Invasive Species Management at MacLeish Field Station

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May 2011
ABSTRACT

The threat of invasive species to both biodiversity and human economy is well documented. Invasive plants outcompete local species, have environmental effects on their introduced ecosystems, and negatively impact the food and fiber industries. Management of invasives is a complicated but necessary subject. This study conducted a survey of invasive species at the site for the proposed Bechtel Environmental Classroom at MacLeish Field Station in order to support the petition for Living Building status under the International Living Building Institute’s Living Building Challenge. Living Buildings generally must be constructed on greyfield or brownfield sites, but the heads of the project at MacLeish hope to argue the point that the site is currently so overrun with invasive species due to past mismanagement that the construction of a Living Building will substantially improve the surrounding area. This study found four aggressive and harmful species covering approximately 60% of the proposed building site: Japanese barberry (*Berberis thunbergii*), oriental bittersweet (*Celastrus orbiculatus*), multiflora rose (*Rosa multiflora*), and wild or riverside grape (*Vitis riparia*). In addition to aiding the petition for Living Building status, this study also proposes low-impact methods of controlling the invasive species at MacLeish, such as use of goats to crop the site.

INTRODUCTION

Invasive plant species

Invasive species are one of the leading threats to biodiversity (Vilà and Weiner 2004). They are defined by the 1999 President’s Executive Order on Invasive Species as “an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health” (Mullin et al. 2000). Invasive plant species are characterized by adaptability, competitiveness, and a lack of natural predators with an ability to keep them in check. Of these, some studies have suggested that competitive ability is the key factor in suggesting successful invasive potential, as competition for limiting resources is often the first contact the invader has with the local plant population (Vilà and Weiner 2004). Vilà and Weiner found that evidence to support the general perception that invasive species are strong competitors in comparison to local species (2004). Kudzu (*Pueraria montana*), a native of Asia, is a classic example of an invasive species outcompeting locals in terms of sheer space to grow. In the United States, kudzu grows at a rate of about a foot a day and is adapted to most soil types and in a wide range of conditions.
As many as thirty vines may be growing from a single root crown, which may reach seven inches in diameter, if not more (Ibid). Kudzu can be fed to livestock, but a concentrated effort is necessary to mount defenses at the rate needed to truly control the plant.

Invasive species are introduced via human vectors, both intentionally and unintentionally. Invasives have frequently been originally introduced to their new habitat as ornamental plants, not recognized as aggressive until they had taken hold (Mullin et al. 2000). Once an invasive has been introduced, it is sometimes lauded for its initially useful qualities and purposefully distributed widely. Kudzu, for example, was planted by many farmers from 1935 until 1953 as a control against erosion, a practice supported and encouraged by federal and local governments (Bergmann and Swearingen Kudzu 2009). Instances such as these show a lack of understanding of the potential dangers of non-native species, and can greatly expand an invasive’s influence. Examples of unintentional introduction are often linked with the current global economy of the world, as invasive species are introduced through the ballast water of ships, contaminations of intentional shipments of food items, and even as a result of private air travel (Mullin et al. 2000).

Invasive species can negatively impact the ecosystems into which they are introduced in a multitude of ways. It is well documented that they reduce biodiversity through outcompetition, but they directly impact humans as well. A conservative estimate of the annual impact of weeds on agriculture is $20 billion (Mullin et al. 2000). Invasives can cause economic losses to the fiber industry as well. They can alter soil chemistry, affecting the pH as well as nitrogen and oxygen levels. They lead to the deterioration of natural resources and habitats and can cause further economic losses due to the restrictions on exporting contaminated commodities (Ibid). The need for preventative measures is well displayed, including efforts ranging from educating the public...
on what not to plant in their gardens to potentially expensive and extensive eradication efforts in affected areas.

**MacLeish Field Station**

The Ada and Archibald MacLeish Field Station is located in Whately, MA, approximately 12 miles north of Smith campus. The station is a 200 acre site of mixed forests and fields purchased by Smith College in the 1970’s for use as an observatory site for the astronomy department (Smith 2008). There are currently two structures on the property, the observatory tower itself and a support building. In the mid-1990’s, however, the observatory fell out of use in favor of the equipment now available on the roof of the college’s McConnell Hall, more highly valued for its easy accessibility by students and faculty. Near the same time, the college made two clearcuts on the property. Since that period, however, the station was left essentially unused for nearly twenty years, and the clearcuts have been thoroughly invaded by a number of invasive species.

