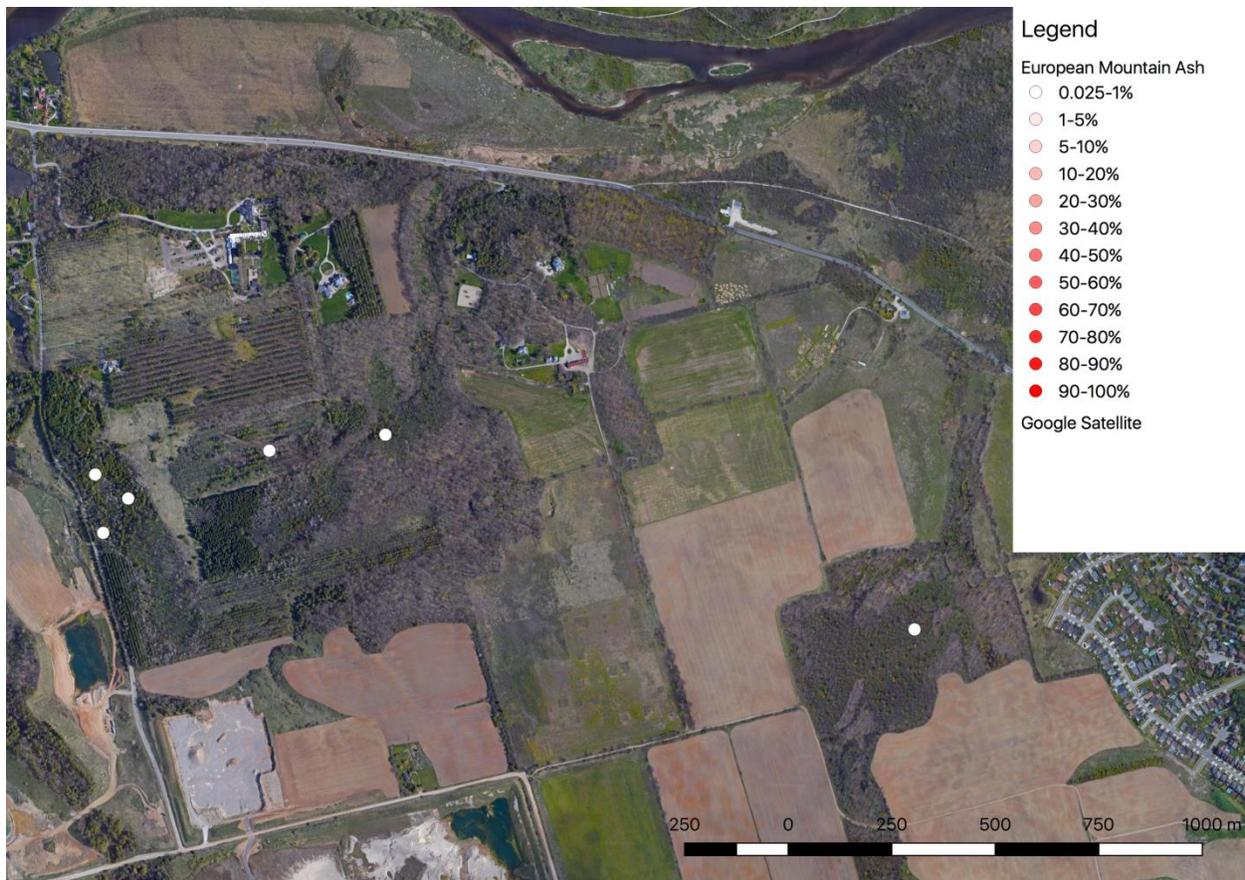
**Figure A-9:** Map of the *rare Charitable Research Reserve* depicting total percent cover of invasive bush honeysuckles, tartarian and Morrow's honeysuckle, *Lonicera tatarica* and *Lonicera morrowii*, in ground (0-0.5m) layer within a 400m<sup>2</sup> plot (11.28 m radius). Eleven out of 35 plots in two forests, Thompson Tract and the Hogsback, contained one of these invasive honeysuckles, with the lowest being 0.025% and the highest being 1.25%. Percent cover is expressed on a gradient, with lower percent cover being white to light red, increasing in colour intensity with increasing percent cover. Values were obtained from randomly regenerated plots sampled during June-September, 2018 in Cambridge, Ontario.



**Figure A-10:** Map of the *rare Charitable Research Reserve* depicting total percent cover of common privet, *Ligustrum vulgare*, in ground (0-0.5m) layer within a 400m<sup>2</sup> plot (11.28 m radius). Six out of 35 plots in two forests, Thompson Tract and the Hogsback, contained common privet, with the lowest being 0.025% and the highest being 1.25%. Percent cover is expressed on a gradient, with lower percent cover being white to light red, increasing in colour intensity with increasing percent cover. Values were obtained from randomly regenerated plots sampled during June-September, 2018 in Cambridge, Ontario.



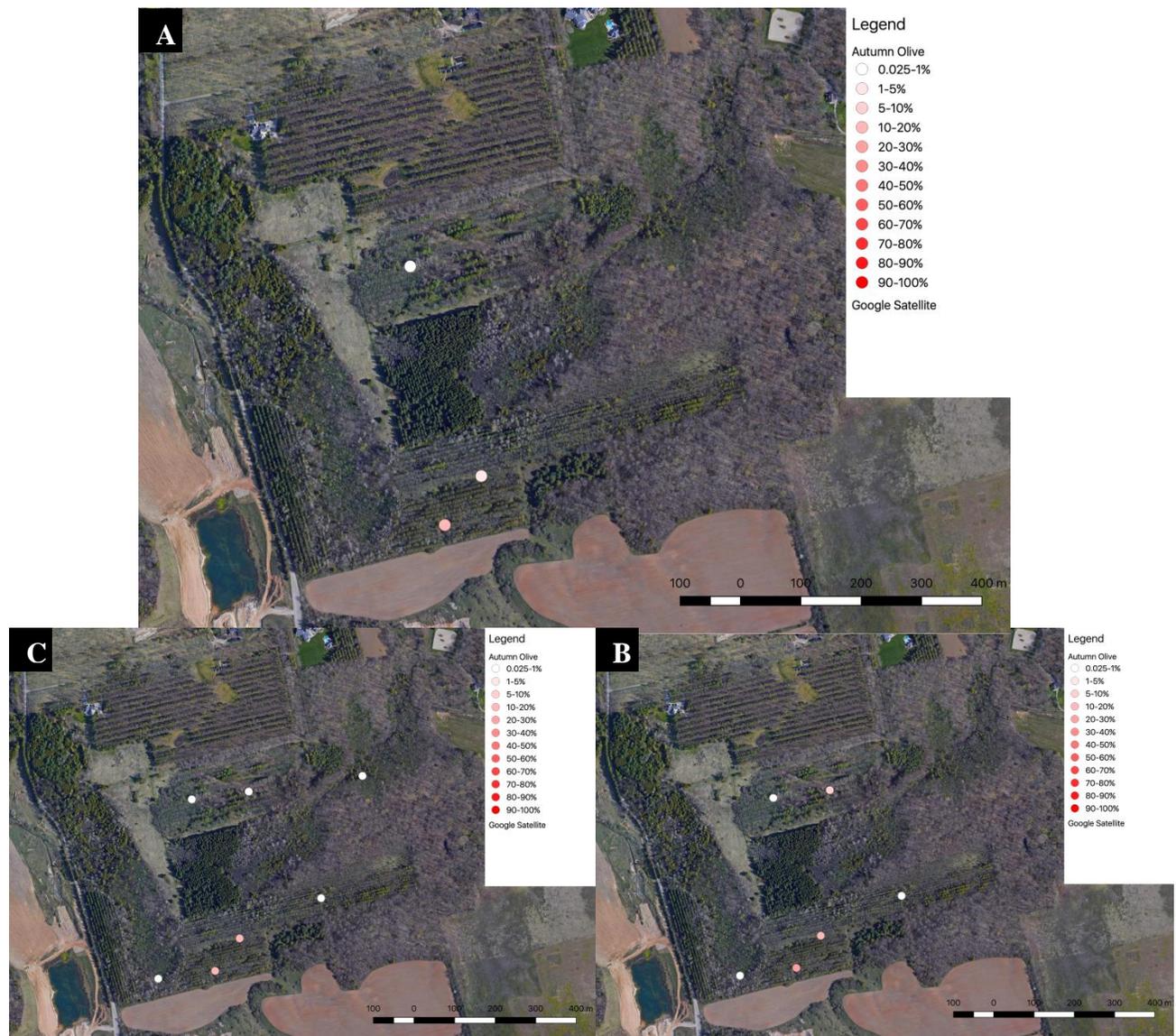
**Figure A-11:** Map of the *rare Charitable Research Reserve* depicting total percent cover of multiflora rose, *Rosa multiflora*, in ground (0-0.5m) layer within a 400m<sup>2</sup> plot (11.28 m radius). Nine out of 35 plots in two forests, Thompson Tract and the Hogsback, contained multiflora rose, with the lowest being 0.025% and the highest being 10%. Percent cover is expressed on a gradient, with lower percent cover being white to light red, increasing in colour intensity with increasing percent cover. Values were obtained from randomly regenerated plots sampled during June-September, 2018 in Cambridge, Ontario.



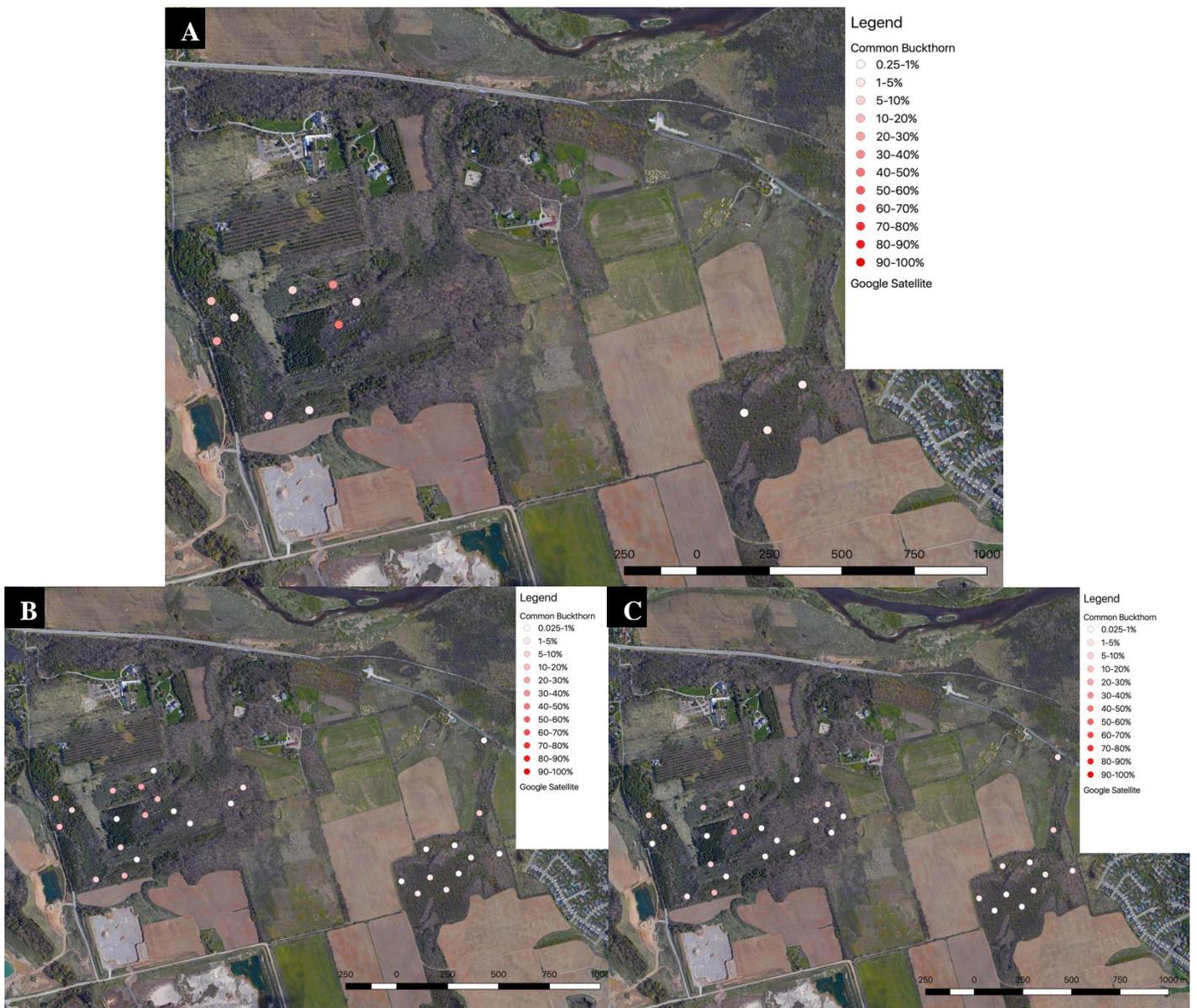
**Figure A-12:** Map of the *rare Charitable Research Reserve* depicting total percent cover of European mountain ash, *Sorbus aucuparia*, in ground (0-0.5m) layer within a 400m<sup>2</sup> plot (11.28 m radius). Six out of 35 plots in two forests, Thompson Tract and the Hogsback, contained European mountain ash, with the lowest being 0.025% and the highest being 0.05%. Percent cover is expressed on a gradient, with lower percent cover being white to light red, increasing in colour intensity with increasing percent cover. Values were obtained from randomly regenerated plots sampled during June-September, 2018 in Cambridge, Ontario.



