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Comparison of Management Techniques for *Heracleum mantegazzianum* in North and Central Europe

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Introduction

Heracleum mantegazzianum, or giant hogweed, is an invasive plant with remarkable height and immense seed dispersal that allows it to invade a wide range of habitats. Giant hogweed was introduced to Europe as an ornamental plant; however, in the past 150 years its invasive behavior has allowed it to spread across natural riparian zones and forest edge habitats. The giant hogweed's rash-causing sap and its role in decreasing biodiversity, has induced the need to eradicate it. However, like most invasive species, it is not easily controlled because the plant is established in a wide area. The best way to control the noxious weed it to continuously manage invaded areas. Without continuous management on a local and regional level, giant hogweed will continue to invade new and previously invaded areas, causing a continuous cycle of management then reinvasion.

Biology

General characteristics

Heracleum mantegazzianum, or giant hogweed, is in the Apiaceae family (Pysek and Pysek, 1995). It is best known as the largest forb in Europe (Pysek and Pysek, 1995). Giant hogweed has been recorded to reach a height of 5.5 meters, while its leaves approach 3 meters wide (Figure 1), and its stalk can be up to 10 centimeters in diameter (Dodd, 1994). Giant hogweed can be easily identified by its beautiful white flowers that extend from umbels (Figure 2); each plant can have up to 60,000 flowers, allowing up to 120,000 seeds to be produced per plant (Dodd, 1994). A stand of giant hogweed can look like a dense forest with a large number of individual plants; however, because of its large size and massive number of flowers, a dense stand may only consist of three or four plants (Caffrey, 1999).

Figure 1. Umbel of a giant hogweed. Photo courtesy of King County Department of Natural Resources (http://dnr.metrokc.gov/wlr/LANDS/Weeds/hogweed.htm).

Figure 2. Giant hogweed at its mature height. Photo courtesy of King County Department of Natural Resources (http://dnr.metrokc.gov/wlr/LANDS/Weeds/hogweed.htm).

Life cycle

The giant hogweed is a monocarpic perennial (Pysek and Pysek, 1995). Its life span is only 3-4 years. In the first 2-3 years, the plant develops and in the final year it flowers.

Seeding in giant hogweed occurs in August. One study in the Czech Republic cited a 3.3 meter tall giant hogweed produced 107,984 seeds (Caffrey, 1999). Once seed is set they can lay dormant in the soil for up to 5 to 7 years (Andersen, 1994). Although a single giant hogweed produces thousands of seeds, few germinate to become seedlings. Caffrey (1999) approximates that less than 10% of seeds germinate to become seedlings the following year.

Seedlings emerge in February, two to three weeks after the first leaves of the previous year's plant emerge (Caffrey, 1999). Seedlings continue to appear throughout the growing season. During April, seedling density is at its peak. Throughout this period, seedlings are competing to survive against one another. By August, only a few hardy plants have survived the intense competition; between 1% to 23% of seedlings remain (Caffrey, 1994). Survival rate variation depends on the resources of the area and the number of seedlings initially produced. Caffrey (1999) studied the factors of why seedlings remained until August in two similar sites, Portmarnock and Mulkear, Ireland. At Portmarnock site, only 1.2% of the seedlings remained in August, where as in Mulkear the rate was 13.7% (Caffery, 1999). Caffrey suggested two reasons for the variation of survival rates. The major reason for variation was that Mulkear had a smaller peak density of seedlings so its seedlings had a better chance to live than at Portmarnock. However, he also contributed the higher disturbance of walkers to the low numbers of remaining seedlings in Portmarnock.

By September, plants are dormant until the following February. In the second year, giant hogweed elongates its taproots to better establish in the soil, increases stalk height, and increases leaf width. By mid- June, giant hogweed reaches its maximum growing capacity for the year; both leaves and stalk are approximately one meter in width and length, respectively (Caffrey, 1999).