In May of 2008, the Whately property was dedicated to Ada and Archibald MacLeish as a “living laboratory for teaching and conducting research about the environment” (Smith 2008). Since that date, both student and faculty use of the field station has increased in a number of fields, including meteorology, air quality, hydrology, land use and ecology (Ibid). The field station is designed to support environmental and forest ecology research within various disciplines. Various Smith classes now include trips to the station, and individual students conduct their own research or work as interns on the MacLeish property. Moreover, Smith’s Center for the Environment, Ecological Design, and Sustainability (CEEDS) has plans to expand the uses of the field station even farther in the near future, including designs for a trail system
throughout the station, campgrounds, and a ropes course, as well as the construction of the Bechtel Environmental Classroom.

**Living Building Challenge**

In 2010, Smith College received a major three-year grant from the S.D. Bechtel, Jr. Foundation to construct an environmental classroom on the MacLeish property (Smith 2010). The classroom will be devoted mainly to research and environmental education, but it will be designed as a flexible structure, able to accommodate a wide range of purposes. It will be open to use by the community, including local primary and secondary schools, as well as to the students of Smith College (Ibid). And, in keeping with the field station’s dedication to environmental awareness and sustainability, Smith’s Center for the Environment, Ecological Design, and Sustainability is planning to register the Bechtel Environmental Classroom with the International Living Building Institute’s Living Building Challenge.

The International Living Building Institute was founded in 2009 by the Cascadia Green Building Council with the goal of “encourag[ing] the creation of Living Buildings, Sites and Communities in countries around the world while inspiring, educating and motivating a global audience about the need for fundamental and transformative change” (Living 2010). It is the most advanced green building rating system in the world (Ibid). There are only two buildings in the world that have received full Living Building certification. The challenge is based on the principles of net zero energy and net zero wastewater. It is currently in version 2.0, and is based on seven “petals”: Site, Water, Energy, Health, Materials, Equity, and Beauty. The petals are divided into various Imperatives. Below are described in brief the requirements of each petal, based on the Living Building Challenge, version 2.0 (Living 2010).
Site

The Site Petal is divided into four Imperatives: Limits to Growth, Urban Agriculture, Habitat Exchange, and Car Free Living. Limits to Growth stipulates where Living Buildings can be built – namely, on previously developed brownfield or greyfield sites sufficiently removed from sensitive ecological habitats such as wetlands, old-growth forest, or prime farmland. Urban Agriculture concerns the requirement that the Living Building have its own agricultural food source. Habitat Exchange requires that an area equal to the area of development be set aside as protected habitat, and Car Free Living is concerned with the promotion of walkable, pedestrian-oriented communities.

Water

The goal of the Water Petal is to realign how people use water, in order to restore water’s status as a precious resource. The petal is composed of two Imperatives, Net Zero Water and Ecological Water Flow. Net Zero Water mandates that the water used by the Living Building come from a closed loop system or be captured as rainwater, and it must be purified without the use of chemicals. Ecological Water Flow details the need for management of building water discharge.

Energy

The Energy Petal operates on the goal of gathering energy only from renewable resources, and without creating pollution of any sort. The petal has only a single Imperative, Net Zero Energy, which mandates the requirement for sustainable and renewable on-site energy sources.
Health

The Health Petal has three Imperatives: Civilized Environment, Healthy Air, and Biophilia. Civilized Environment requires operable windows in every occupiable space. Healthy Air describes the criteria for the promotion of high indoor air quality. Biophilia requires that the building be “designed to include elements that nurture the innate human attraction to natural systems and processes.” These elements include natural shapes and forms, light and space, and evolved human-nature relationships.

Materials

The Materials Petal is the most complex of the seven, with five separate Imperatives. The first Imperative is a Red List of prohibited materials and chemicals that cannot be used by project at any juncture. The next is the Embodied Carbon Footprint, which requires a complete offset of the building’s carbon footprint. The Responsible Industry Imperative dictates that the materials used in the project must be both sustainable in itself as well as sustainably and equitably harvested. The fourth Imperative is Appropriate Sourcing, which lays out the requirements for materials and services sourcing. Finally, the last Imperative, Conservation + Reuse, strives to optimize usage of the materials and reduce or eliminate waste to the greatest possible extent.