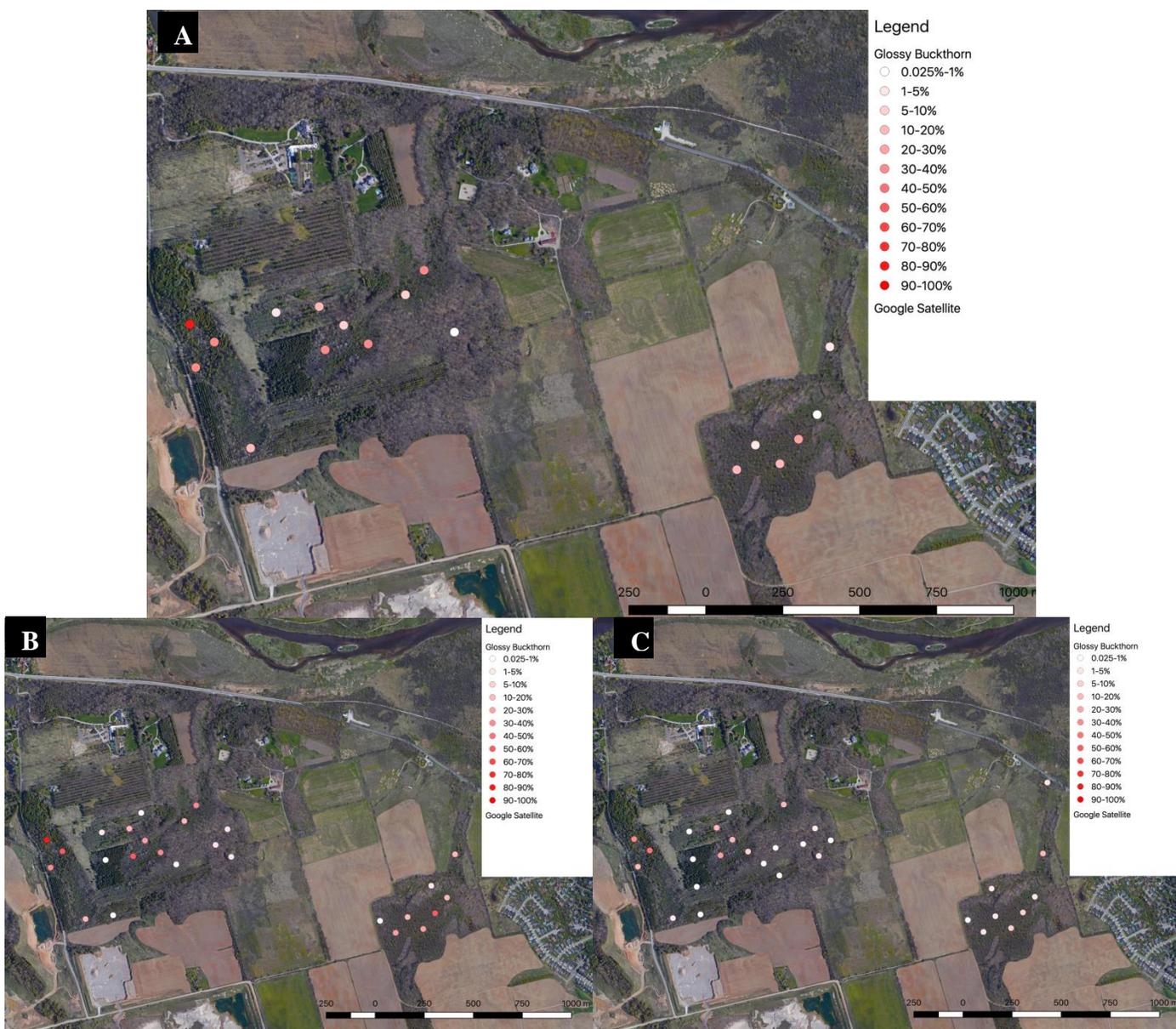
**Figure A-13:** Map of the *rare Charitable Research Reserve* depicting total percent cover of Manitoba maple, *Acer negundo*, in both ground (0-0.5m) and shrub (0.5-2m) layers within a 400m<sup>2</sup> plot (11.28 m radius). Four out of 35 plots in two forests, Thompson Tract and the Hogsback, contained Manitoba maple, with the lowest being 0.025% and the highest being 2.5%. Percent cover is expressed on a gradient, with lower percent cover being white to light red, increasing in colour intensity with increasing percent cover. Values were obtained from randomly regenerated plots sampled during June-September, 2018 in Cambridge, Ontario.



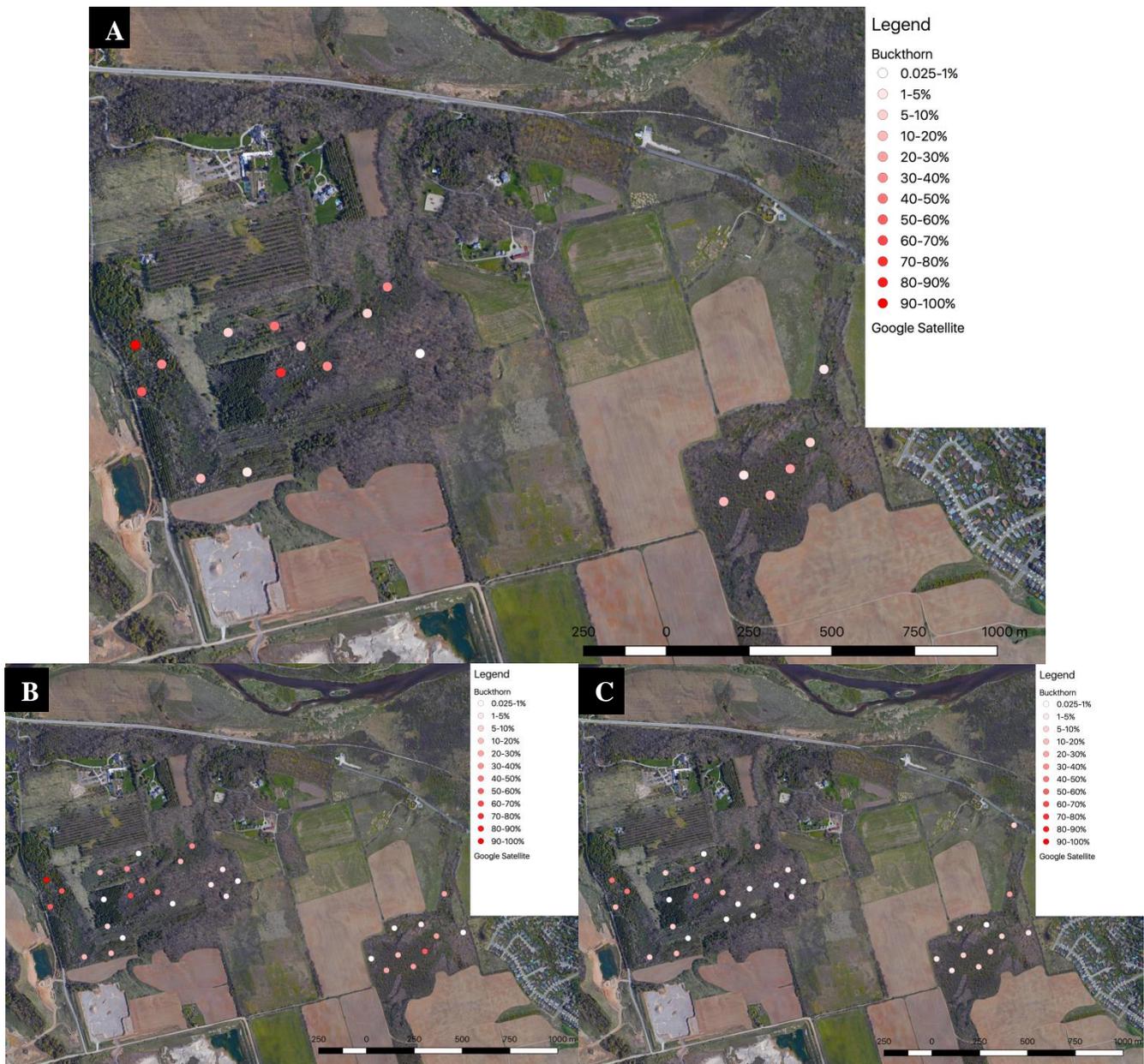
**Figure A-14:** Map of the *rare* Charitable Research Reserve depicting total percent cover of autumn olive, *Elaeagnus umbellatas*, in sub-canopy layer (map A; 2-10m), shrub layer (map B; 0.5-2m) and ground layer (map C; 0-0.5m) within a 400m<sup>2</sup> plot (11.28 m radius). Seven out of 35 plots in two forests, Thompson Tract and the Hogsback, contained autumn olive. The sub-canopy had a maximum percent cover of 12.5; the shrub layer had a maximum percent cover of 12.5%; and the ground layer had a maximum of 17.5%. Percent cover is expressed on a gradient, with lower percent cover being white to light red, increasing in colour intensity with increasing percent cover. Values were obtained from randomly regenerated plots sampled during June-September, 2018 in Cambridge, Ontario.



