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MONITORING INVASIVE PLANT SPECIES: SUMMER INTERNSHIP AT HABITAT WILDLIFE SANCTUARY, BELMONT, MASSACHUSETTS

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HOLLY ZANONI

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A MASTER'S PROJECT

Submitted to the faculty of Clark University, Worcester, Massachusetts, in partial fulfillment of the requirements for the degree of Master of Science in the department of International Development, Community, and Environment

And accepted on the recommendation of

Yelena Ogneva-Himmelberger, Ph.D., Chief Instructor

ABSTRACT

MONITORING INVASIVE PLANT SPECIES: SUMMER INTERNSHIP AT HABITAT WILDLIFE SANCTUARY, BELMONT, MASSACHUSETTS

HOLLY ZANONI

Habitat Wildlife Sanctuary, located in Belmont, Massachusetts is a dynamic suburban sanctuary that effectively upholds Mass Audubon's three-part mission of advocacy, conservation, and education. Invasive plants threaten ecological integrity; however, proactive measures are taken to mitigate further encroachment. This is accomplished by surveying and taking inventory for presence of invasive species, then prioritizing them, and finally by incorporating high priority species into the immediate management strategy. Four invasive plants were formally analyzed using geographic information science during the 2014 growing season: Garlic mustard, Black swallowwort, Japanese knotweed, and Dame's Rocket. The resulting density maps detected pattern changes from 2011, 2012, and 2014, ranging from subtle to conspicuous, by measuring concentrations of invasive species. This report describes my internship experience at Habitat Sanctuary.

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Teen Clinic Project Manager, Ethembeni Clinic, KwaZulu-Natal, South Africa, 2009-2012

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Geospatial Analyst, Science Applications International Corporation, Chantilly, Virginia, 2000-2002

DEDICATION

To Brian who is the best friend a person could ever have;

has taught me what is possible through hard work and delayed gratification;

has shown me the world in ways only few will ever see;

and has never lost sight of the endgame.

To Alana and Bryce because only with your fierce independence could this day be possible.

To the GISDE class of 2015 because your encouragement truly made a difference;

especially my lab partner-in-crime, to whom I owe 20% of my degree.

ACKNOWLEDGEMENTS

I wish to thank Professor Yelena Ogneva-Himmelberger for her guidance and patience and Professor Alex Gardner for setting the bar incredibly high from day one.

Additionally, I would like to thank the unceasing dedication my teaching assistants.

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CHAPTER 1: INTRODUCTION

I have always considered myself as an explorer. My childhood summers were spent travelling with my Grandmother across the United States; she would hand me a map and tell me to make a plan. That is where my love of maps, geography, and exploration begins.

Since that time, I have extensively studied about the Earth and its people. Exploring the world has remained a priority. During the six years I lived in South Africa, global health also became significant. As a result, I completed a graduate program in global health to develop expertise in the subject. During the second epidemiology course, I became determined to use geographic information science (GIS) as a tool to study the relationship between people and their environment as it pertains to global health. The Geographic Information Science for Development and Environment (GISDE) master's degree at Clark University is an ideal match. There are several rigorous requirements for graduation, one of which entails an internship during the summer bridging years 1 and 2 of the program.

I had several internship options; however, I chose to work at the Habitat Wildlife Sanctuary, which is located in Belmont, Massachusetts. The internship was not related to my professional path; however, I had been volunteering at Habitat since arriving in Belmont from South Africa in 2012. Sanctuary staff needed help managing invasive plants and I saw an opportunity to incorporate GIS

to help meet their goals by measuring distribution and determine the effectiveness of control efforts over time. Thus, an internship soon ensued.

CHAPTER 2: BACKGROUND

Mass Audubon History

The mission of the Massachusetts Audubon Society, more commonly referred to as Mass Audubon, is *to protect the nature of Massachusetts for people and wildlife* (Mass Audubon, 2014). With more than 35,000 acres permanently protected, Mass Audubon is one of the most prominent conservation organizations in New England (Mass Audubon, 2014) and is appreciated for using sound science, successful advocacy, and innovative approaches to connect people with nature.

Two women, Harriet Hemenway and Minna Hall, established Mass Audubon in 1896 in an effort to “discourage the buying and wearing of the feathers of any wild birds” (Packard, 1921). Together, the two women convinced nearly a thousand women to join their society to protect birds (Souder, 2013). The society used its political influence to pass two laws: a Massachusetts State law that banned the wild bird feather trade in 1897 (Weidensaul, 2008) and the Lacey Act in 1900, which was the first federal law to address wildlife protection by limiting the killing and sale of plants and wildlife across state lines (Department of the Interior, 2000). Interestingly, the Massachusetts Audubon Society is not associated with the National Audubon Society; however, Mass Audubon helped organize the National Organization of Audubon Societies, which later became the National Audubon Society in 1905 (Weidensaul, 2008).

Habitat Sanctuary Description

Habitat Education Center and Wildlife Sanctuary is located in Belmont, Massachusetts, merely six miles from Downtown Boston. Established in 1970, it currently encompasses ninety acres of deciduous and evergreen forests, meadows, ponds, and vernal pools. Habitat is a dynamic sanctuary that effectively upholds Mass Audubon's three-part mission of advocacy, conservation, and education.