Equity

The Equity Petal is new in Version 2.0 of the challenge and concerns the ability of the project to foster a sense of community by being open and welcoming to people of varying needs and backgrounds. The petal has three Imperatives: Human Scale + Humane Places, Democracy + Social Justice, and Rights to Nature. Human Scale + Humane Places strives to create human-centric places, as opposed to automobile-centric places, in an effort to “[bring] out the best in
humanity and [promote] culture and interaction.” Democracy + Social Justice is concerned with equal access to the building by all demographics of society. Rights to Nature requires that the project not diminish any natural resource (such as quality of fresh air or sunlight) to any adjacent development or other members of society.

**Beauty**

The Beauty Petal intends to promote awareness and care for the environment through creating physical environments that inspire conservation and protection of the natural environment. The petal’s two Imperatives are Beauty + Spirit and Inspiration + Education. Beauty + Spirit requires that the project “must contain design features intended solely for human delight and the celebration of culture, spirit and place appropriate to its function.” Inspiration + Education states that educational materials about the performance and operation of the project must be open to the public, to motivate others to facilitate change.

**Research objectives**

As the proposed site for the Bechtel Environmental Classroom is not a previously developed brownfield or greyfield site, it deviates from the stipulated requirements for the Living Building Challenge. Thus, the proposal submitted to the International Living Building Institute must make the argument that the construction of a living building on this site will substantially improve the local environment. This project hopes to make the case that due to the widespread nature of invasive plant species that have arisen in the former clearcut location in which the classroom is to be constructed, the construction of the living building would fulfill its purpose. The Living Building Challenge’s Site Petal does mention the dangers of invasive species to natural ecosystems through irresponsible construction, so it is hoped that the institute will
consider this proposal (Living 2010). The project also hopes to propose sustainable and 
ecologically aware methods to manage invasive species at MacLeish in the future.

MATERIALS AND METHODS

The proposed building site for the Bechtel Environmental Classroom on MacLeish Field 
Station was visited three times, on April 20th, 22nd, and May 4th. A visual survey was conducted 
of all the plants growing both within the proposed confines of the building and its immediate 
proximity within the clear cut area. Invasive and excessively aggressive native species were 
identified based on guidance by Professor Reid Bertone-Johnson. Patches of invasives were then 
tagged with flagging tape and labeled for the plant or plants comprising the bulk of the invasives 
in that location. Representative samples were taken of each of the four invasives identified in the 
site, along with identifying photographs, both of the invasives on site and later of each sample.

On the final day of work at the field station, all the invasive species that had been 
identified were marked on a map of the building site for an assessment of the percentage of land 
on the site that was covered by invasives, as well as approximate locations of invasive species. 
The process was followed by research into potential methods of control for these invasives, both 
species-specific and general.

RESULTS

There were three invasive species and one excessively aggressive native species 
identified at the proposed building site for the Bechtel Environmental Classroom. The three 
invasive species were Japanese barberry (*Berberis thunbergii*) (Fig. 1), oriental bittersweet
(Celastrus orbiculatus) (Fig. 2), and multiflora rose (Rosa multiflora) (Fig. 3). The aggressive native was wild grape, also called riverbank grape (Vitis riparia) (Fig. 4).

All four of the invasive species are widely spread throughout the site (Fig. 5). The entire eastern border of the site, separating the clearcut from the adjacent field, is a mass of all four invasive species, with the dominant species for each segment highlighted by Figure 5. Altogether, invasive species cover at least 60% of the building site. The four species are in roughly equal proportion to each other. There are perhaps more rose plants, for example, but the grape covers a larger area of ground wherever it is found. Furthermore, the ground on the site was thoroughly seeded with berries from the oriental bittersweet and the Japanese barberry, suggesting that the seedbase of the site is largely invasive species.