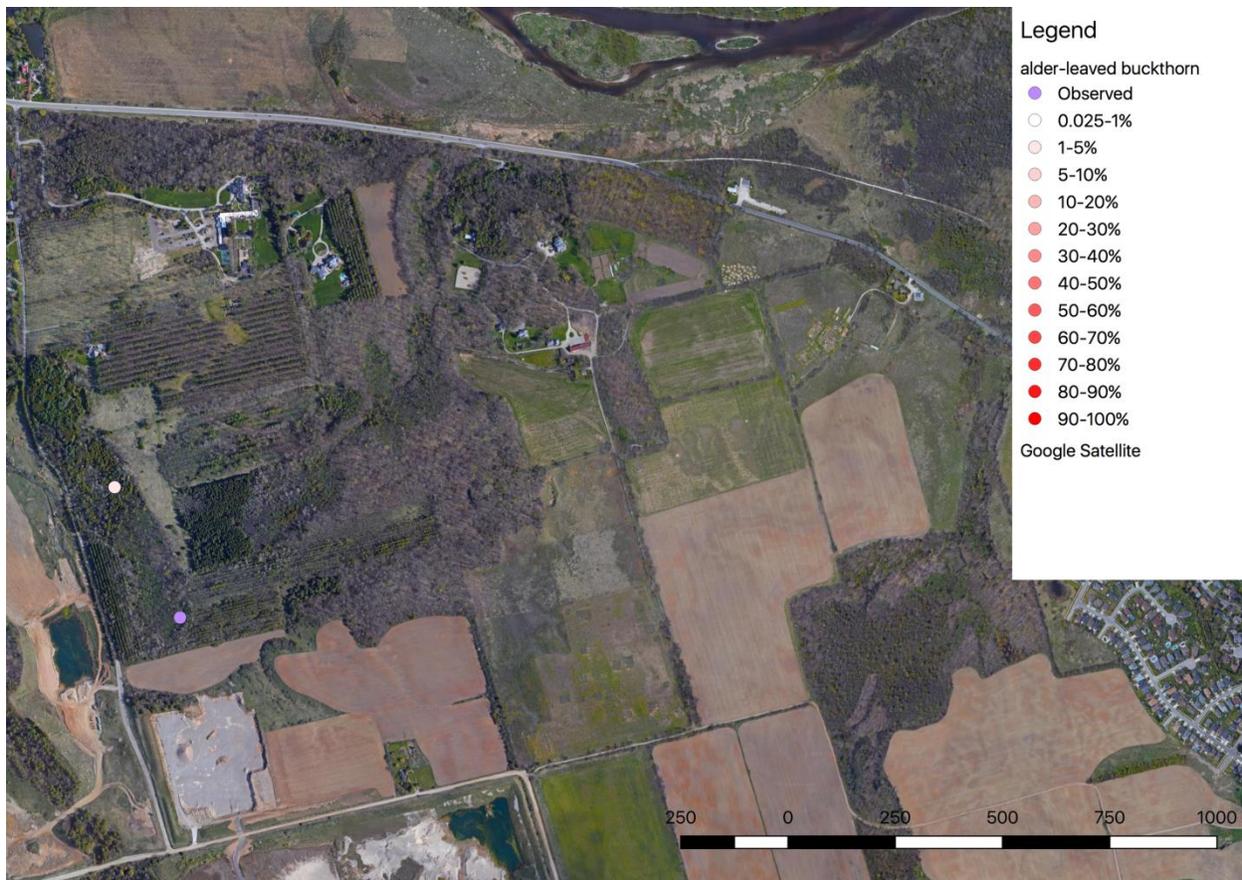
**Figure A-15:** Map of the *rare Charitable Research Reserve* depicting total percent cover of common buckthorn, *Rhamnus cathartica*, in sub-canopy layer (map A; 2-10m), shrub layer (map B; 0.5-2m) and ground layer (map C; 0-0.5m) within a 400m<sup>2</sup> plot (11.28 m radius). Thirty-three out of 35 plots in two forests, Thompson Tract and the Hogsback, contained common buckthorn. The sub-canopy had a maximum percent cover of 41.25%; the shrub layer had a maximum percent cover of 22.525%; and the ground layer had a maximum of 21.25%. Percent cover is expressed on a gradient, with lower percent cover being white to light red, increasing in colour intensity with increasing percent cover. Values were obtained from randomly regenerated plots sampled during June-September, 2018 in Cambridge, Ontario.



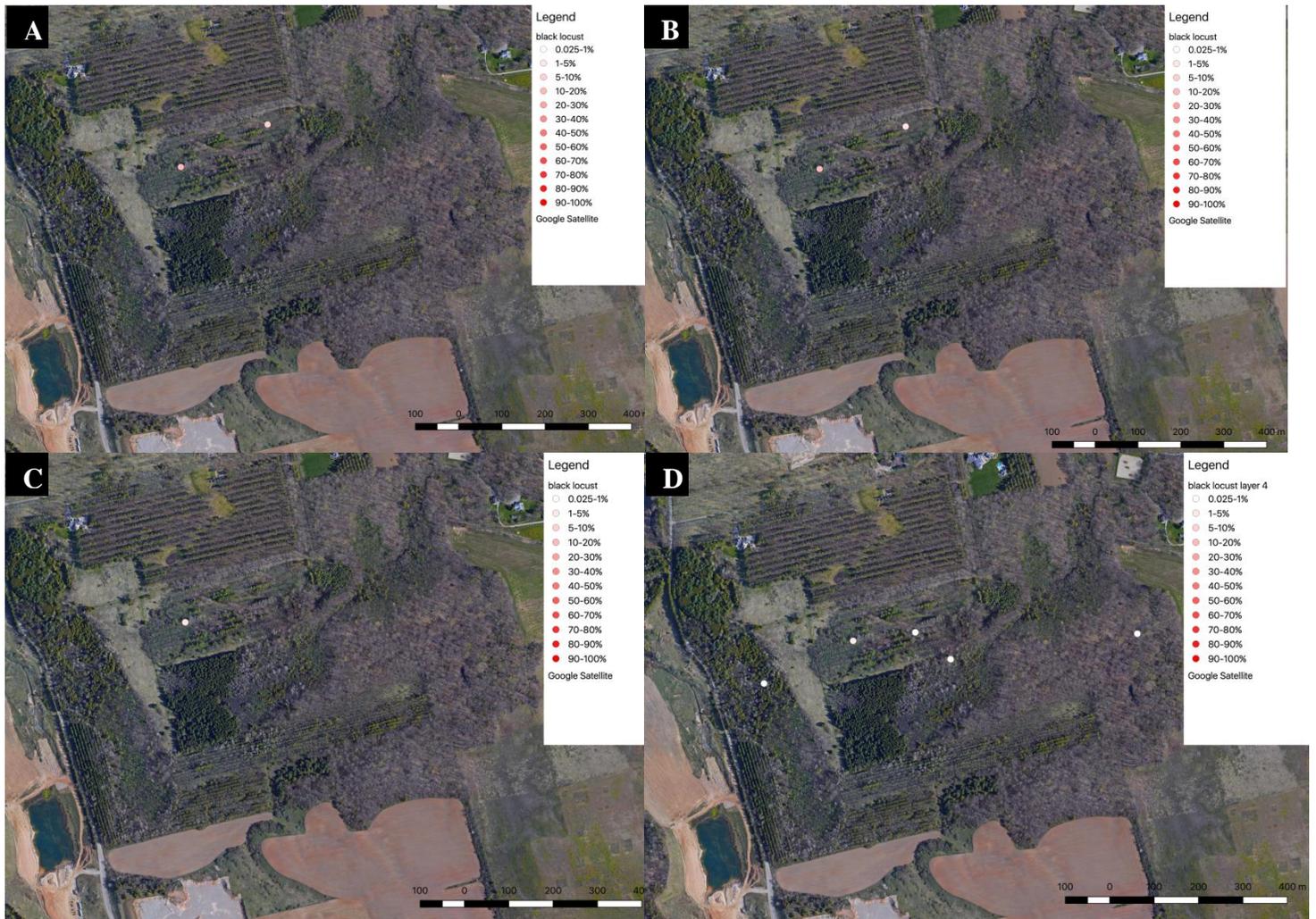
**Figure A-16:** Map of the *rare* Charitable Research Reserve depicting total percent cover of glossy buckthorn, *Rhamnus frangula*, in sub-canopy layer (map A; 2-10m), shrub layer (map B; 0.5-2m) and ground layer (map C; 0-0.5m) within a 400m<sup>2</sup> plot (11.28 m radius). Thirty-three out of 35 plots in two forests, Thompson Tract and the Hogsback, contained glossy buckthorn. The sub-canopy had a maximum percent cover of 36.25%; the shrub layer had a maximum percent cover of 38.75%; and the ground layer had a maximum of 43.75%. Percent cover is expressed on a gradient, with lower percent cover being white to light red, increasing in colour intensity with increasing percent cover. Values were obtained from randomly regenerated plots sampled during June-September, 2018 in Cambridge, Ontario.



**Figure A-17:** Map of the *rare Charitable Research Reserve* depicting total percent cover of both common and glossy buckthorn, *Rhamnus cathartica* and *Rhamnus frangula*, in sub-canopy layer (map A; 2-10m), shrub layer (map B; 0.5-2m) and ground layer (map C; 0-0.5m) within a 400m<sup>2</sup> plot (11.28 m radius). All of the 35 plots in two forests, Thompson Tract and the Hogsback, contained at least one buckthorn species. The sub-canopy had a maximum percent cover of 78.75%; the shrub layer had a maximum percent cover of 96.25%; and the ground layer had a maximum of 48.75%. Percent cover is expressed on a gradient, with lower percent cover being white to light red, increasing in colour intensity with increasing percent cover. Values were obtained from randomly regenerated plots sampled during June-September, 2018 in Cambridge, Ontario.

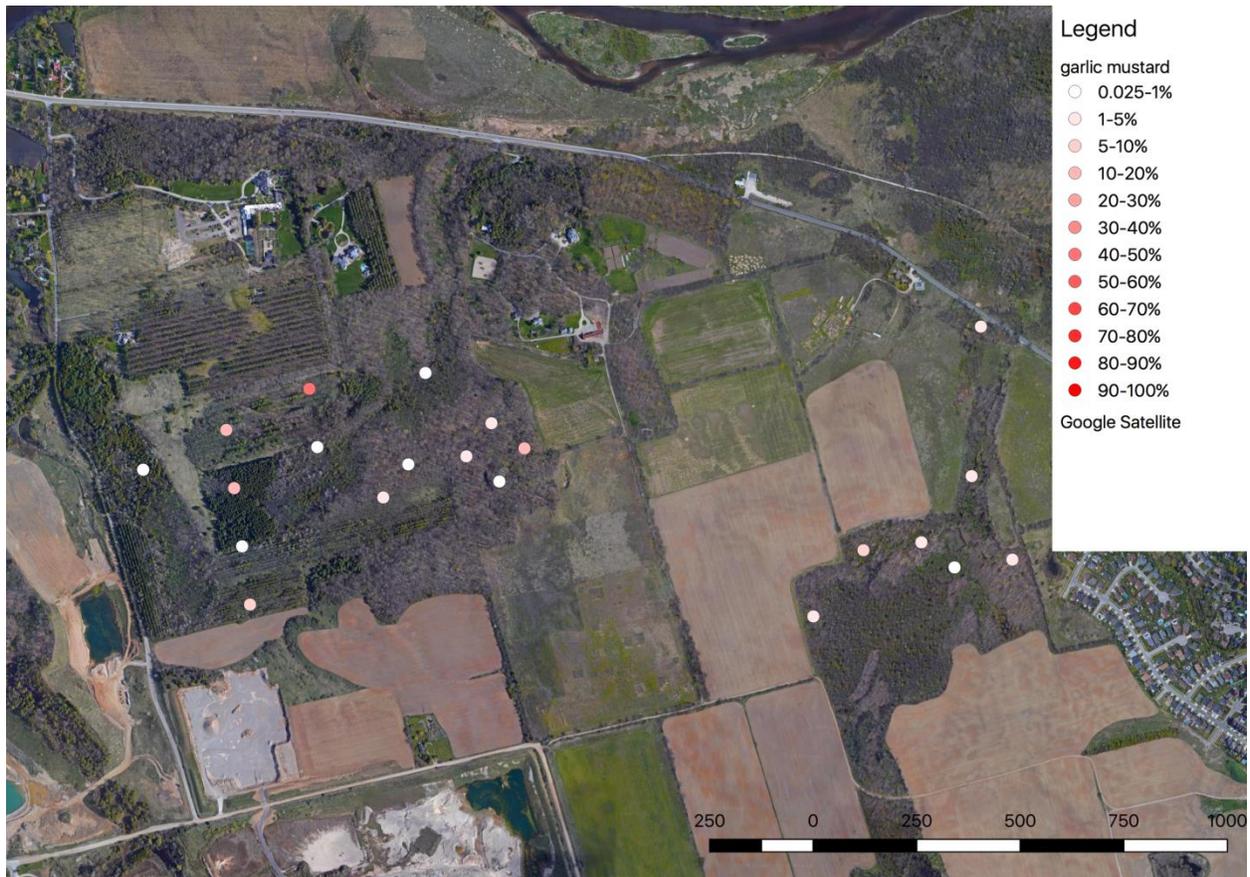


**Figure A-18:** Map of the *rare Charitable Research Reserve* depicting total percent cover of alder-leaved buckthorn, *Rhamnus alnifolia*, in ground (0-0.5m) layer within a 400m<sup>2</sup> plot (11.28 m radius). One out of 35 plots in two forests, Thompson Tract and the Hogsback, contained alder-leaved buckthorn, comprising of 1.25% of the plot. Percent cover is expressed on a gradient, with lower percent cover being white to light red, increasing in colour intensity with increasing percent cover. Purple indicates the presence of Alder-leaved Buckthorn observed outside of defined plots. Values were obtained from randomly regenerated plots sampled during June-September, 2018 in Cambridge, Ontario.