Habitat (figure 1), like many of the sanctuaries in the Mass Audubon system, is relatively small and relies heavily on volunteer community involvement. Geographic Information Science (GIS) and formal mapping projects are predominantly confined to the headquarter office in Lincoln. Although there is great interest in permanently implementing GIS at Habitat, projects are currently limited to volunteer support.

Overview of Invasive Plants

The 1999 presidential Executive Order (Federal Register, 1999) defines an invasive species as a species that is both nonnative to the ecosystem and is likely to cause environmental harm, economic harm, or harm to human health (USFS, 2014). For clarification, the definition of a nonnative species is a species that did not historically exist in the area and has since been introduced into a new environment. It is important to note that that because a plant is nonnative does not mean it is invasive. For example, various crops and garden plants become

established but do not become invasive. Furthermore, because a plant is a nuisance does not mean it is invasive. For example, poison ivy is a nuisance to some humans but is not invasive; in fact, it shares an important cooperative relationship with native animals. Newly introduced invasive species must withstand low population densities before becoming established in a new location. Thus, invasive plants are especially opportunistic because they possess specific characteristics that make them especially well-suited for colonizing a new ecosystem (USFS, 2014). Opportunistic traits include: Rapid growth and reproduction, multiple modes of reproduction, abundant seed production and high dispersal capability, release of chemicals inhibiting native plant growth, tolerance to wide-ranging environmental conditions, aggressive competition for resources (i.e., greens earlier in spring and remains green throughout winter resulting in a longer growing season), and lack of natural enemies in the new environment.

There are many ways that invasive plants threaten their surrounding ecosystem. Invasive plants can decrease biological diversity by making the habitat less suitable for native plants and animals by reducing or displacing native species. Also, they can impede efforts to restore native species already threatened and endangered. Invasive plants are spread via multiple pathways that include both natural dispersal and human transmission. However, anthropogenic activity is especially pronounced; for example, along modes of transportation (bicycles, shoe treads, snow plows, planes), by cross-contamination (improperly cleaned professional landscaping tools), by introducing materials (i.e., woodchips) from

outside sources, or for exotic specimens. When introduced into a new environment, native species have little mechanism to combat the opportunistic traits prolific among invasive species. As a result, the native landscape can be rapidly transformed. Thus, ecological management is especially critical.

Ecological Threat

Significant threats to ecological integrity at the sanctuary include invasive species, overuse and incompatible use of the sanctuary, and wildlife predation by cats and native wildlife species well-adapted to life in mixed suburban-urban environments (Habitat, 2011).

Mass Audubon identifies five goals for invasive species management within its sanctuary system (Mass Audubon, 2011), including: 1) Prevent establishment of new populations of known or suspected invasive species, including species known to be invasive elsewhere, 2) protect from invasive species encroachment, 3) protect exceptional natural communities from invasive species, 4) restore potentially high quality natural communities already degraded by invasive species where restoration is feasible, and 5) protect actively managed habitats to preserve biologically or culturally important landscape features. Habitat Wildlife Sanctuary executes meets these goals by (Mass Audubon, 2011) by surveying and taking inventory for presence of invasive species, prioritizing them, and incorporating high priority species into the immediate management plan.

CHAPTER 3: INTERNSHIP DESCRIPTION

As an intern, I assisted Habitat staff with management of invasive plants throughout the property. There is no formal GIS management within the sanctuary; however, the most recent “Ecological Management Plan” (Habitat, 2011) emphasizes priority be given to ecological management of invasive plants. Tasks outlined in the document include monitoring to detect new or expanding invasive plant populations with specific priority placed on mapping and controlling Garlic mustard, Black swallowwort, Japanese knotweed, and goutweed.

Four invasive plants were formally analyzed during my internship: Garlic mustard, Dame’s rocket, Black swallowwort, and Japanese knotweed. Three of the plants formally analyzed, Garlic mustard, Black swallowwort, and Japanese knotweed are considered a high priority risk for invasion within the sanctuary. Other priority plants informally analyzed included, Glossy buckthorn, Goutweed, Kudzu, Oriental bittersweet, Porcelain-berry, and the Tree of heaven. Table 1 describes prioritization within the reserve and appendix 1 provides a detailed description for each plant that was formally analyzed.

Early detection and rapid response of invasive species is essential for controlling infestations. By monitoring invasive plants, this allows staff to prioritize their removal and follow-up monitoring, prevents establishment of new species, and encourages seamless collaboration among adjacent properties.

Responsibilities

Primary duties during my internship included managing invasive plants at Habitat Sanctuary. This was accomplished by surveying and taking inventory for presence of invasive species and incorporating high priority species into my work strategy. First, I evaluated the 2011 park survey of invasive plant distribution by comparing previous distribution maps and field surveys. Then, using a Global Positioning System (GPS) receiver, I returned to areas of previously recorded observations, evaluated changes within the population since the last survey, and documented newly detected observations within the sanctuary boundaries.

Significant time was spent merging and editing data from the previous inventory with newly collected points to produce an updated, seamless data layer that could be used for measuring the extent of invasive plants on the property. Substantial emphasis was placed on ensuring attribute data accuracy resulting from various data collection methods across the three years.