DISCUSSION

Background of MacLeish invasives

Invasive plants species are clearly a significant problem on the proposed site for the Bechtel classroom, making the site a solid candidate for the Living Building Challenge requirements. The matter of sustainable and effective removal is therefore highly relevant. To better understand the problems posed by these invasive and aggressive species, though, it is useful to examine both their individual origins and histories in New England.

Japanese barberry

Japanese barberry was introduced to the United States from its native Japan in 1875 as an ornamental shrubbery in the Arnold Arboretum in Boston, MA, and has been cultivated in the United States as an ornamental plant ever since (Swearingen Japanese 2009). The plant was later promoted as a substitute for the native common barberry (Berberis vulgaris), which was
commonly used for hedgerows, dye, and jam before it was found to host the fungus causing black stem grain rust (Ibid). At the present, it is reported as invasive in twenty states, as well as the District of Columbia (Fig. 6).

True to its status as an invasive species, Japanese barberry is highly adaptable and has a large capability for dispersal. Japanese barberry reproduces prolifically by seed and a very efficient germinator, at a rate estimated to be as high as 90% (Swearingen Japanese 2009). The seeds are eaten and distributed by both birds and small mammals, and the plant can also spread via vegetative expansion, when the branches reach out and root themselves in a new patch of ground (Ibid). Barberry prefers full sun, but can grow and flower even in complete shade. The plant is also drought tolerant and can adapt to a variety of different habitats (Ibid). The plant has been found to raise soil pH levels where it has taken hold, as well as disturbing soil nitrogen levels and biological activity and reduce the depth of leaf litter in forests (Ibid).

Oriental bittersweet

Oriental bittersweet was introduced to New England from Eastern Asia in the 1860’s, also as an ornamental plant (Swearingen Oriental 2009). It too is still planted and cultivated intentionally, and is often found wild in areas near homesites from where it has escaped. The vine is reported as an invasive in 21 states, from New York to North Carolina (Fig. 7).

Oriental bittersweet is another prolific seed-producer, using multiples bird species to distribute its seeds (Swearingen Oriental 2009). It also can expand vegetatively, through root suckering (Ibid). The vines are highly aggressive and often strangle and smother existing vegetation, killing trees and plants through excessive shading and breakage, as well as adding to the risk of uprooting and blow-over during snowfall or high winds due to its increased weight on
the tree in question (Ibid). Oriental bittersweet is also outcompeting the native American bittersweet (*Celastrus scandens*), as well as displacing it via hybridization (Ibid).

*Multiflora rose*

Multiflora rose originates from Japan, Korea, and eastern China, and was introduced to New England in 1866 as rootstock for ornamental roses (Bergmann and Swearingen Multiflora 2009). Its distribution was encouraged beginning in the early 1930’s by national and statewide conservation groups for use as erosion control, “living fences” for livestock, and groundcover for pheasant, bobwhite quail, and cottontail rabbit (Ibid). It has also been used in highway median barriers as a crash barrier and to reduce headlight glare (Ibid). It was not until much more recently that its aggressive growth was identified as a problem, leading to the rose’s classification as an invasive species in 31 states today, spanning both coasts (Fig. 8).

Multiflora rose reproduces via seeds, which are transported mainly by birds, as well as utilizing vegetative expansion via arching branches taking root in the ground after the manner of the Japanese barberry (Bergmann and Swearingen Multiflora 2009). The rose is estimated to produce up to one million seeds per year, and these seeds can remain viable in the ground for up to twenty years (Ibid). The shrub has a wide tolerance for shade, light, and moisture conditions in the soil, and it expands rapidly to form dense and impenetrable thickets that exclude native species (Ibid).

*Wild grape*

As previously mentioned, the wild grape is actually a native species in New England. Due to the deleterious effect the grape has had on the other native plants at the Bechtel...
Environmental Classroom site, however, it will be referred to in the same “invasive” category as the other three species mentioned for the purposes of this study.