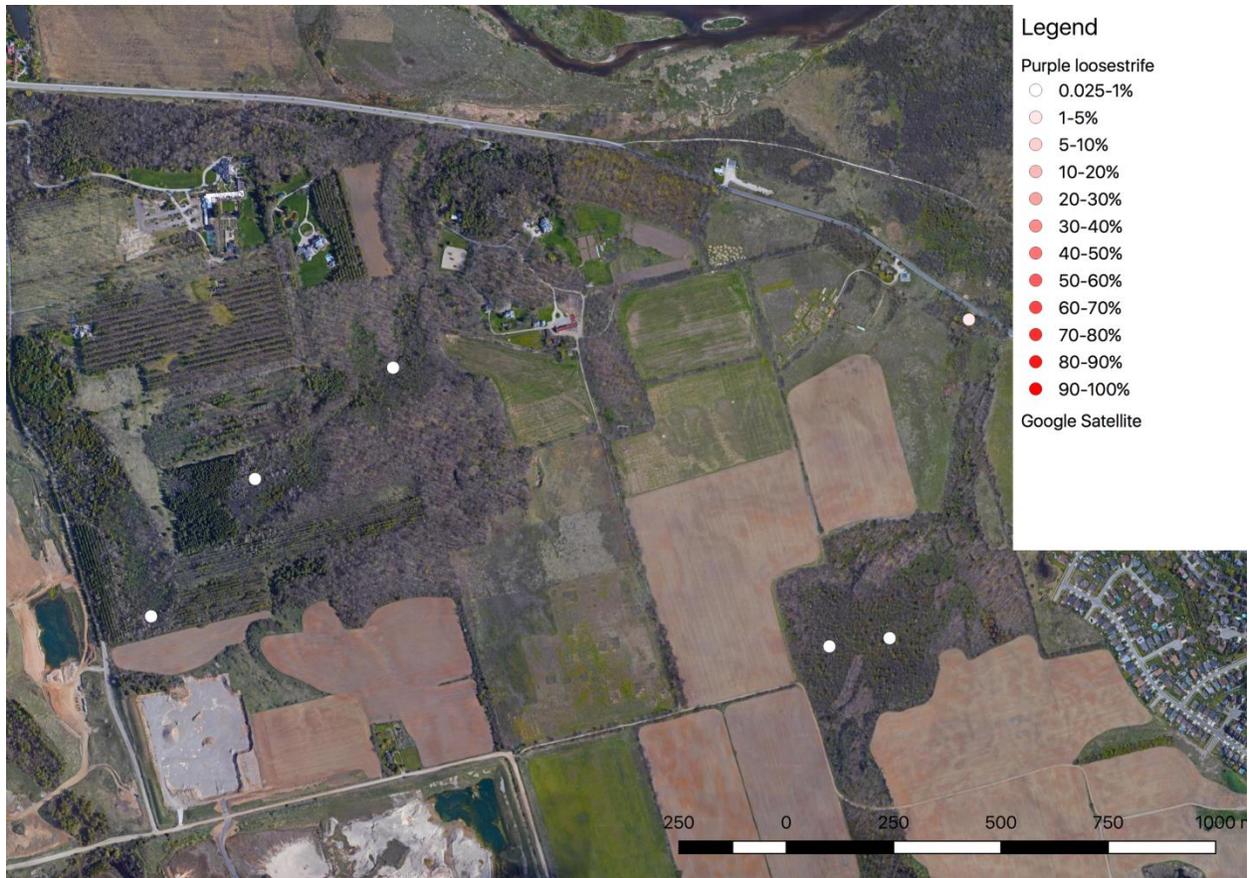


**Figure A-19:** Map of the *rare* Charitable Research Reserve depicting total percent cover of black locust, *Robina pseudo-acacia*, in canopy layer (map A; >10m), sub-canopy layer (map B; 2-10m), shrub layer (map C; 0.5-2m) and ground layer (map D; 0-0.5m) within a 400m<sup>2</sup> plot (11.28 m radius). Five out of 35 plots contained black locust in at least one of the layers. The canopy layer had a maximum percent cover of 15.025%; the sub-canopy had a maximum percent cover of 13.75%; the shrub and ground layer both had a maximum percent cover of 1.3. Percent cover is expressed on a gradient, with lower percent cover being white to light red, increasing in colour intensity with increasing percent cover. Values were obtained from randomly regenerated plots sampled during June-September, 2018 in Cambridge, Ontario.

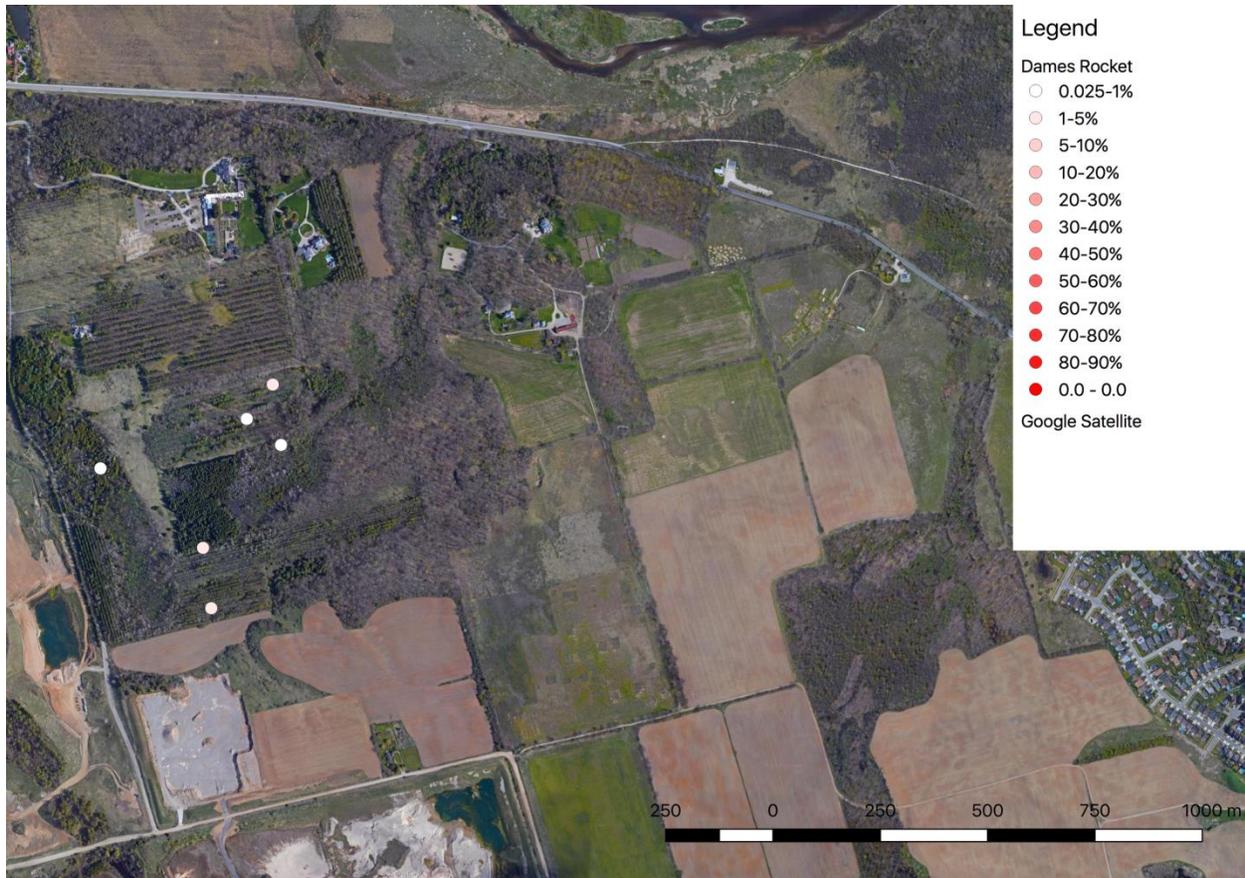
## Invasive ground vegetation



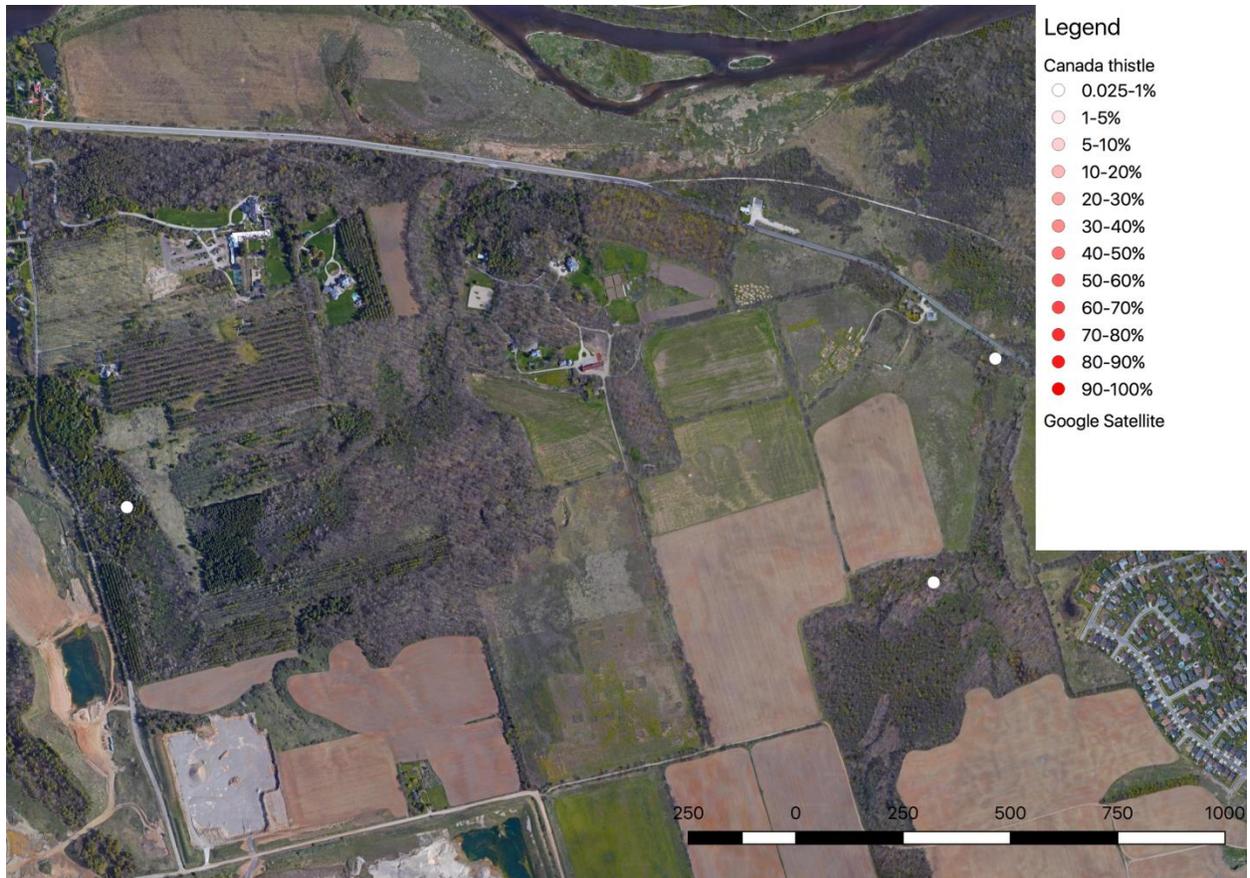
**Figure A-20:** Map of the *rare* Charitable Research Reserve depicting total percent cover of garlic mustard, *Alliaria petiolata*, in ground (0-0.5m) layer within a 400m<sup>2</sup> plot (11.28 m radius). Twenty-one out of 35 plots in two forests, Thompson Tract and the Hogsback, contained garlic mustard, with the lowest being 0.025% and the highest being 45%. Percent cover is expressed on a gradient, with lower percent cover being white to light red, increasing in colour intensity with increasing percent cover. Values were obtained from randomly regenerated plots sampled during June-September, 2018 in Cambridge, Ontario.