After two winters giant hogweed flowers and seeds. The plant flowers in either the third or fourth year, depending on when the seedling sprouted. If a seedling is established late in the season, it will not flower until the fourth year, otherwise it will flower and seed the third year. Giant hogweed flowers between June and July. The plant produces two flower types- hermaphroditic from the terminal umbels and male from the lower satellite umbels. Having hermaphroditic flowers allows giant hogweed to reproduce asexually (Caffrey, 1999). After reproduction has occurred, seeds set in August, and the plant dies (Tiley and Philip, 1994).

Geography and Affected Ecosystems

Giant hogweed is native to northwestern Caucasus; a mountain range region in Russia (Pysek and Pysek, 1995). Western Caucasus is on the boundaries of moderate and warm climatic belts. In the northern part of Caucasus temperatures are usually below zero in the winter and can reach 20 degrees Celsius in June. Being an alpine region Caucasus temperature decreases by 0.5 degrees Celsius with every 100-meter increase (Noxious Weed Identification Page). Winds in Caucasus usually flow south; since giant hogweed is native to southern slopes, it is adapted to the windy and dry climate (Onipchenko, 1994). In Caucasus, giant hogweed appears in montane regions, in meadows, forest edges, and clearings (Pysek and Pysek, 1995).

Giant hogweed was introduced to northern and central Europe in the 1880s as an ornamental garden flower (Caffrey, 1994). Since the establishment of giant hogweed in Europe, the plant has invaded many types of ecosystem and widely increased its range. In Europe, giant hogweed has been recorded in Sweden, the Czech Republic, and the UK (Pysek, 1994). Pysek (1994) described the giant hogweed's European invasion in three main timetables: establishment in the 1940s, the 1940 to the 1960s, and the 1960 to the 1970s. In these three periods, giant hogweed has progressively become established in three different types of ecosystems: managed, riparian, and forest edge, meadows, and clearings.

In the first period, establishment in the mid-1800 to the 1940s, giant hogweed only occurred in national botanical and domestic gardens. During this time giant hogweed did not invade other ecosystems; this is due to the plants lowered ability to invade ecosystems while being managed by humans. Since the plant does not aggressively reproduce in areas that are managed (gardens, agriculture fields, and pastures), giant hogweed did not become a "noxious weed" until the 1940s (Pysek, 1994).

During the second period, the 1940 to the 1960s, the giant hogweed's range widened exponentially via rivers. Giant hogweed seeds can travel 10 to 50 meters (Caffrey, 1994) if wind transports them. However, in riparian zones, where water is the transport mechanism, the travel distance increases. Riverbanks are also great habitats for giant hogweed seedlings because there are few species along the river to compete against it (Pysek, 1994). In the 1940 to the 1960s,

giant hogweed depended on the river to increase its population size and range. By the 1960 and 1970s, populations were large enough in riparian zones that giant hogweed was no longer dependent on the rivers to transport seeds and increase population range. Since giant hogweed's range was stable in riparian areas, it had the capability to become established in terrestrial areas.

In the 1960 and 1970s, giant hogweed became established in areas similar to its native ecosystem: unmanaged forest edge, meadows, and clearings. During this phase, giant hogweed populations became "naturalized" (Pysek and Prach, 1994). These habitats provide ample sunlight to the shade-intolerant species (Pysek, 1994) and a soil pH similar to its native soils (pH 6.5-8.0) (Dodd, 1994). It was found that once giant hogweed populations do become established in terrestrial areas they actually prefer terrestrial areas to riparian zones. Pysek (1994) did a study in the Czech Republic, where he found that in 1950, 66.7% of giant hogweed was in riparian areas, but in 1990, only 36.4% of giant hogweed populations were in riparian zones.

The three periods of invasion are similar among all countries in Europe: establishment of giant hogweed in gardens, invasion of riparian zones, and the transition to invasion of forest edges, meadows, and clearings. Based on these patterns, it can be predicted that this invasion trend will continue in areas where the giant hogweed is newly introduced.

Impacts of Giant Hogweed

Loss of biodiversity

Giant hogweed's hearty characteristics, to include size and seed dispersal, helps it better compete for resources. Like other invasive species, this ultimately leads to the invasive plant acquiring a niche and decreasing biodiversity.