*Vitis riparia* is one of the most common species of wild grapevine, and is found naturally across North America from Quebec to Louisiana, as well as in Washington and Oregon (Fig 9). It is widely cultivated for its fruit, which is appreciated by both humans and animals, but due to its aggressive nature it has been classified as a weed in some states, and even as a noxious weed in Ohio (*Vitis* 2011). The seed spread root is slow, but the vine is also propagated by numerous other methods, including cuttings and bare roots (Ibid). Furthermore, the vines spread very quickly when untended, smothering trees and leading to potential blow-over and uprooting in the same manner as the oriental bittersweet. *Vitis* can tolerate soil pH’s from 6.1 to 8.5 and temperatures as low as -33 °F, as well as being moderately drought-tolerant and adapted to a range of soil textures (Ibid).

**Recommendations**

Two general approaches to management of these invasive species are proposed. The first is a highly sustainable biological approach, using goats to crop the invasive species on site. The second is a more traditional approach based mainly on the methods recommended by the New England Wild Flower Society, using a combination of low-impact herbicides and physical labor. It is probable that some combination of the two approaches will need to be used.

**Biological controls**

While relatively uncommon in Massachusetts, the use of goats to control weeds and invasive plants has become relatively widespread in Washington State where programs such as Rent-A-Ruminant have been running for years. Goats are touted as a weed control method for
their low environmental impact, low volume of noise, relatively cheap cost, speed of clearing, and effectiveness. Thorny plants, including multiflora rose, are some of their preferred foods, as the inside of their mouths are tough enough to render them essentially impervious to the thorns (Luginbuhl 1996). Goats also select for vines, including bittersweet, in their browsing habits (Ibid). Such tastes would suggest that they are ideally suited for clearing a site such as the one at the Bechtel Environmental Classroom.

Goats have been used effectively in a number of situations. In one example in the Seattle area, 60 goats took four days to completely clear a steep quarter-acre hillside of impenetrable brush, including thorny blackberries, as well as saving the project manager from $6000 to $9000 from what he would have had to pay a human removal company (McDonald 2007). In a North Carolina experimental plot, goats cleared an abandoned apple orchard of multiflora rose in four sessions, clearing this species selectively before others were attacked (Luginbuhl 1996). Another North Carolina study compared the effectiveness of goats versus chemicals in clearing kudzu from an infested area, and found the goats to be drastically more effective than were the chemicals (Fig. 10) (Spooner et al. 2004). The message is clear: goats are cheap, good at clearing the correct things, and effective.

The one difficulty in using goats at MacLeish is the source of the goats. The goat rental companies so ubiquitous in other locations are much rarer in Massachusetts. However, there are a few options. There is an Amherst company called Goat Girls that does explicitly rent out goats for the purpose of invasive species and irritants. Hampshire College also has goats as part of its farm center, and could be receptive to renting their animals out for invasive management. Finally, there are a number of goat farms throughout Massachusetts who could be contacted to inquire about goat rentals. There are multiple reports of various Massachusetts cities working out
a deal with a local goat farmer to browse the farmer’s goats on their invasive species plots, meaning that this source of ruminant labor should not be overlooked (Bray 2009, Littleton 2008).

Chemical and physical controls

To remove any plants that the goats leave behind or that spring back after grazing, there will likely be a need to resort to chemical and/or physical controls, albeit hopefully on a much smaller scale than would have existed without the use of goats. The New England Wild Flower Society (NEWFS) has a number of recommendations for non-biological control methods of invasive species. These fall under several main categories: pulling and digging, cutting and mowing, chemical treatments, and cut-stem treatment (Mattick 2009). NEWFS does not recommend mechanical treatments, as those generally result in the sort of disturbances in which invasive species thrive (Ibid).

Pulling is best performed in the spring when the soil is moist. Small specimens (woody stems less than 1" in diameter) may be pulled by hand, but a weed wrench should be used for stems up to 3" in diameter. If digging is to be utilized, the recommended method is to use a digging fork (Mattick 2009). Cutting and mowing work by removing most of the plant’s leafy green material, thus reducing the plant’s ability to photosynthesize. Plants should be re-cut or mowed every time they reach knee height or form buds. This process will have to be repeated three to four times a year for three to five years to be effective (Ibid).

All chemical treatments must be approached carefully, as even relatively sustainable herbicides have the risk of contaminating other plants and having harmful effects on animals. NEWFS does recommend using glyphosate and triclopyr, the active ingredients in Round Up and Brush-B-Gone respectively (Mattick 2009). These compounds are made up of non-toxic organic compounds that become toxic to plants upon combination, but then break down rapidly into
harmless organic compounds again in the soil (Ibid). The society also recommends mixing a dye into the treatment to track what has already been treated.

