


Controlling Invasive Knotweed and Restoring Impacted Habitat on an Organic Farm in Western Washington State

Tests of two mechanical control methods, two herbicide mixes, and comments on an integrated strategy for control and restoration at Oxbow Farm & Conservation Center, Carnation, WA.

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8/18/21

Contents

Executive summary 3
Introduction 4
Methods 5
Foliar herbicide application 6
Repeated cutting 6
Cutting equipment 6
Covering 7
Results 7
Foliar herbicide application 7
Repeated cutting 8
Cutting equipment 9
Covering 10
Discussion 11
Herbicides and organic buffers 11
Repeated cutting 12
Cutting equipment 13
Covering 13
Acknowledgments 15
References 15

Executive summary

Invasive knotweeds, including itadori (aka Japanese) knotweed, hybrid (aka bohemian) knotweed, and giant knotweed, are ecologically and economically damaging species in the Pacific Northwest. As part of a 3-year project to control knotweeds and restore native streamside forests on our property, Oxbow Farm & Conservation Center and King County have tested several approaches to knotweed control and demonstrated how these approaches can be used as part of a holistic control and restoration strategy on an organic farm in western Washington.

King County Noxious Weed Control Program and Oxbow Farm & Conservation Center collaborated to test foliar application of two herbicide mixes (based on glyphosate and imazapyr herbicides, respectively) to control patches that were outside of and well-buffered from the organic-certified field areas. Annual surveys of test plots showed no significant differences in stem numbers, maximum height, or estimated biomass between these two herbicide treatments. Both herbicide mixes substantially reduced height, density, biomass, and footprint of knotweed stands. At year 4, some stands have been completely controlled, while others are approaching full control.

Oxbow Center staff also used 2 mechanical control methods (cutting and covering) in areas that were too close to organic-certified fields to use herbicides. Cutting was examined most closely with 3 replicates each of 4 cutting frequencies (3, 6, 9, and 12 times/season). Covering with woven polypropylene landscape fabric was tested in two larger stands.

Over the course of 3 growing seasons, cutting substantially reduced the height, density, and vigor of re-growth for test stands, particularly in plots cut 12 times per season (every two weeks during growing season, April to October). Increased cutting frequency significantly reduced 14-day regrowth (a proxy for root resource [carbohydrate] exhaustion), but complete eradication in these stands has not yet been achieved.

Oxbow staff and volunteers replanted native riparian trees and shrubs in and directly around knotweed patches as knotweed control progressed. Cutting Himalayan blackberry on the periphery of knotweed patches in March, before knotweed emergence was an effective way to improve access. Replanting worked well as an iterative process, beginning with grubbing blackberry roots and planting native plants in areas around knotweed patches, then beginning to plant into the original footprint of knotweed patches as knotweed stem density and height decreased sufficiently. As knotweed moves toward complete control, full density of native plantings can be established. In areas where covering treatments are applied, live-staking through fabric can jumpstart restoration, but requires additional maintenance to remove knotweed that emerges from live-stake holes. Live willow/dogwood stakes or poles are also important tools for re-establishing native cover on steep or often-flooded banks.

Control of knotweed on organic farms is possible, though challenging, and is facilitated by using multiple control approaches. Mechanical control methods are critical tools for controlling knotweed within organic-certified areas and their buffers. Glyphosate- or imazapyr-based herbicides can be much more cost-effective than mechanical methods and can be compatible with organic farm practices if sufficiently large and vegetated buffer areas can be maintained between invaded riparian areas and organic-certified field areas. Where sufficient buffer areas do not exist, cutting or covering can substantially reduce or eliminate at least small stands with repeated and diligent maintenance.