Detailed information was collected and entered into an Excel database using data recorded from a GPS unit, field data sheets (table 2), and a voice recorder. The sanctuary rarely relies upon herbicide application for plant control, preferring to use natural removal processes; thus, invasive plant control is conducted by manually removing plants whenever feasible. Both data collection and plant extraction required meticulous plant identification and routine follow-up site visits to ensure data accuracy and to inhibit regrowth.

Additional internship duties encompassed trail maintenance (i.e., removal of fallen branches, cutting back poison ivy from trail edge), assisting with outreach, and facilitation of volunteer events. Occasionally, I worked with goats, generally moving their enclosure to an area where they function as an alternative method for plant control (i.e., goat lawnmower).

After data were collected and tested for quality assurance, various GIS analyses were performed; the resulting density maps serve as the end product of my internship, which may be incorporated into the updated Ecological Management Plan.

Results

In order to visualize where invasive plant points are concentrated on the property, kernel density analysis was performed. Density analysis takes the known quantities of plant stems and spreads them across the landscape based on the quantity that is measured at each location and the spatial relationship of the locations of the measured quantities. The resulting density surface displays plant stem magnitudes. By comparing the changes in 2011, 2012, and 2014, trends can be detected. Figures 2-4 show the change in pattern for Garlic mustard, Black swallowwort, and Japanese knotweed between 2011 and 2014.

Garlic mustard is expanding both in magnitude and position throughout the property. Black swallowwort appears to be holding steady both in concentration and property position. For the area that can be compared, the Japanese knotweed

population appears to be remaining steady. However, further data collection and analysis are required to accurately measure the overall trend for two reasons: 1) the data (Week's Meadow) were corrupt resulting in null values for part of the 2014 survey and 2) thick vegetation coverage hindered estimates of smaller specimens. Only points from 2014 were available for Dame's rocket; therefore, there is no relevant trend represented in figure 5. However, at the moment, Dame's rocket is isolated to a small area of the property that can be easily monitored and removed.

CHAPTER 4: INTERNSHIP ASSESSMENT

The internship at Habitat Sanctuary required meticulous planning and execution to reinforce accurate data collection, data management, and quality assurance. Data management and data collection are two topics interwoven into our education at Clark but neither topic is explicitly required as part of our coursework. Many skills acquired at Clark transferred to the internship, including manipulation of data using ArcGIS, GPS point collection, satellite imagery manipulation, and the Spatial Analyst extension. Data management and project management skills were sharpened. Additional skills acquired during the internship include plant ecology, identification, and taxonomy; plant-specific management techniques; trail maintenance; and goat care as alternative method for plant control.

The internship at Habitat Sanctuary provides an excellent opportunity to independently plan and develop a GIS project from start to finish by performing independent research, collecting field data, and experimenting with GIS analysis techniques. Additional projects (i.e., integrated trail guide apps, caterpillar monitoring, long-term invasive analysis, etc.) are encouraged and greatly appreciated. Two drawbacks associated with the internship are that resources are limited and there is no technical guidance. However, there is incredible overall support, new ideas are highly valued, and all staff work together to uphold Mass Audubon's mission *to protect the nature of Massachusetts for people and wildlife*

(Mass Audubon, 2014). The staff at Habitat and Mass Audubon is progressive in their approach toward ecological management, which is based on scientifically sound principles, making this internship particularly suitable for people interested in ecological management. Overall, the experience was stimulating and provided an incredible opportunity to acquire, investigate, and polish skills regarding environmental applications of GIS. Although a fulfilling experience, my professional focus is on public health.

CHAPTER 5: CONCLUSION

The highlight of my internship included intermittent property walks with the property manager, the property director and resident entomologist, and the Mass Audubon regional scientist. Each offered a wealth of information regarding history, near-term, and long-term ecological management within the Habitat Sanctuary and throughout New England. Through their guidance and practical experience, I successfully developed skills pertaining to invasive plant ecology, taxonomy and identification and invasive species management practices.

I also became highly practiced with poison ivy, was relentlessly ambushed by mosquitoes and ticks, got stuck in Velcro Weed (accurately named for its stickiness), and removed several trees left dangling after straight-line storms pushed through the region—using nothing but ropes and a handheld saw.

This internship highlighted the potential regarding what can be achieved by integrating GIS to monitor invasive plant species. By drawing upon the diverse suite of tools learned at Clark, I was able to effectively analyze and visually describe the concentration of invasive plant species within the Habitat Sanctuary.