Giant hogweed's characteristic of light stress to surrounding vegetation is its most important factor in competition. Being the largest forb in central Europe, the giant hogweed's large leaves allows it to absorb most available light (Pysek, 1994). The surrounding plants receive little to no light and ultimately die. Giant hogweed is so successful that even its seedlings will not survive under its parent plant.

The second reason the plant is a good invader is its capability to become established in new areas. Giant hogweed seeds can usually only travel 10 to 50 meters away from the parent plant if wind dispersal is the medium (Caffrey, 1994). However, in riparian zones where water is the major transporter of seeds there is an increase in dispersal length. Once a seed establishes in the ground it can stay dormant for up to 7 years because of its rich and abundant food source (Andersen, 1994). With increase density of giant hogweed and the eradication of native plant, not only does biodiversity lower, but also the potential for soil erosion increases.

Erosion

In August, the giant hogweed loses its huge leaves keeping only the stalk. Since there are few other plants on these lands, it means the soil is left open and vulnerable to wind and water erosion (Dodd, 1994). Areas with steep inclines, such as riverbanks, are especially vulnerable.

In addition to competing for resources, soil erosion makes it is even harder for native plants to grow the following spring.

Human Safety Risks

Not only is the giant hogweed dangerous to biodiversity and possible erosion, but the plant is also dangerous to humans. The plant produces a sap that comes out when the stalk is cracked. The sap is made of a photosensitizing ingredient called furocoumarins (Caffrey, 1994). When it is exposed to the skin, it reacts with the sun's radiation and causes hyperpigmentation. This causes the skin to have an allergic reaction and break out into watery blisters (Caffrey, 1994). Cases have been reported of children getting blisters on their mouths and tongue because they used the stalk as a "spit wade dart" (Caffrey, 1994). Studies have also shown that grazers that eat these plants can get sores on their mouths and tongue, and that their appetites become impaired (Andrews, 1985).

Management Techniques

Chemical

Chemical treatment is the most used management tool against giant hogweed because it is highly effective. Currently the only two chemicals widely used for giant hogweed management are glyphosate and triclopyr. Glyphosate is considered the safest and only effective chemical treatment for giant hogweed in riparian zones. Triclopyr is largely used in grasslands and non-crop lands to control giant hogweed (Tiley and Philip, 1994).

When treating giant hogweed with chemicals, timing is critical. Chemical treatment should be put directly on the plant's leaves and be done no later than early June, with a follow up in July or August (Tiley and Philip, 1994). Spring treatment allows chemicals to be applied before the leaves come out (Caffrey, 1994). If herbicides are applied after leaves are out, then the smaller giant hogweed plants may not be treated because larger plants' leaves may shade them. (Caffrey, 1994). Second, spring treatment decreases the chance of the herbicide applicator technician getting sap on their skin because the plant is not as tall and full as it is in the summer.

Mechanical

The second technique, mechanical, is not as effective as chemical treatment, but if persistently done will stop both biomass and seed production. Mechanical control is achieved by manually cutting the plant down, which can be both time-consuming and dangerous. Mechanical mechanisms should be done in early summer before seed set (Dodd, 1994).

There are two methods for mechanically controlling giant hogweed: digging below the ground and cutting above the ground. The first option, is to dig out the entire root from the ground, this leaves no residual taproot thus prevents regeneration (Dodd, 1994). However, this option is time consuming and is only viable in small plots (Lundstrom and Darby, 1994). The second method is to cut giant hogweed above ground, leaving the roots intact. By leaving part of the taproot in

the ground, the auxiliary buds are still present in the soil and may produce new flower shoots capable of setting seed (Dodd, 1994).

Grazing

The last technique, grazing, is still being tested by Danish scientists (Andersen, 1994). To control giant hogweed using grazing, it is suggested to first cut the plant above ground and have sheep graze on the remaining vegetation. So far, studies have shown positive results in the management of giant hogweed. A study by Andersen (1994) showed that sheep effectively control giant hogweed populations after initial cut down (Andersen, 1994). In Andersen's study, he took seven plots, two of which were controls, and cut down giant hogweed (Andersen, 1994). He then placed sheep on the test plots to feed on the remaining vegetation. In the test plots, sheep heavily grazed giant hogweed, decreasing its abundance and increasing biodiversity (Andersen, 1994). By eliminating giant hogweed, bare soil was opened up allowing native species from adjacent fields and the seed bank to reestablish. In Andersen's study, an influx of annuals became established on the test plots. However, in the control plots (areas without grazing) there was regular regeneration of giant hogweed without native plant reestablishment (Andersen, 1994).