Introduction

Hybrid knotweed on the Snoqualmie River

Knotweeds, including Itadori knotweed (also known as Japanese knotweed, *Fallopia japonica*), hybrid (or bohemian knotweed, *Fallopia x bohemica*) and giant knotweed (*Fallopia sachalinensis*) are tall perennial plants with hollow bamboo-like stems and broad, heart-shaped or elongate-triangular leaves. These plants were introduced to Europe and North America in the 19th century (Del Tredici 2017, Grabar 2019) and have impacted biodiversity and ecosystem functions. Knotweeds are considered by some to be among the most pernicious invasive plants in the world (Global Invasive Species Database 2021, Lowe et al. 2000). Costs of knotweed control are estimated at 250 million dollars per year in Britain and 2 billion euros per year in Europe (Lavallée et al. 2019). Due to knotweed's negative impact on plant diversity and forest regeneration (Aguilera et al. 2010) and its likely role in increasing streambank erosion and sedimentation (Colleran et al. 2020, Mummigatti 2008), land managers in the Pacific Northwest consider it a major threat to aquatic systems and endangered salmon species (King County 2015). Substantial efforts are being made and resources expended to control these plants along rivers in western Washington using herbicide mixes based on glyphosate or imazapyr.

Manual and mechanical control methods, such as mowing, pulling, root-grubbing, or covering with landscape fabric, have been successfully integrated into some management efforts, but are relatively labor intensive and impractical for control of large stands. However, mechanical control of smaller stands is still a viable goal for landowners who wish to avoid herbicides, including organic-certified farms, where certification might be endangered by spraying on or near the certified areas. For some farms or landowners, a successful strategy might include a combination of careful chemical control (directed toward larger stands or portions of stands farther from certified fields) and manual/mechanical control of smaller stands or portions of stands that are closer to organic-certified areas. Continuing to identify the best methods for effective chemical and mechanical control is critical to improving outcomes for landowners seeking to control these plants.

Physical/mechanical control methods require consistent and dedicated efforts spanning several (3 to greater than 10) years. As with chemical control, the required duration of treatment before stands are successfully controlled appears to vary substantially, perhaps depending on factors such as soil fertility, the vigor and age of the targeted knotweed stands, and the knotweed species/taxon targeted. There is evidence, for example, that itadori (Japanese) knotweed is more capable of regeneration from rhizomes than giant knotweed, and that hybrid knotweed is more resilient to clipping than either giant or itadori knotweed (Clements et al. 2016).

The end goal of mechanical control methods is to deplete root carbohydrate reserves required for continued regrowth, eventually leading to failure of the plant to resprout. In one of the few experiments that directly observed root biomass, researchers at George Washington University grew itadori knotweed plants in containers and subjected the plants to various frequencies of stem-cutting, from 1 to 4 cuts/season. While a single cut per season had no significant effect on root biomass, three or four cuts produced substantial reductions in stored biomass by season's end (Seiger and Merchant 1997). The authors suggest that four or more cuts per season would be necessary to produce a net decrease in rhizome reserves annually. They also caution that the relationship between cutting frequency and belowground biomass may not be linear, and that complete eradication may not be possible through cutting due to the capacity of the plant to regenerate from small fragments of rhizome. Another study, based on modelling of rhizome growth and calibrated against mowing trials in the French Alps indicates that over a decade of mowing would be needed to eradicate even small knotweed stands. The best-case scenario from this study suggests it requires 11 years of mowing with a frequency of 15 times a year to eradicate a population 60 m^2 (646 ft^2) in area (Lavallée et al. 2019). Covering knotweed with geotextile fabrics is another approach that may be effective in certain situations (King County 2015), though other practitioners warn that complete control may only be achieved after many years, if at all (Munger 2019, Soll 2004).

Despite this evidence for long-term resilience of knotweed in the face of mechanical treatment, some managers in the United States have reported success in controlling small knotweed stands with mowing or cutting once monthly over approximately 3 years (17 cuttings total) or by grubbing out roots once per year (in autumn), each over 3 consecutive years (McHugh 2006). In general, less frequent cutting or grubbing strategies appear to produce very slow reduction of knotweed patches, if any. Replicated control trials on the Bronx River in New York involving either 3 monthly cuttings (repeated over 3 years) or a single spring cutting followed by grubbing down to 15 cm depth produced modest reductions in knotweed cover (-44% over 2 years) and, in some plots, increased stem density (Haight, 2017). Experimental treatments in Belgium showed that both herbicide and physical methods held promise for control (Delbart et al. 2012). This Belgian study concluded that either monthly cutting or monthly cutting coupled with willow planting led to substantial (79-99.7%) reductions in stem volume after a single year of treatment. This was comparable to the effectiveness of several of the herbicide treatments tested, including the most effective chemical treatments (which were injected or foliar application of glyphosate). In contrast, a single summer cutting actually led to increased density and height of stems.