FIGURES

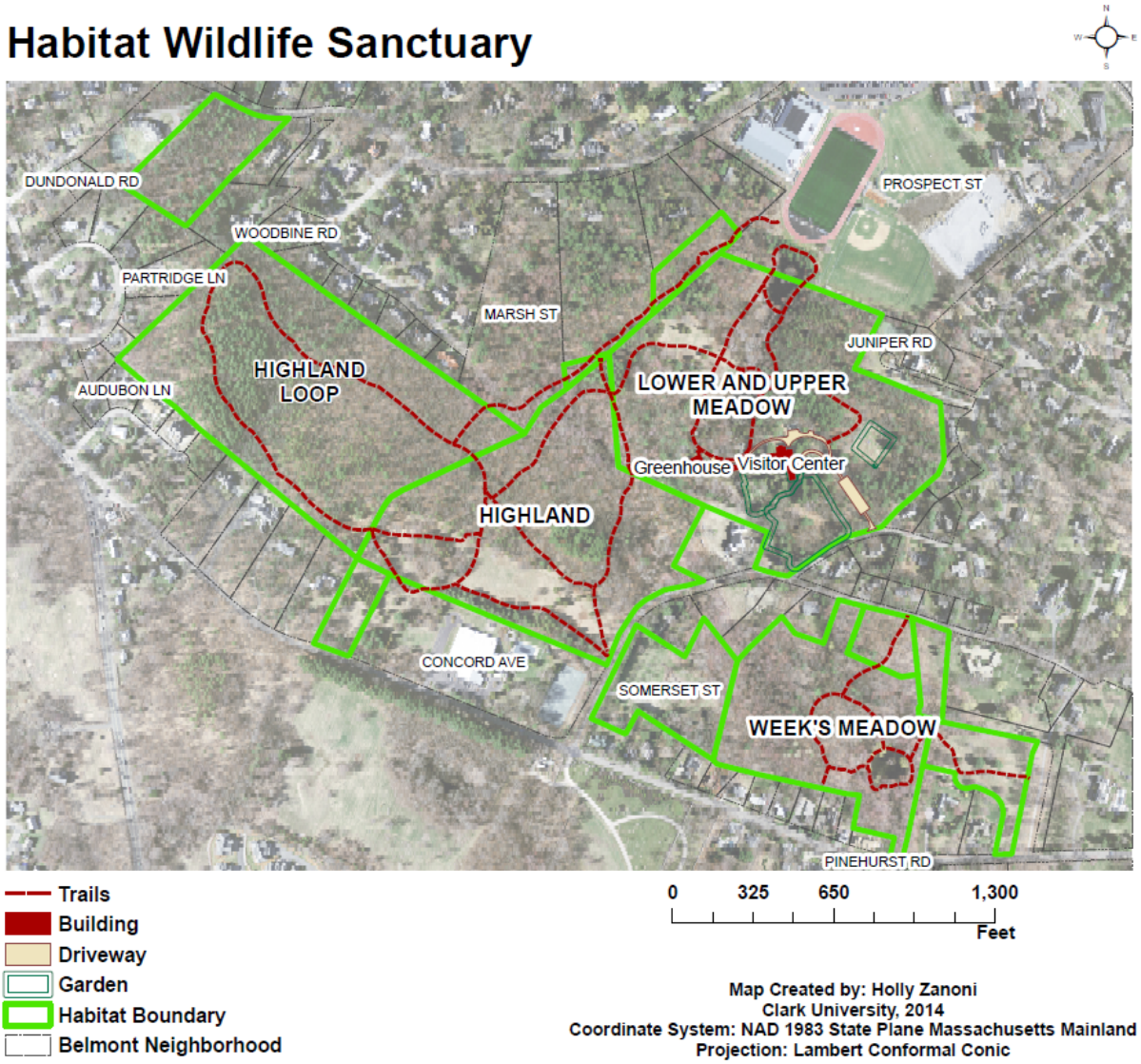

Figure 1. Property Map of Habitat Wildlife Sanctuary

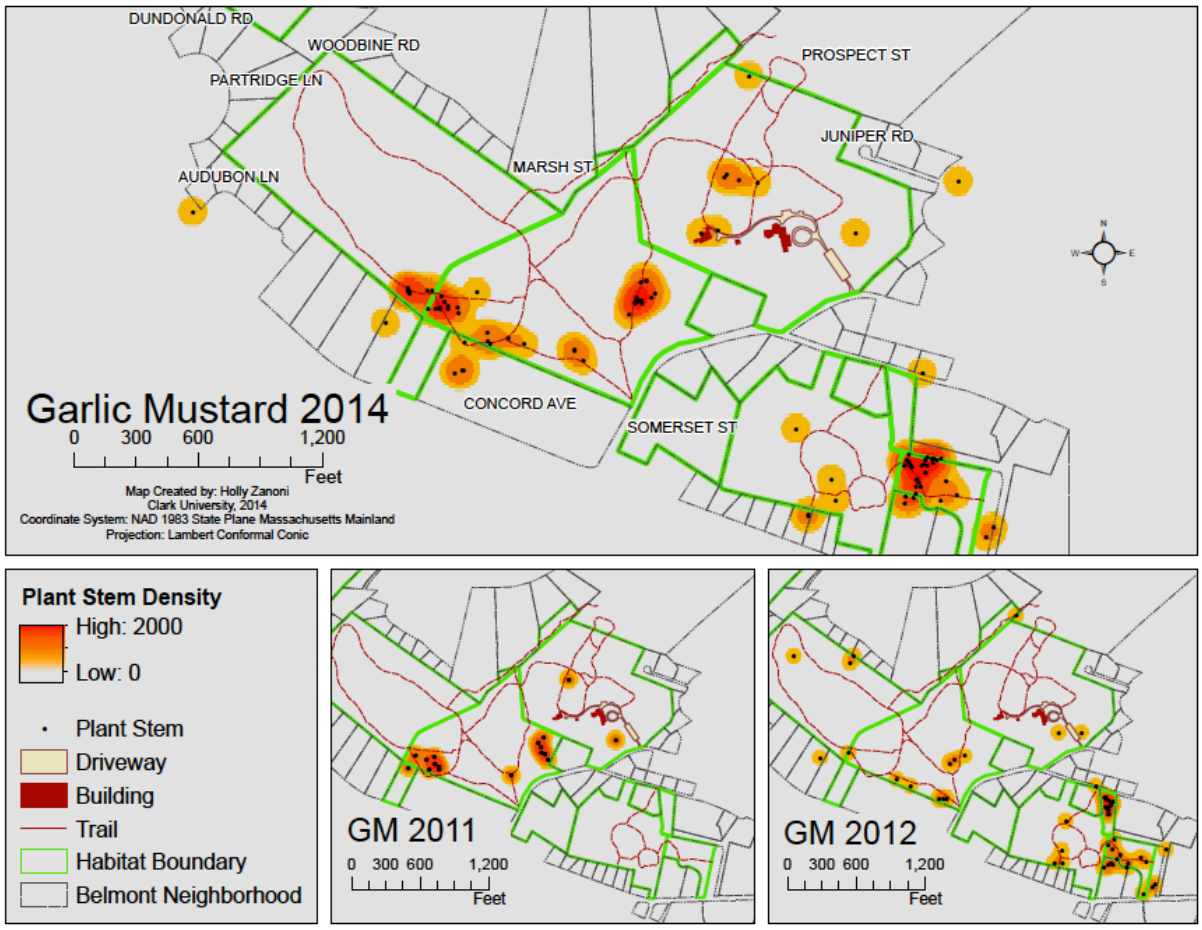

Figure 2. Garlic Mustard

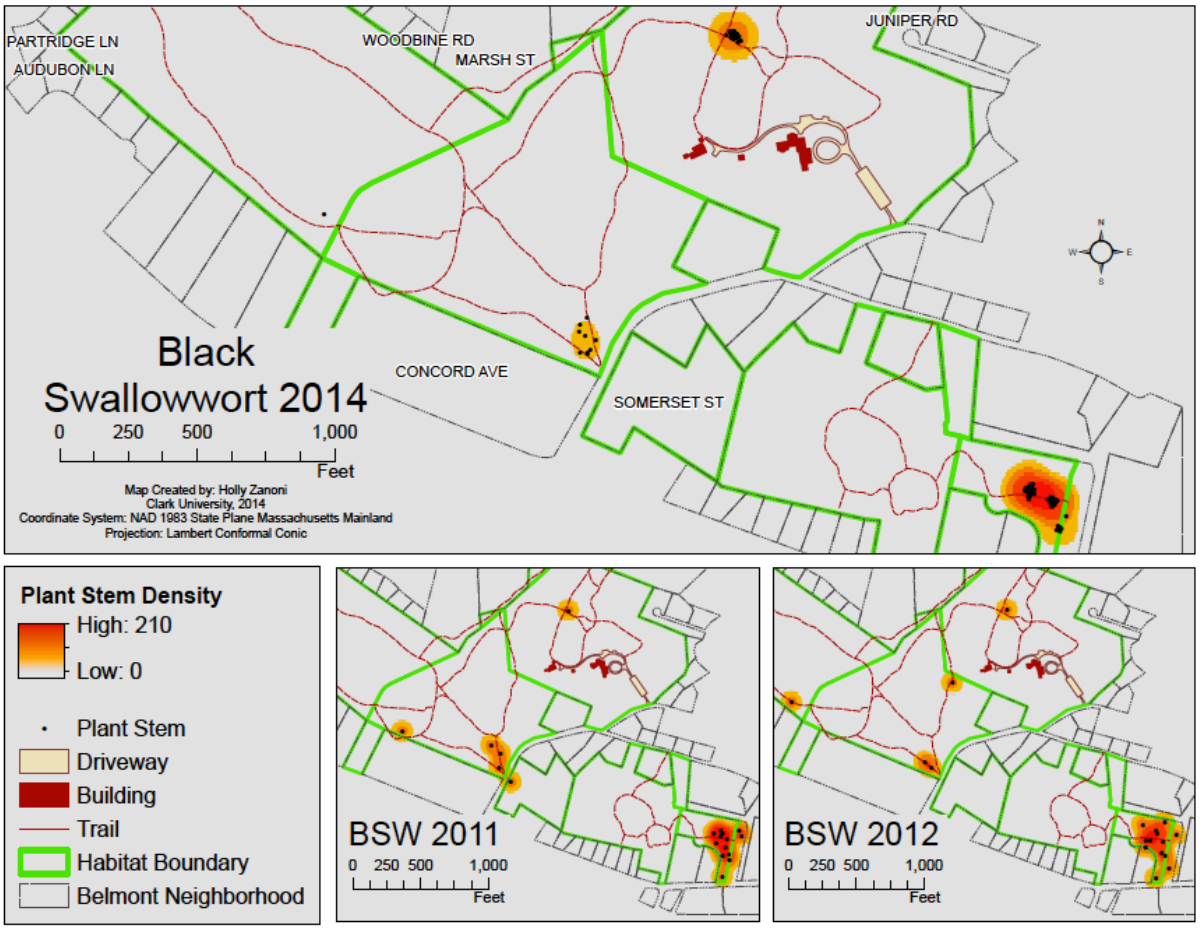

Figure 3. Black Swallowwort

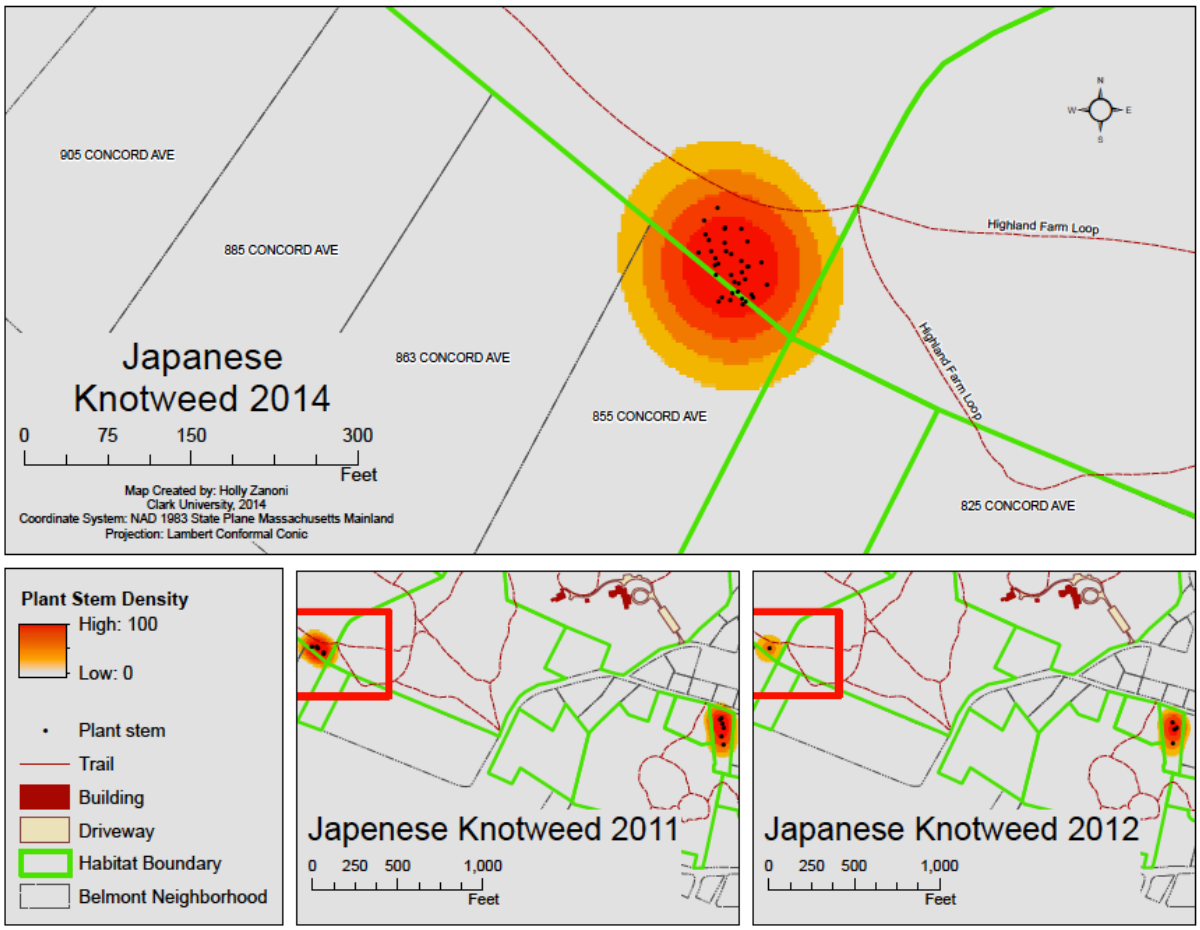

Figure 4. Japanese Knotweed

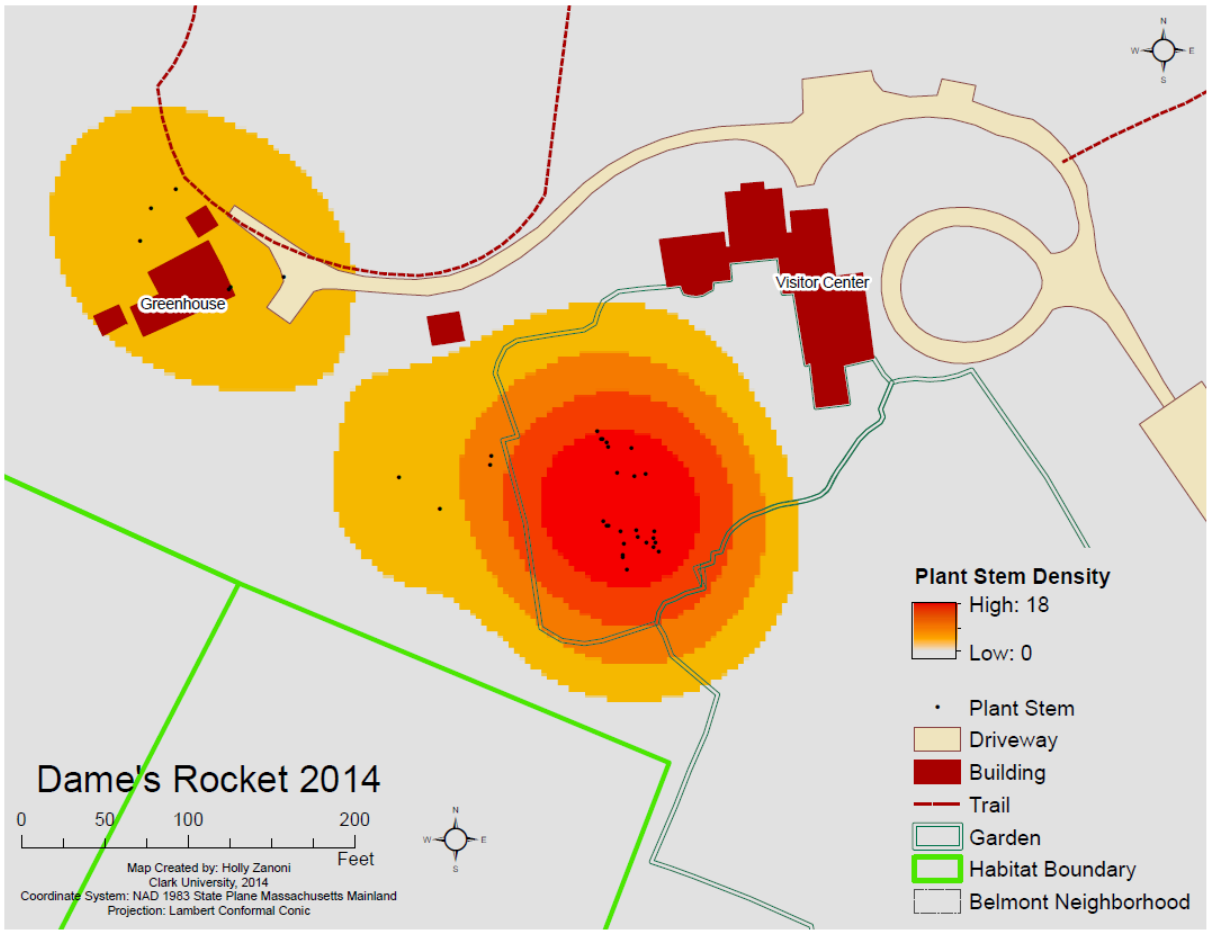

Figure-5. Dame's Rocket

TABLES

Table 1. Prioritization of Invasive Plant Species at Habitat Sanctuary

Management Priorities	Priority	Season	Annual Commitment	Property Location	Comments
Garlic mustard	High	March—May	7-10 days	All	Continue annual control measures; monitor for new populations and eradicate
Black swallowwort	High	June, Aug—Sep	5 days	All	Monitor property annually and eradicate
Japanese knotweed	High	May	1 day	Weeks Meadow	Eradicate to prevent further spread
Purple loosestrife	High	June	2 days	Weeks Meadow	Control small purple loosestrife population in Weeks Meadow before it expands