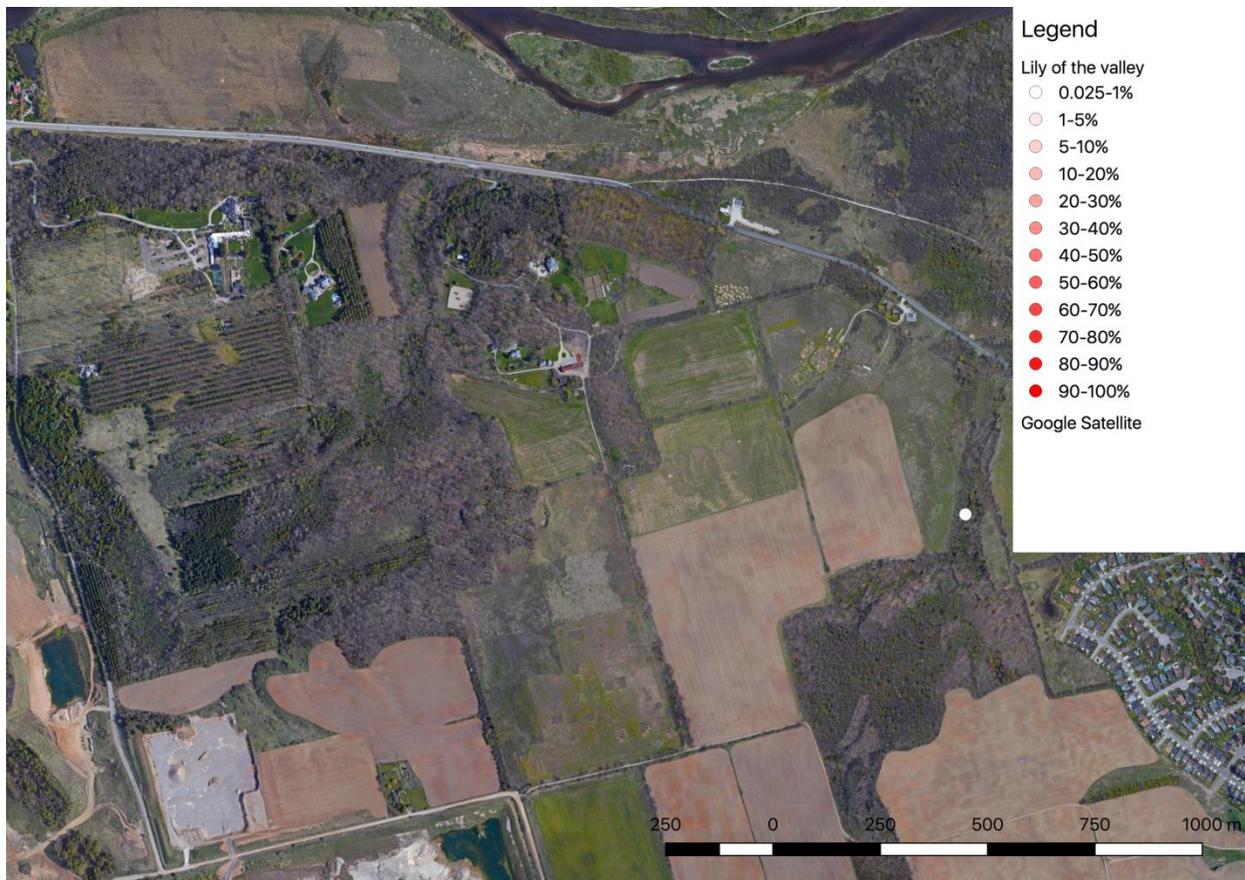
**Figure A-21:** Map of the *rare Charitable Research Reserve* depicting total percent cover of purple loosestrife, *Lythrum salicaria*, in ground (0-0.5m) layer within a 400m<sup>2</sup> plot (11.28 m radius). Six out of 35 plots in two forests, Thompson Tract and the Hogsback, contained purple loosestrife, with the lowest being 0.025% and the highest being 1.275%. Percent cover is expressed on a gradient, with lower percent cover being white to light red, increasing in colour intensity with increasing percent cover. Values were obtained from randomly regenerated plots sampled during June-September, 2018 in Cambridge, Ontario.



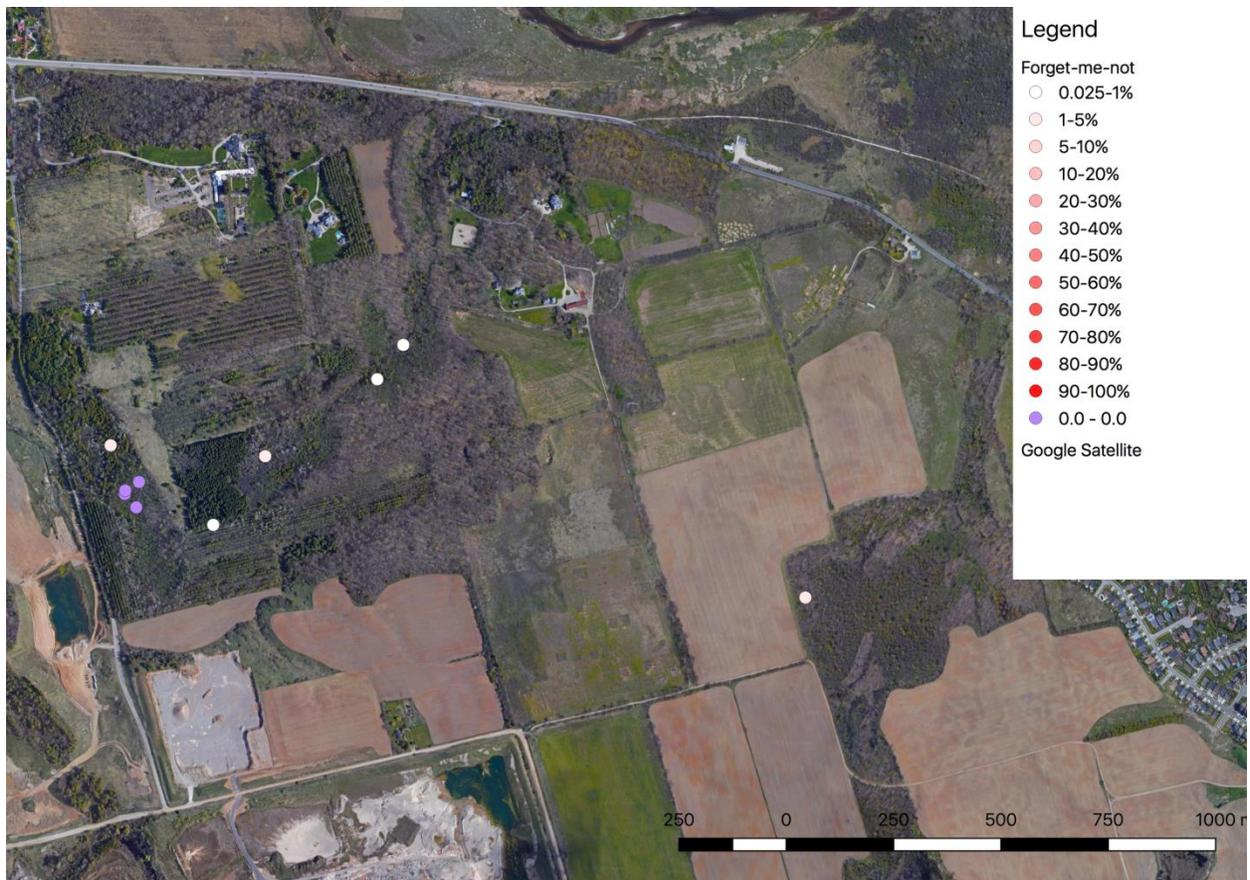
**Figure A-22:** Map of the *rare Charitable Research Reserve* depicting total percent cover of dame's rocket, *Hesperis matronalis*, in ground (0-0.5m) layer within a 400m<sup>2</sup> plot (11.28 m radius). Six out of 35 plots in two forests, Thompson Tract and the Hogsback, contained dame's rocket, with the lowest being 0.025% and the highest being 3.775%. Percent cover is expressed on a gradient, with lower percent cover being white to light red, increasing in colour intensity with increasing percent cover. Values were obtained from randomly regenerated plots sampled during June-September, 2018 in Cambridge, Ontario.



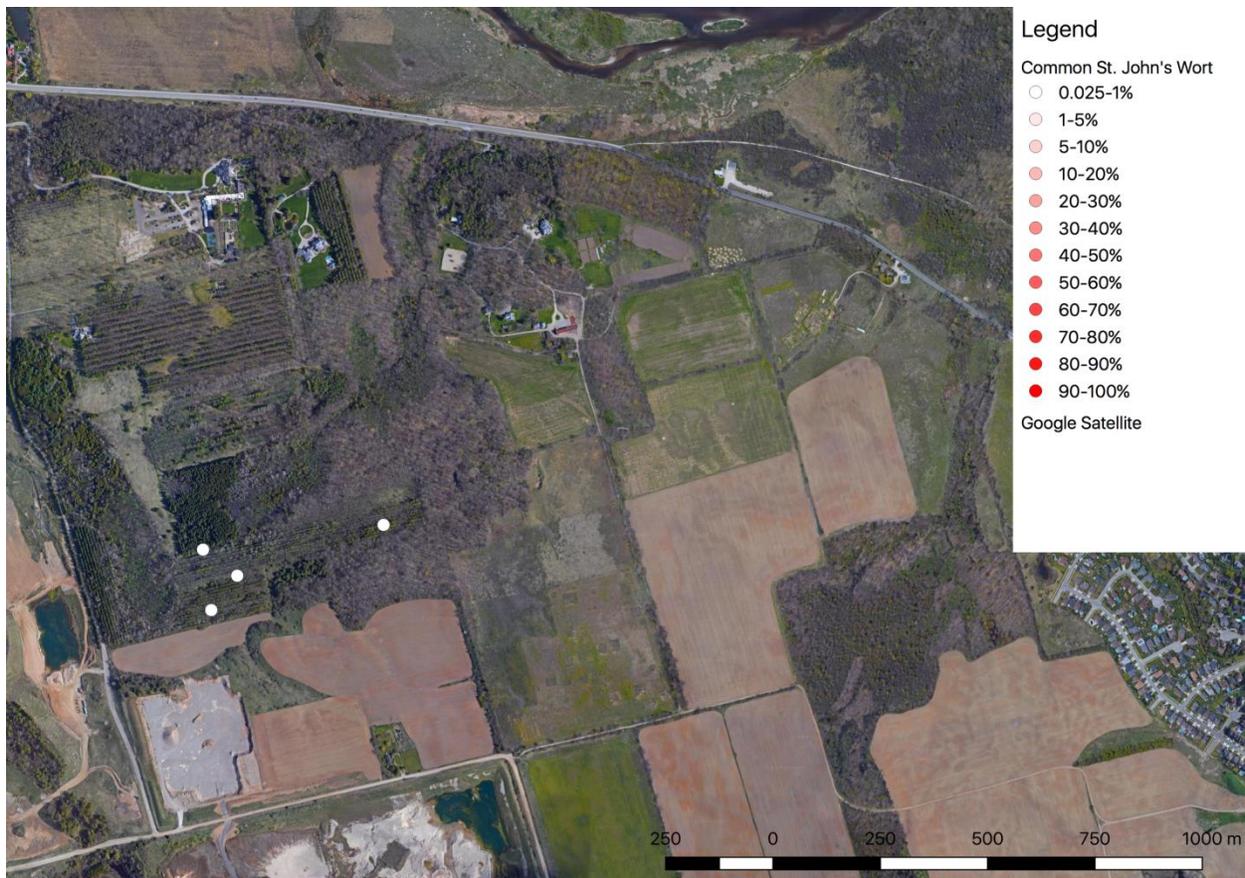
**Figure A-23:** Map of the *rare Charitable Research Reserve* depicting total percent cover of Canada thistle, *Cirsium arvense*, in ground (0-0.5m) layer within a 400m<sup>2</sup> plot (11.28 m radius). Three out of 35 plots in two forests, Thompson Tract and the Hogsback, contained Canada thistle, with the lowest being 0.025% and the highest being 0.1%. Percent cover is expressed on a gradient, with lower percent cover being white to light red, increasing in colour intensity with increasing percent cover. Values were obtained from randomly regenerated plots sampled during June-September, 2018 in Cambridge, Ontario.