The spring following initial grazing, giant hogweed did reappear on test sites, but all were immature and unable to produce a new generation of seeds (Andersen, 1994). Although the study was still in process when the paper was published, the results of the study seem to show eradication of giant hogweed in the area using grazing techniques.

General management

Continuous management is the only way to stop giant hogweed regeneration. No matter what management technique is used or where it is used, the restored area needs to be consistently managed for at least seven years. This would stop regeneration from both seed bank and plants. If there is any lapse in the management system, giant hogweed could easily reestablish and its invasive properties would allow it to take over the entire restored area. Even after seven years sites can still be vulnerable, and measures should be taken to prevent giant hogweed reestablishment. Since giant hogweed does not do well in managed areas, it is suggested to establish gardens, agriculture, or grazing in areas previously invaded by giant hogweed. Adding hardy plants after chemical management is the best way to prevent erosion in riparian zones with steep slopes.

Evaluation of Management Techniques

Chemical

Chemical treatment has proven to be the most effective form of management of giant hogweed. In most studies, chemical treatment resulted in greater than 80% mortality, with a small reestablishment of giant hogweed the following growing season. In Caffrey's study (1994), four out of five sites had 100% mortality using glyphosate or triclopyr; while the fifth site experienced an 80% kill (Caffrey, 1994). Triclopyr showed leaf senescence after only 6 days

and within 4 to 5 weeks all giant hogweed vegetation was dead. Glyphosate effects were not as rapid but eventually had the same effectiveness as triclopyr. Glyphosate treatment resulted in senescence by the fourth to fifth week; but decay immediately followed. Although the effectiveness of the two chemicals was similar, sites with triclopyr treatment seemed to have less an adverse effect on the reestablishment of native plants. Within four week, native grasses were growing on triclopyr sites, where as no vegetation grew on sites with glyphosate control. The following growing season there was regrowth of giant hogweed for both chemicals. The regrowth was most likely from seeds in the seed bank, and chemical controls would not have prevented germination (Caffrey, 1994).

Mechanical

In Caffrey's study of management techniques (1994), previously discussed in the chemical section, mechanical techniques were also evaluated. However, unlike chemical treatment, mechanical treatment is not very effective. The study showed that there was only 5% to 10% mortality of giant hogweed. Caffrey concluded that regrowth from auxiliary buds was actually induced by cutting giant hogweed. Not only did plants reestablished new umbels in a week, but some were even capable of setting seed (Caffrey, 1994). If mechanical techniques are used, it is suggested that that below ground digging should be done to insure auxiliary buds are removed (Lundstrom and Darby, 1994).

Grazing

As discussed earlier, evaluation of grazing is still underway. Based on Andersen's study (1994), the treatment seems effective. In his study, grazing decreased giant hogweed abundance. This increased resources to allow native species to reestablish in the disturbed areas. Although there was success in Andersen's study, other studies like Andersen's still need to be done to ensure the effectiveness of grazing.

Conclusion

Giant hogweed has rapidly spread across north and central Europe the last 150 years. With its invasion to riparian zones and forested edges, the plant has become a menace. Local communities want giant hogweed eradicated because of its adverse characteristics. Giant hogweed, like most invasive plants, will continue to increase its range. The only way to stop if from taking over undisturbed areas is to start management programs on existing giant hogweed plots now. However, giant hogweed is frustrating to control because it rapidly invades new areas. The only way to control giant hogweed is continuous management to prevent regeneration from plants or seed banks. Management needs to be done on a region scale. Without eliminating all sources of the giant hogweed, this species could easily become reestablished, thus perpetuating the vicious cycle of invasion and management.

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