Tree-of-heaven	Medium	Year-round	Varies	Education Center, Highland (new), Weeks Meadow	Monitor existing population and determine if spreading; eradication could be conducted over several years, beginning with mature trees to prevent further seed production
Glossy buckthorn	Medium	Year-round	Varies	Education Center, Weeks Meadow	Ongoing; priority focused on areas least heavily invaded and then move to more invaded areas
Goutweed	Medium	Year-round	1 day	Education Center	Establish baseline distribution to determine of threat to natural areas and to assess spread

Table 2. Field Data Sheet

Field	Description
WAYPT	Waypoint number specific to GPS device
DATE	Date of data collection
LAT (N)	Latitude in degrees
LONG (W)	Longitude in degrees
ELEV (M)	Elevation in meters
SPECIES	Name of plant under observation
PLACE	Location description within property
AC (M)	Accuracy reading of GPS unit in meters
STEMS	Estimated number of plant stems
R (FT)	Estimated radius of colony in feet
HT (IN)	Estimated height of tallest plant in inches
FIRST GTH	Plant in first year of lifecycle
SECOND GTH	Plant in second year or greater of lifecycle
CHARACTER	Spatial characteristic of plant: i.e., clustered, dispersed, isolated
SOIL	Description of immediate ground cover: i.e., bare soil, leaf litter, road, trail, wood chips
PHOTO	Photo of plant situation
NOTES	Nearby landmarks, surrounding vegetation, etc.

APPENDIX: DESCRIPTION OF INVASIVE PLANTS

Garlic Mustard

NAME: Garlic Mustard **SCIENTIFIC NAME**: *Alliaria petiolata*
NATIVE RANGE: Europe
INTRODUCTION INTO THE UNITED STATES: Introduced during 1860s in Long Island, New York for medicinal and culinary purposes
ECOLOGICAL IMPACT: Garlic mustard is an aggressive invader that poses a severe threat to native plants and animals in forest communities. Once introduced to an area, it outcompetes native plants by aggressively monopolizing resources and produces allopathic compounds that inhibit seed germination of other species. Several species of spring wildflowers known as "toothworts," also in the mustard family, are the primary food source for the caterpillar stage of the butterfly and invasions of garlic mustard cause local extinction of toothworts; the chemicals in garlic mustard are toxic to the eggs of the butterfly and the eggs fail to hatch when laid on garlic mustard plants.
DESCRIPTION: Related to the mustard family, garlic mustard is a cool season biennial herb with stalked, triangular to heartshaped, coarsely toothed leaves that smell like garlic when crushed. First-year plants appear as a rosette of green, heart shaped, 1-6” long leaves close to the ground, which remain green throughout the winter and develop into mature flowering plants the following spring. Second year plants produce a 1-4’ tall flowering stalk with buttonlike clusters of small white flowers, each with four petals in the shape of a cross. In May, seeds appear as erect, slender pods that become shiny black when mature and by late June, the plants die but seedpods remain viable throughout the summer; seeds can remain viable in the soil for more than five years.
SOURCE: Invasives.org, 2010