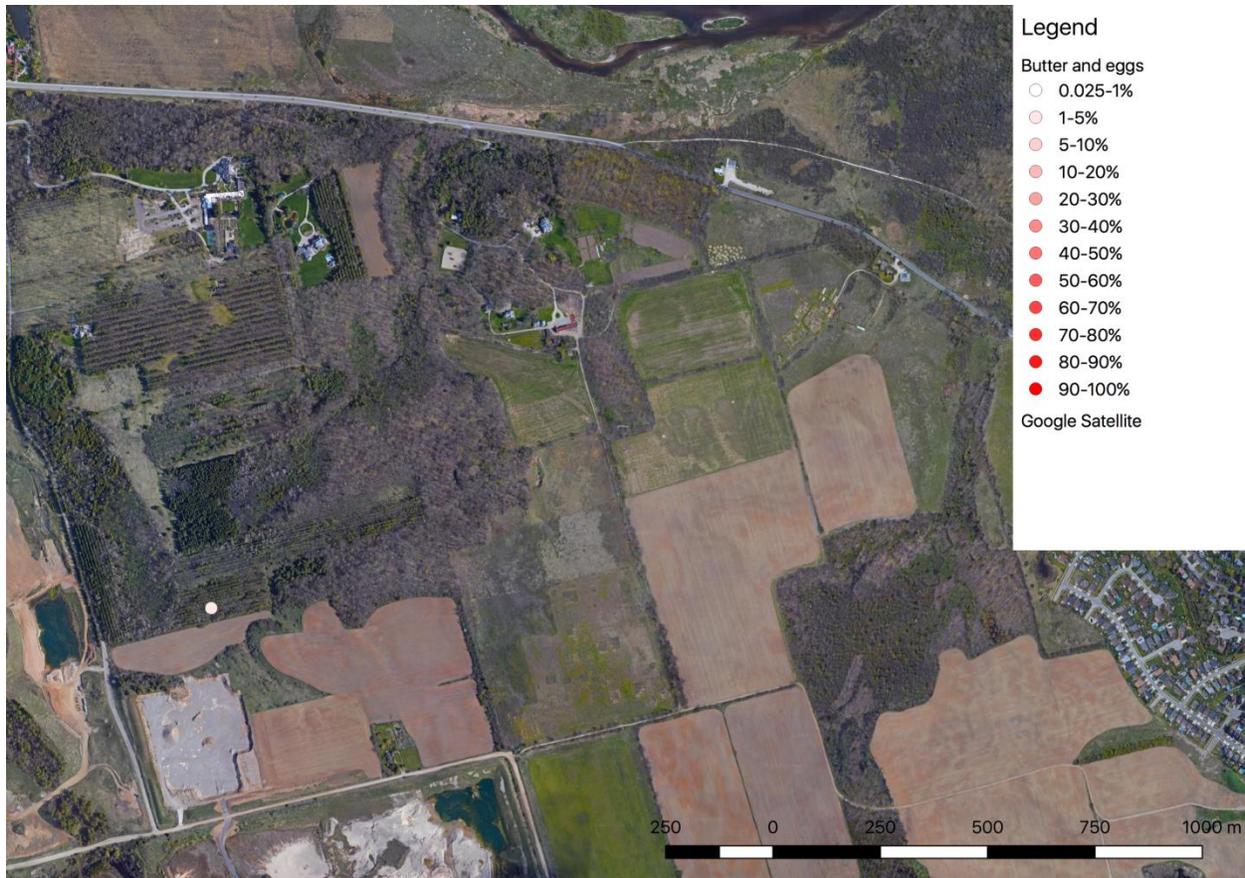
**Figure A-24:** Map of the *rare Charitable Research Reserve* depicting total percent cover of lily of the valley, *Convallaria majalis*, in ground (0-0.5m) layer within a 400m<sup>2</sup> plot (11.28 m radius). One out of 35 plots in two forests, Thompson Tract and the Hogsback, contained lily of the valley, comprising 0.025% of the plot. Percent cover is expressed on a gradient, with lower percent cover being white to light red, increasing in colour intensity with increasing percent cover. Values were obtained from randomly regenerated plots sampled during June-September, 2018 in Cambridge, Ontario.



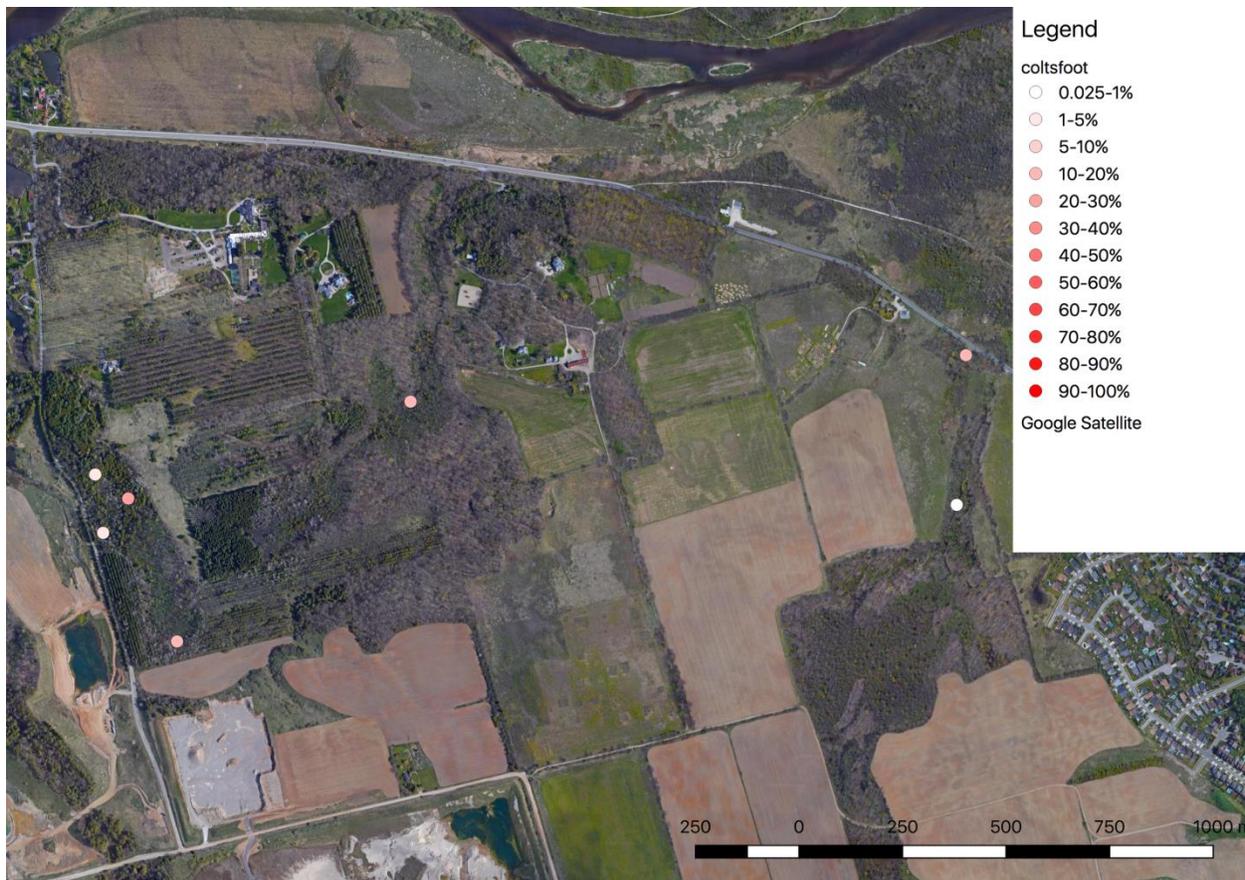
**Figure A-25:** Map of the *rare Charitable Research Reserve* depicting total percent cover of forget-me-not species, *Myosotis sp.*, in ground (0-0.5m) layer within a 400m<sup>2</sup> plot (11.28 m radius). Six out of 35 plots in two forests, Thompson Tract and the Hogsback, contained forget-me-not species, with the lowest being 0.025% and the highest being 2.525%. Percent cover is expressed on a gradient, with lower percent cover being white to light red, increasing in colour intensity with increasing percent cover. Purple indicates additional large presence of forget-me-not species observed outside of defined plots, along a stream in Thompson Tract. Values were obtained from randomly regenerated plots sampled during June-September, 2018 in Cambridge, Ontario.



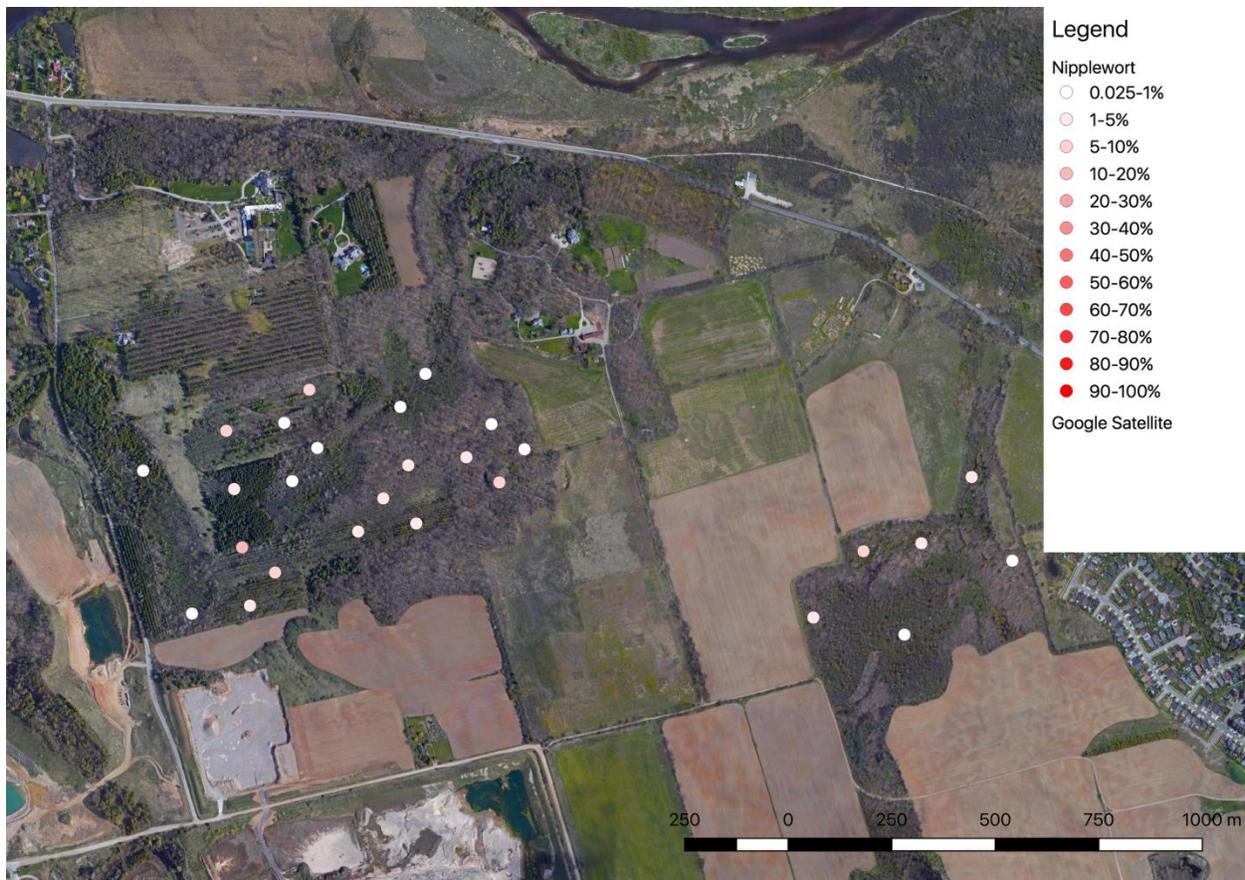
**Figure A-26:** Map of the *rare Charitable Research Reserve* depicting total percent cover of common St. John's-wort, *Hypericum perforatum*, in ground (0-0.5m) layer within a 400m<sup>2</sup> plot (11.28 m radius). Four out of 35 plots in two forests, Thompson Tract and the Hogsback, contained common St. John's-wort, with the lowest being 0.025% and the highest being 0.1%. Percent cover is expressed on a gradient, with lower percent cover being white to light red, increasing in colour intensity with increasing percent cover. Values were obtained from randomly regenerated plots sampled during June-September, 2018 in Cambridge, Ontario.