Cut-stem treatments involve spreading a solution of a chemical herbicide to a low cut woody stem of an invasive plant, ideally at least 1" in diameter (Mattrick 2009). The chemicals will be transported directly to the root system, killing the plant from the bottom up. The stems should be treated no more than two hours after cutting for the greatest effect (Ibid).

For the Japanese barberry, the society recommends a cut-stem application of 25% glyphosate in the late summer or fall. Physically pulling the plants and seedlings is also generally effective (Brumback et al. 2010). The oriental bittersweet is best attacked by a 25% solution of triclopyr to a cut stem, again in the late summer or early fall, although more established stands may require an earlier cut-stem application followed by spraying resprouts later in the season. The bittersweet may also be pulled when small, but the entire root must be removed for this method to be effective (Ibid). The best approach for the multiflora rose is to apply a 25% glyphosate solution to a cut stem in the late summer, although repeated cuttings three to six times per growing season for several years would also be effective. These too can be pulled in the spring; a weed wrench should be used for larger specimens (Ibid).

As the wild grape is not truly an invasive species, the NEWFS does not have specific recommendations for its removal. However, based on the information the society provides on the various proposed methods, some recommendations can be made. Small specimens are likely candidates for pulling, although care would have to be taken to remove all of the roots in this scenario. As with the other species in this study, a cut-stem treatment will likely be very effective. Either glyphosate or triclopyr should work on the grapevines; tests can be run to determine which of these is the most effective.
Acknowledgments

I would like to thank Professor Reid Bertone-Johnson, the manager of the MacLeish Field Station, for his help in framing this project and also assistance in plant identification, as well as Professor Smith for his guidance and suggestions throughout the project and seminar. It is my hope that this project will assist MacLeish in making their proposal for the Bechtel Environmental Classroom to the Living Building Challenge, as well as lead to future plans for invasive species management at the field station.
References


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Appendix of Figures

Figure 1: Japanese barberry (*Berberis thunbergii*). 1A) *Berberis* in autumn with berries (Mattrick et al. 2009). 1B) *Berberis* at MacLeish Field Station. Photo taken 20 April 2011. 1C) Close up on branch of *Berberis* clipped from MacLeish on 20 April 2011.

Figure 2: Oriental bittersweet (*Celastrus orbiculatus*). 2A) *Celastrus* in autumn with berries (Mattrick et al. 2009). 2B) Close up on *Celastrus* at MacLeish Field Station. Photo taken 20 April 2011.
Figure 3: Multiflora rose (*Rosa multiflora*). 3A) *Rosa* in bloom in the summer (Mattrick et al. 2009). 3B) *Rosa* at MacLeish Field Station. Photo taken 20 April 2011.

Figure 4: Wild grape (*Vitis riparia*). 4A) *Vitis* with fruit in early fall (http://www.nativehaunts.com/Vitis%20riparia.JPG). 4B) Close up of *Vitis* at MacLeish Field Station. Photo taken 20 April 2011. 4C) *Vitis* strangling native trees at MacLeish. Photo taken 22 April 2011.
Figure 5: A map of invasives located on and directly adjacent to the proposed building site for the Bechtel Environmental Classroom. Japanese barberry is represented by dark green, oriental bittersweet is represented by black, multiflora rose is represented by red, and wild grape is shown in light blue. The eastern edge of the site bordering the field is composed of a thick mass of all four invasives, with the dominant plant for each segment shown above.

Figure 6: Map of the spread of Japanese barberry (*Berberis thunbergii*) in the United States (Swearingen Japanese 2009).

Figure 7: Map of the spread of oriental bittersweet (*Celastrus orbiculatus*) in the United States (Swearingen Oriental 2009).
Figure 8: Map of the spread of multiflora rose (*Rosa multiflora*) in the United States (Bergmann and Swearingen 2009).

Figure 9: Map of the spread of wild grape (*Vitis riparia*) in North America (*Vitis* 2011).

Figure 10: A comparison of the effectiveness of goats versus chemicals in clearing an infested plot of kudzu (Spooner et al. 2004).