An exploration of the efficacy of manual removal of Japanese knotweed (*Fallopia japonica*) at Mount Pisgah in Winthrop, Maine.

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Introduction

Invasive species are a global threat to biodiversity. Many of these introduced plants lack natural control agents and are able to spread rapidly, compete with native species, and successfully sequester nutrients from the soil. In addition to affecting species richness, or the number of species in a given area, invasive plants may also affect soil chemistry (10). Consequently, invasives may decrease habitat quality for native fauna.

Japanese knotweed (*Fallopia japonica*) is considered to be one of the world's most challenging invasive species (2). Urgenson *et al.* found in a 2009 study that the richness and abundance of native understory species is inversely correlated with the density of knotweed (9). This pattern is exacerbated once the knotweed patch reaches a density of 57 ft^2 ($>5.3m^{-2}$) at which point it causes a 70% decrease in the density of native species (3). Additionally, the presence of knotweed impacts the ability of native species to effectively absorb nitrogen from the soil. Knotweed's ability to fix and store nutrients efficiently allows it to compete successfully with native plants. In addition to altering the natural environment, knotweed may also affect human infrastructure, since its powerful root system can damage the foundations of buildings and destroy the capacity of flood channels to hold water (7).

As the name suggests, this species is native to Asia. It was introduced to the United Kingdom in 1825 and to the United States soon after. (7). Knotweed, with its spade-shaped leaves and large rhizomes,[1] is one of the most rapidly spreading invaders in North America. In the century and a half after its introduction to the U.S., it has spread to thirty-nine states. Knotweed is tolerant of harsh environments and resilient to rhizome damage, making it an efficient colonizer.

The plants' rhizomes can reach 49-66 feet (7 to 20 m) in length and contain approximately two thirds of the plant's biomass (4). Knotweed is a prolific resprouter and can grow up to 6 inches (15 cm) a day (3). Two studies have focused on the resiliency of the species. In one case, knotweed grew through two inches of asphalt (7). In the other, knotweed sprouted from a depth of one meter of soil (4).

Despite its wide distribution and harmful ecological impacts, no successful removal method has been documented. A 2007 study found that the use of herbicides, even in combination with cutting, does not eradicate knotweed in the short term (3). Similarly, researchers who cut the plant three times in a season found this means of control to be ineffective (3). However, this lack of success was likely due to the fact that the amount of cutting in the growing season was insufficient to limit the photosynthetic ability of the plants and rhizomes were able to persist (7).

The current experiment explored the efficacy of a weekly cutting regime on knotweed at Kennebec Land Trust's Mount Pisgah Fire Tower conservation easement property in Winthrop, Maine.

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[1] A root system that grows horizontal to the ground and has lateral shoots.

Methods

The study site, at the base of Mount Pisgah, is part of a 950-acre conservation property that features a mixed hardwood-conifer forest. Cuttings occurred once a week from June 19 to August 14, 2017. This period was marked by lower than average rainfall (June: 2.04 inches [5.18 cm], with a historical average of 3.54 [9 cm]; July: 1.53 inches [3.89 cm], with a historical average of 3.43 [8.7122]). The mean monthly temperature was 65º F (18ºC) in June and 69ºF in July (8)[2].

Two study sites were selected, one on each side of the Tower Road path. The northern plot was 8.25 x 2.75 ft (2.5 m x 0.9 m). The western plot was approximately 60 x 32 ft (18.3 m x 9.8 m). Both were selected for proximity to the Tower Trail.

In order to efficiently remove the large stems that had sprouted since the beginning of the growing season, a brush saw and clippers were used. Following the initial cutting, smaller sprouts were pulled weekly by hand with a focus on maximizing rhizome removal when possible. Each week the new growth was manually removed by three individuals and the duration of the procedure was recorded. During this period, two weekly cuttings were skipped due to the presence of a hornet nest, which was removed using a permethrin-based insecticide.

To record weekly growth of the two study sites, photographs were taken prior to removal each week on a Fujifilm X-T10.

Results

Time spent cutting was used as a proxy for measuring sprout growth and density. The sprouts were the shortest and the least dense during the week of June 26, which was the week following the initial cutting. The sprouts showed the most growth during the week of July 3, when they required one hour and thirteen minutes of removal (Table 1). Cutting time decreased slightly from July 3 to July 31.