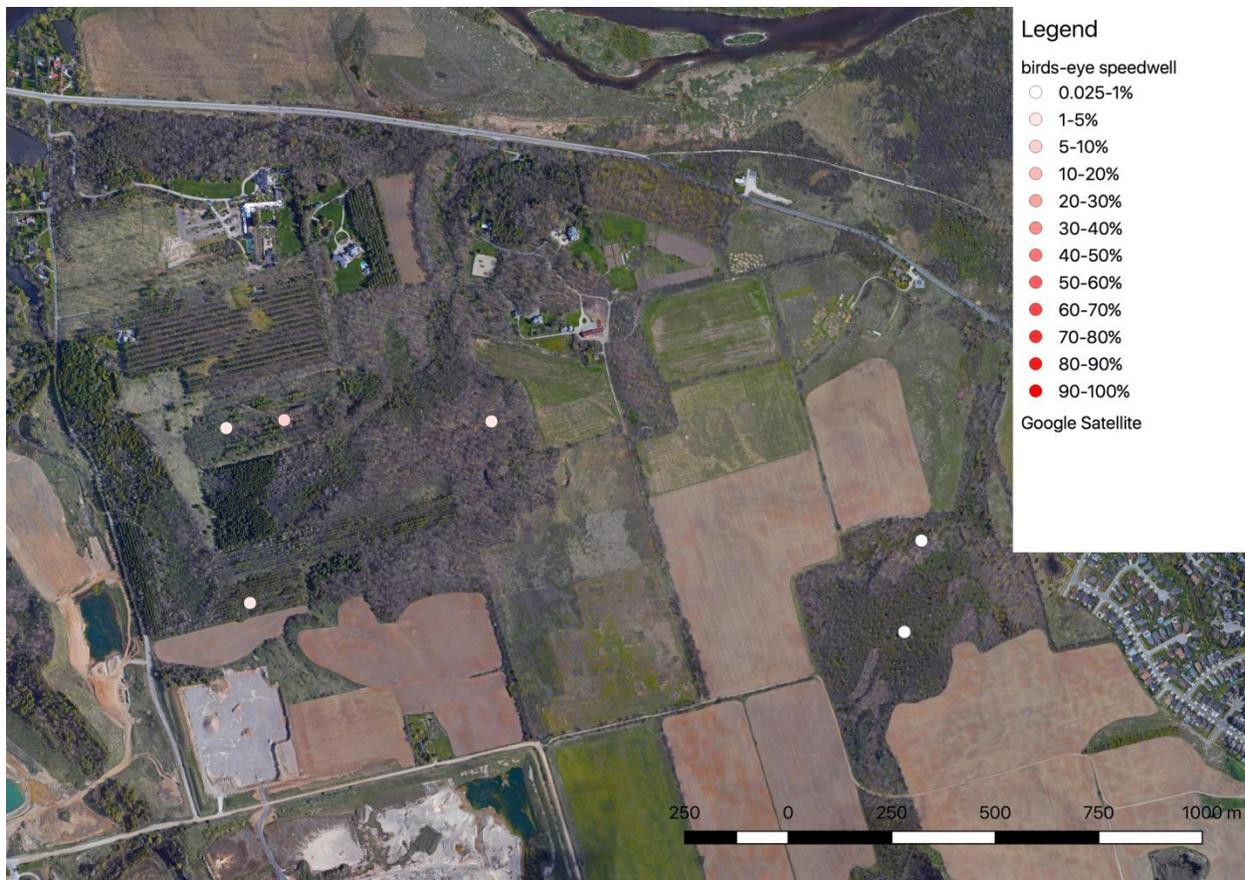
**Figure A-27:** Map of the *rare Charitable Research Reserve* depicting total percent cover of butter-and-eggs, *Linaria vulgaris*, in ground (0-0.5m) layer within a 400m<sup>2</sup> plot (11.28 m radius). One out of 35 plots in two forests, Thompson Tract and the Hogsback, contained butter-and-eggs, comprising of 1.275% of the plot. Percent cover is expressed on a gradient, with lower percent cover being white to light red, increasing in colour intensity with increasing percent cover. Values were obtained from randomly regenerated plots sampled during June-September, 2018 in Cambridge, Ontario.



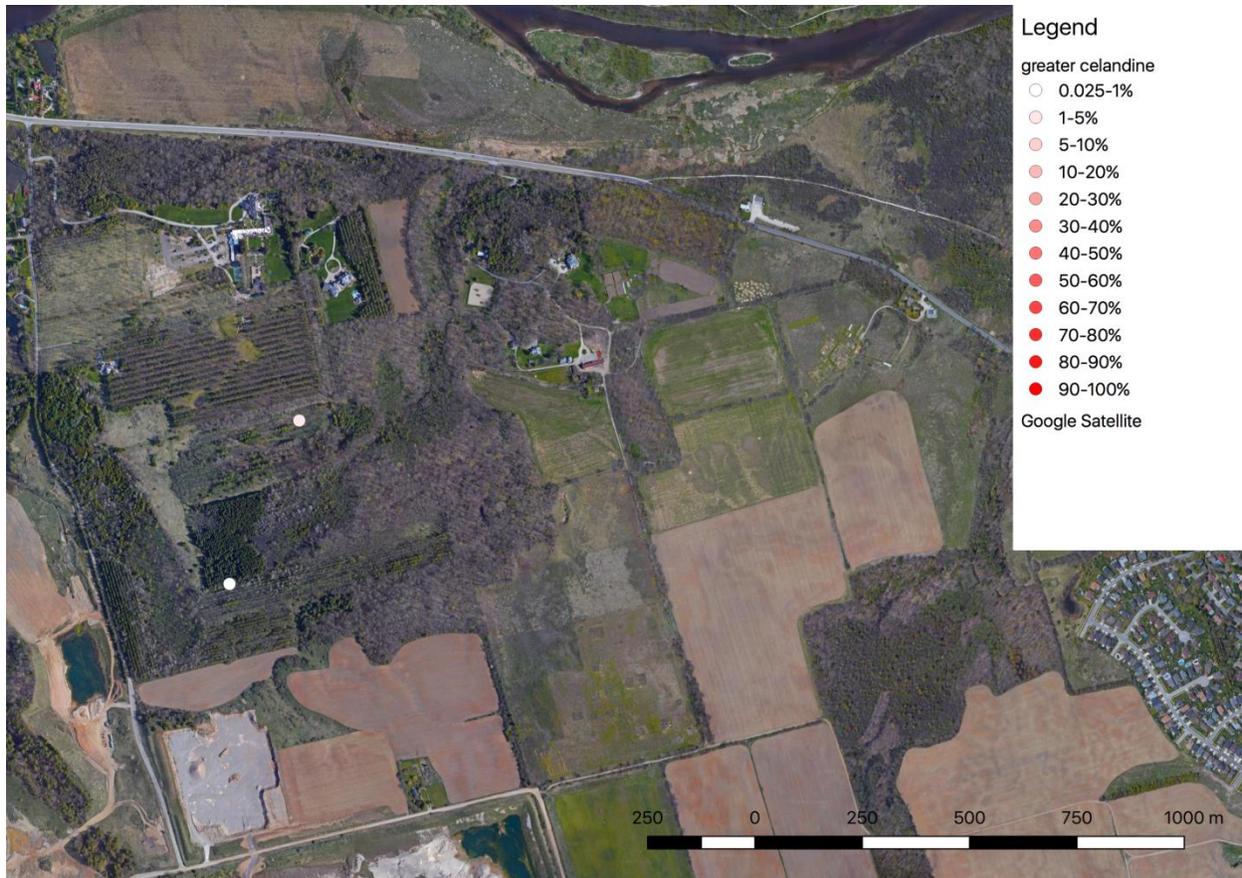
**Figure A-28:** Map of the *rare Charitable Research Reserve* depicting total percent cover of coltsfoot, *Tussilago farfara*, in ground (0-0.5m) layer within a 400m<sup>2</sup> plot (11.28 m radius). Seven out of 35 plots in two forests, Thompson Tract and the Hogsback, contained coltsfoot, with the lowest being 0.075% and the highest being 28.75%. Percent cover is expressed on a gradient, with lower percent cover being white to light red, increasing in colour intensity with increasing percent cover. Values were obtained from randomly regenerated plots sampled during June-September, 2018 in Cambridge, Ontario.



**Figure A-29:** Map of the *rare Charitable Research Reserve* depicting total percent cover of nipplewort, *Lapsana communis*, in ground (0-0.5m) layer within a 400m<sup>2</sup> plot (11.28 m radius). Twenty-seven out of 35 plots in two forests, Thompson Tract and the Hogsback, contained nipplewort, with the lowest being 0.05% and the highest being 12.5%. Percent cover is expressed on a gradient, with lower percent cover being white to light red, increasing in colour intensity with increasing percent cover. Values were obtained from randomly regenerated plots sampled during June-September, 2018 in Cambridge, Ontario.



**Figure A-30:** Map of the *rare Charitable Research Reserve* depicting total percent cover of birds-eye speedwell, *Veronica chamaedrys*, in ground (0-0.5m) layer within a 400m<sup>2</sup> plot (11.28 m radius). Six out of 35 plots in two forests, Thompson Tract and the Hogsback, contained birds-eye speedwell, with the lowest being 0.025% and the highest being 5.025%. Percent cover is expressed on a gradient, with lower percent cover being white to light red, increasing in colour intensity with increasing percent cover. Values were obtained from randomly regenerated plots sampled during June-September, 2018 in Cambridge, Ontario.