Mehrhoff, 2006


Cappaert, 2006

APPENDIX: DESCRIPTION OF INVASIVE PLANTS

Black Swallowwort

NAME: Black swallowwort **SCIENTIFIC NAME:** *Cynanchum louisae*
NATIVE RANGE: Europe, specifically France, Italy, Portugal, and Spain
INTRODUCTION INTO THE UNITED STATES: Recorded by a collector in Ipswich, Massachusetts in 1854 as "escaping from the botanic garden where it is a weed and promising to become naturalized" (NPS, 2010)
ECOLOGICAL IMPACT: Black swallowwort forms extensive patches that outcompetes native vegetation by completely changing the physical structure of the soil. The monarch butterfly requires milkweeds for reproduction; however, the butterflies will lay eggs on black swallowwort, but the larvae do not survive.
DESCRIPTION: Black swallowwort emerges in spring and flowers from June to July. It is an herbaceous, twinning, perennial vine. The leaves are oval shaped with pointed tips, 3-4” long by 2-3” wide, and occur in pairs along the stem. The leaves are dark green, almost with a bluish tint. Flowering occurs from June to July, when dark purple, five-petaled, star-shaped flowers appear in clusters, which are approximately 0.25” across. The fruits are slender tapered pods turning from green to light brown as they mature. The number of pods is directly related to the level of light available. Flowers are self-pollinating and the plant root system consists of rhizomes (underground stems) that sprout new plants and grow in clumps of stems, forming extensive patches. Full sun can result in thick infestations whereas populations growing under a dense canopy may have inadequate resources to produce flowers or seeds.
SOURCE: Invasives.org, 2010


Mehrhoff, 2006


Mehrhoff, 2006

APPENDIX: DESCRIPTION OF INVASIVE PLANTS

Japanese Knotweed

NAME: JAPANESE KNOTWEED **SCIENTIFIC NAME:** *Fallopia japonica*
NATIVE RANGE: Eastern Asia
INTRODUCTION INTO THE UNITED STATES: Japanese knotweed and giant knotweed are often indistinguishable species; both were introduced in the mid-1800s as ornamentals.
ECOLOGICAL IMPACT: Related to the buckwheat family, both Japanese knotweed and giant knotweed can grow so voraciously that little light can penetrate their canopy; resulting in almost total suppression of any other vegetation.
DESCRIPTION: Japanese knotweed is large and may spread by seed or rhizome although rhizomes tend be the primary means of reproduction, especially in areas where populations are well established. Flowering occurs in late summer, in long flower clusters along the stems of the leaves. Leaf shape and flower color and structure, distinguish these two species: Japanese knotweed has smaller, broadly ovate alternate leaves 6” long by 3-4” wide, which distinctly truncate and have white flowers that increase in size as the plant matures; giant knotweed has large leaves that are often over a foot in length, and greenish-white flowers that do not increase in size with maturity of the plant.
SOURCE: Invasives.org, 2010


Grieser, 2005


UAF, 2005

APPENDIX: DESCRIPTION OF INVASIVE PLANTS

Dame's Rocket

NAME: Dame's Rocket **SCIENTIFIC NAME**: *Hesperis matronalis*
NATIVE RANGE: Europe
INTRODUCTION INTO THE UNITED STATES: Introduced as an ornamental around the time of European settlement. It is still widely used as an ornamental and can be found throughout North America.
ECOLOGICAL IMPACT: Dame's rocket competes with native herbaceous plants and inhibits tree seedling germination and growth. Part of its success as an invasive plant is because of its widespread distribution in commercial "wildflower" seed mixes; seeds readily escape gardens and enter natural areas.
DESCRIPTION: Dame's rocket have 4-petaled flowers that bloom from Mid-May through June. It resembles Phlox—but all phlox species have opposite leaves and 5-petaled flowers that bloom from July to September. Dame's rocket is a short-lived perennial in the mustard family that grows up to 4' in height. The attractive, fragrant flowers vary in color from white to pink to purple develop in the late spring, just before the similar-looking phlox. Flowers develop in clusters on 3' tall stalks. First-year plants develop into low rosettes at ground level and stay green throughout the winter. Flowering plants start as a rosette in early spring, but soon yield a 2-4' tall flower stem. Flower clusters branch out from the upper parts of the plant. Flowering-stem leaves are pointed, 2-6" long, which decrease in size up the stem, and are attached alternately along the stem. Flowers bloom from mid-May through June. Thin, wiry seedpods that are 2-5 inches long will split and release in late summer. The seeds remain viable in the soil for many years.
SOURCE: invasive.org, 2010


Mehrhoff, 2006


Mehrhoff, 2006

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