Week	Time spent cutting
June 19 & 20 (Initial cutting)	4 hours
June 26	25 minutes
July 3	1 hour 15 minutes
July 10	1 hour 5 minutes
July 17	N/A
July 24	45 minutes
July 31	50 minutes
August 7	N / A
August 14	1 hour 5 minutes*

Table 1. Time required for three individuals to manually remove Japanese knotweed (Fallopia japonica) *at Mount Pisgah in Winthrop, Maine, during the period from June 19, 2017, to August 14, 2017. Time is rounded to the nearest 5-minute interval. *Only two individuals were present for removal on this day.*

[2] Average temperatures and rainfall were calculated over three decades from 1981 to 2010.

Photos taken of each plot each week show little to no difference in the density of Japanese Knotweed over the course of the study period (Photoset 1).

*Photo set 1. Photos showing progress of Japanese knotweed (*Fallopia japonica*) removal at Mount Pisgah in Winthrop, Maine. A) North plot before cutting (June 29, 2017); B) South plot before cutting (June 29, 2017); C) North plot mid cutting (July 19, 2017); D) South plot mid cutting (July 19, 2017); E) North plot after final cutting (August 16, 2017); F) South plot final cutting (August 16, 2017).*

After the initial cutting on June 19, other species began to colonize the area. The largest of these is black willow (*Salix nigra*) which is an extremely successful and rapid colonizer. Understory plants include: Virginia creeper (*Parthenocissus quinquefolia*), red maple (*Acer rubrum*), and sugar maple (*Acer saccharum*). Herbacious plants surrounding the study site include: ragweed spp (*Ambrosia spp.*), goldenrod spp (*Solidago spp.*), jewelweed (*Impatiens capensis*), and jack in pulpit (*Arisaema triphyllum*). Trees which surround the study site and may colonize in the future are: American elm (*Ulmus americana*), grey birch (*Betula populifolia*), white birch (*Betula papyrifera*), white ash (*Fraxinus americana*), red oak (*Quercus rubrum*), and black cherry (*Prunus serotina*).

Discussion

While this study period was too brief to make a definitive determination of the success of this manual control technique, continuing to explore the efficacy of cutting could prove immensely valuable. Manual control, as compared to chemical control, is better for the health of both the landscape and the watershed, since it removes the risk of adding harmful chemicals to the environment. Among other effects, herbicides are known to impact aquatic ecosystems, contaminate groundwater, and kill non-resistant non-target plants, thus reducing genetic diversity (6,5,1). Additionally, employing a cutting-only control technique has been found to be a more effective long-term solution than other management strategies, including the use of herbicide (3). Offsetting these numerous benefits is the fact that the methodology is time-consuming. It required approximately an hour's worth of removal a week during the growing season for even a small plot of 60 x 32 ft (18.3 m x 9.8 m).

However, this investment of time and energy in knotweed control will yield numerous benefits for the local ecosystem. The removal of knotweed promotes plant diversity, since new species are able to colonize the area, and forage, and therefore the habitat is improved for local fauna. Also, making soil nutrients that would otherwise be sequestered by knotweed available to other species will promote ecosystem health (9). Finally, the removal of knotweed has aesthetic benefits, as visitors will enjoy the new biodiversity.

It will take years of work to control this species and reestablish the site's former biodiversity. Some studies have found that it takes at least three years of regular cutting during the growing season to eradicate a population of knotweed (7).

At the Mount Pisgah site, a possible extension of the existing gravel parking lot into the study site will likely control the sprouts as well as facilitate the mowing and cutting of any future growth.

Recommendations for future studies

In order to observe changes in a knotweed population more accurately, changes in density can be recorded weekly by counting the sprouts in a defined area. In addition, in order to prevent spreading of the existing population, cutting should be focused on the removal of individuals on the edge of the infestation.

More long-term changes can be made by introducing to the infested area native species that may be able to outcompete knotweed. Species chosen should be early colonizers that are able to thrive in sunny, nutrient-poor soils. Examples include birches (*Populus spp.*), dogwoods (*Swida spp.*), and *red* maple *(Acer rubrum)*.

It is important to create a persistent and thorough long-term management plan for Japanese knotweed, for it is through perseverance that the spread of this prolific invasive can be controlled.

Resources

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