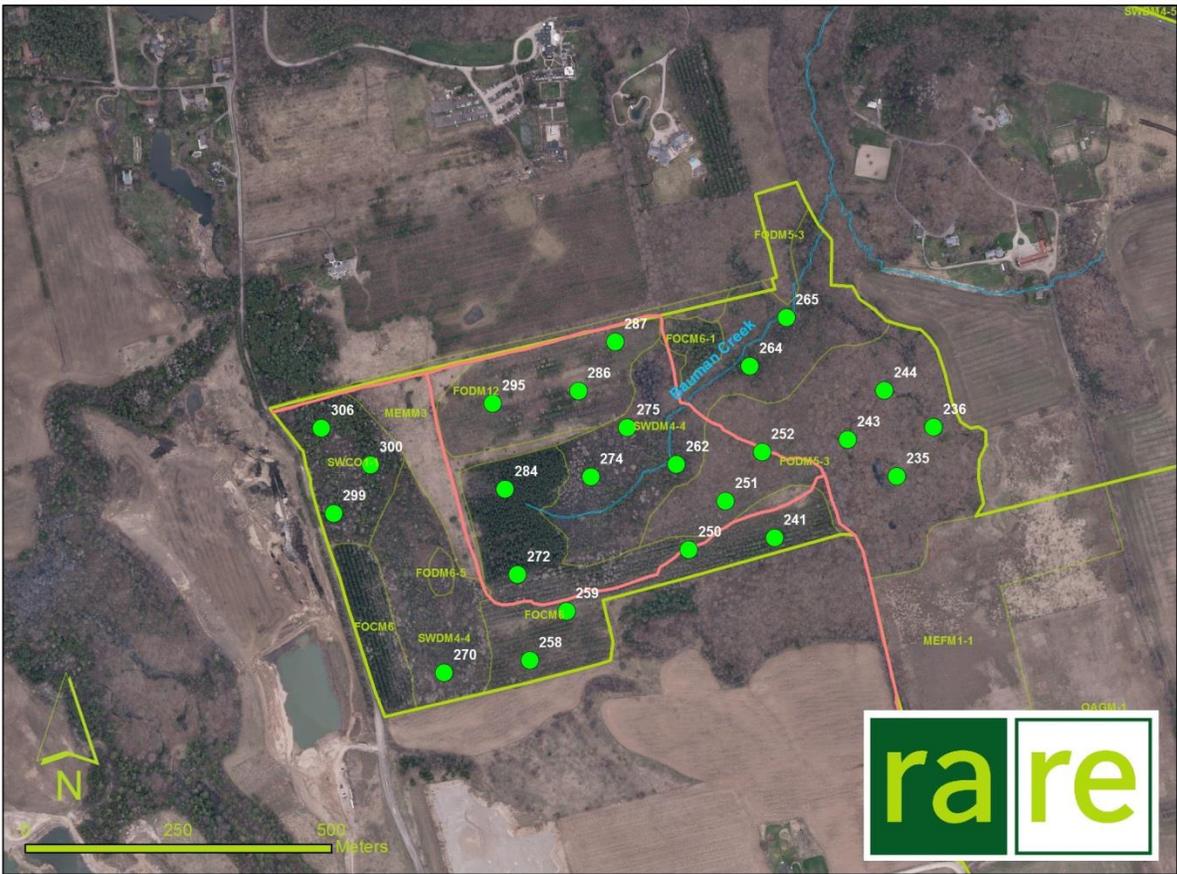


**Figure A-31:** Map of the *rare Charitable Research Reserve* depicting total percent cover of greater celandine, *Chelidonium majus*, in ground (0-0.5m) layer within a 400m<sup>2</sup> plot (11.28 m radius). Two out of 35 plots in two forests, Thompson Tract and the Hogsback, contained greater celandine, with the lowest being 0.025% and the highest being 2.525%. Percent cover is expressed on a gradient, with lower percent cover being white to light red, increasing in colour intensity with increasing percent cover. Values were obtained from randomly regenerated plots sampled during June-September, 2018 in Cambridge, Ontario.

## Appendix B:



**Figure B-1:** Map of the *rare* Charitable Research Reserve depicting established VSP plots in the Hogsback with corresponding plot numbers. Plot numbers for the Hogsback include: 27, 44, 45, 46, 67, 68, 70, 72, 92, 94, and 125.



**Figure B-2:** Map of the *rare* Charitable Research Reserve depicting established VSP plots in Thompson Tract with corresponding plot numbers.

## Appendix C:

### *Equipment list*

The following is a comprehensive list of all necessary equipment and their purpose when following the Vegetation Sampling Protocol:

- Field data sheets (page 1-7; found on **rare's** server, level 4 under VSP in Research and Monitoring)
  - To record the vegetation being sampled
- Waterproof paper and clipboard
  - Sampling takes place rain or shine
- The VSP field inventory and monitoring pocket guide (Puric-Mladenovic & Keeney, 2015; also available **rare's** server, level 4 under VSP in Research and Monitoring)
  - For a full comprehensive explanation of the protocol
- GPS:
  - Option 1: High-powered GPS with sub-metre accuracy (SX Blue II + GNSS) paired with a tablet synced to ArcPad to find the exact plot centre selected randomly in GIS
    - Pros: High accuracy, no bias in staking plot centre. High accuracy in plot centres is critical for re-sampling efforts every 5 years
    - Cons: Expensive –requires high-powered GPS, ArcPad, tablet, and waterproof and shockproof cases for tablet.
  - Option 2: Using a Garmin GPS (etrex 20) which typically has a 3-5 metre accuracy (sometimes greater) to get close to plot centres that were randomly selected in GIS
    - Pros: **rare** already has this GPS, so there would be no additional cost. Once plot centres are found, rebar stakes can be used to permanently mark plot centres to ensure accuracy in re-sampling efforts every 5 years despite a less accurate GPS.
    - Cons: Potential for bias, staking plot centre in more ideal/comfortable vegetation conditions within the 5 metre range of true plot centre; plot centre is never the exact spot generated in GIS due to lower accuracy.
  - For the Hogsback and Thompson Tract 2018 vegetation survey following Vegetation Sampling Protocol, a high-powered GPS with sub-metre accuracy was used (borrowed from Danijela Puric-Mladenovic).
- Flagging tape
  - For flagging plot centres
  - To be used during sampling if the plot has a particularly dense shrub layer and plot boundaries need to be marked higher up
- Florescent marking flags
  - To mark plot centre
  - To be used during sampling to visually mark plot boundaries (N, S, E, W) and mid-points.
- Rebar (and potentially a metal detector)
  - To permanently mark plot centres –of high importance to maintain accuracy when resampling in 5 years if lower accuracy GPS is used establish plots
  - Metal detector not necessary if high-powered GPS is used

- 2x Ropes
  - To define plot boundaries along each cardinal direction
    - Option 1: 2x CFE Measuring Chains (minimum 20m)
    - Option 2: 2x Pre-measured and cut to 11.28 m Steal Core Chains
      - Both with clothesline clips to hold the ends (loops) together, with coloured tape indicating plot dimensions, pre-measured and pre-marked
- 5x camping pegs
  - To hold down the ends of each rope (N, S, E, W, and centre)
- Two-way ultrasonic range finder/laser distance meter
  - Helpful in plots with lots of coarse woody debris or thick vegetation where it would be difficult to accurately lay the ropes flat out
  - Can be used with two people to measure distance from plot centre to plot boundaries at each cardinal direction (11.28m) and subplots (5.64m)
  - Even when ropes are used to define plot boundaries, a range finder can be used to measure midpoints (NE, SE, SW, NW at 11.28m from centre) to create the circle. This is especially important when measuring dbh if you are uncertain if a particular tree falls 50% or more within the plot boundary
  - Helpful for measuring tree height with clinometer
- Two 2 metre collapsible
  - To make your 1x1 m subplots
  - Helpful if they are collapsible for both easy storage in a backpack, and in case there are large trees or coarse woody debris in the way of forming a complete square –this way you can unfold the metre sticks only partially to avoid the obstacle while still forming your subplot
- Caliper
  - To measure sapling dbh when sampling regeneration within the subplots
  - Must be able to measure 2.5 cm to < 5 cm
- dbh tape
  - To measure the diameter of all trees greater than 5 cm within the plot
- Small cylinder with grid (i.e.: moosehorn densitometer, or something made with PVC pipe)
  - To assist with percent canopy closure estimates
- Binoculars
  - To assist with tree identification, particularly important if the observer relies less on bark to identify a tree and if there are no low branches or available leaves in the litter
- Phone/Camera
  - To assist with plant identification
  - Photos should aim to capture any fruiting heads, flowers, stem, leaf margins and roots (for sedges and grasses)
  - Photos should be taken against a solid background (i.e.: clipboard) and should be labeled with habitat to narrow down the ID
- Masking tape, sharpie, plastic bag
  - The masking tape and sharpie is used to keep grass samples together and mark unknown plants
  - The plastic bag is to safely store them in the field (so the seed heads and ID features don't get damaged) until they are brought back to the office for herbarium preparation and future ID
- Clinometer

- To measure tree height in the future

*Helpful resources*

- Books:
  - Farrar, J.L. 2017. *Trees in Canada*. Ottawa, Ontario: Fitzhenry & Whiteside Ltd.
  - Soper, J.H. & M.L. Heimbürger. 1990. *Shrubs of Ontario*. Toronto, Ontario: Royal Ontario Museum.
  - Newcomb, L. *Newcomb's Wildflower Guide*. Little, Brown and Company
  - Voss, E.G. 1972. *Michigan Flora: Part 1 Gymnosperms and Monocots*. Michigan: Cranbrook Inst of Science.
- Websites:
  - Ontario Wildflower: <http://www.ontariowildflowers.com/>
  - Go Botany –New England Wild Flower Society: <http://gobotany.newenglandwild.org/full/>
- Apps:
  - iNaturalist: VSP teams can join the *VSP iNaturalist Project* to have experts assist with plant ID

**Appendix D:**

Scientific Name	Common Name	Form
<i>Carex debilis</i>	Weak Sedge	SE
<i>Carex radiata</i>	Eastern Star-like Sedge	SE
<i>Cinna latifolia</i>	Drooping Woodreed	GR
<i>Doellingeria umbellata</i> var. <i>umbellata</i>	Southern Flat-topped White Aster	FO
<i>Galium odoratum</i>	Sweet Bedstraw	FO
<i>Geranium molle</i>	Dovefoot Geranium	FO
<i>Geum macrophyllum</i>	Large-leaf Avens	FO
<i>Ilex mucronatus</i>	Mountain Holly	SH
<i>Ludwigia palustris</i>	Marsh Purslane	FO
<i>Ranunculus ficaria</i>	Fig Buttercup	FO
<i>Tanacetum balsamita</i>	Costmary	FO
<i>Viola pubescens</i> var. <i>scabriuscula</i>	Smooth Yellow Violet	FO

## Literature Cited

- Abrams, A. 2017. Ecological Monitoring Summary. Available on *rare's* server, pp. 2.
- Andersen, H.E., Reutebuch, S.E., & McGaughey, R.J. 2006. A rigorous assessment of tree height measurements obtained using airborne lidar and conventional field methods. *Can. J. Remote Sensing*, 32(5): 355-366.
- Converse, C.K. 1984. *Rhamnus cathartica* and *Rhamnus fragula*. Element Stewardship Abstract, The Nature Conservancy. 17pp.
- Frapplier, B., Eckert, R., & Lee, T.D. 2003. Potential impacts of the invasive exotic shrub *Rhamnus frangula* L. (Glossy Buckthorn) on forests of southern New Hampshire. *Northeastern Naturalist*, 10(3): 277-296.
- Juknys & Augustaitis, 1998. Indicators of crown and their application in forest health monitoring. *Baltic Forestry*, 2: 51-58.
- Pope, C. 2014. Invasive species management: work plans in priority areas. Available on *rare's* server, pp. 6.
- Puric-Mladenovic, D., & Keeney, A. 2015. The VSP field inventory and monitoring pocket guide.
- Urban Forest Associates Inc. 2002. Invasive exotic species ranking for Southern Ontario. Retrieved from, <http://chapter.ser.org/ontario/files/2012/08/exotics.pdf>
- Warne, A. 2016. Black locust (*Robinia pseudoacacia* L.) Best management practices in Ontario. Ontario Invasive Plant Council, Peterborough, ON.