In most cases, control of knotweed is a necessary step to the final goal of re-establishing desired vegetation at control sites. Active restoration of desired vegetation is an important consideration as part of an ecological restoration approach (Clements et al. 2016) and can assist in suppression of knotweed during the control process (Skinner et al. 2012). The importance of active replanting depends in part on the landscape position of the treatment sites. While knotweed control areas on 2^{nd} or 3^{rd} order streams in the Pacific Northwest may recover native-dominated vegetation passively due to connectivity with surrounding native forest, sites on larger (4^{th} order or larger) rivers, where agricultural and other human land uses are more predominant, may need active restoration to guide sites away from continued invasion and toward diverse native vegetation (Claeson and Bisson 2013).

Methods

In 2017 Oxbow Farm & Conservation Center, in collaboration with King County Noxious Weed Control Program (with funding from King County Flood Control District/WRIA 7) began testing several chemical and mechanical control methods to provide more information on the degree of effort and duration of treatment required for full control. Methods assessed were:

1) Foliar spray with 1-5% glyphosate (once annually)
2) Foliar spray with 1% Imazapyr (once annually)

3) Cutting, 12x per season (2x per month, April – October)
4) Cutting, 9x per season
5) Cutting 6x per season
6) Cutting 3x per season
7) Covering

In addition to knotweed control, restoring healthy native riparian vegetation in and around knotweed-impacted areas was (and continues to be) an essential part of Oxbow's property-wide knotweed strategy.

Foliar herbicide application

Foliar spray, either glyphosate-based (5% Aquaneat) or imazapyr-based (1% Polaris), was applied with a vegetable oil adjuvant by King County Noxious Weed Control Program staff annually from summer 2017 to 2021. Foliar spray applications were assessed by annual measurement of stem height, maximum diameter, and density in 10 circular 5m^2 plots (N=5/per treatment).

Foliar herbicide application

Repeated cutting

A repeated-cutting plot, with uncut knotweed behind

Oxbow Farm & Conservation Center staff applied four cutting treatments to knotweed within (and immediately surrounding) 5m^2 plots at Oxbow and neighboring Carnation Farms. The treatments represented 4 cutting frequencies: 3, 6, 9, or 12 cuttings per growing season between approximately April 30 to October 15, with 3 replicate monitoring plots per treatment. The impact of cutting treatments on knotweed stands was assessed by measuring height, stem density, and wet biomass accrued over 14-day periods (for most frequent cutting treatment) in 5m^2 plots (N=3 per treatment). Biomass regrowth over a 14-day period after the first spring cutting was used as an indicator of remaining availability of carbohydrate reserves after the previous year's treatments.

Cutting equipment

String-trimmer-mounted cutting heads are convenient for some knotweed cutting treatments but can throw fragments and thereby spread infestations. We measured distances and weights of fragments thrown by two different styles of cutting heads on a FS240 Stihl trimmer: 1) standard monofilament nylon string trimmer line and 2) a Stihl hedge-trimmer attachment. Each cutting attachment was used to cut through 10 mature (~7' height) hybrid knotweed stems held erect over a tarped area to capture fragments.

Testing fragment spread from cutting equipment

Covering

In 2 areas, each covering approximately 1000-2000 ft^2, knotweed was cut to the ground and covered with woven polypropylene landscape fabric (WSF 200, ACF West, Woodinville, WA), which was secured with wooden stakes and weighed with large rocks. In one of the areas, willow and cottonwood live stakes were installed through the fabric to provide additional shading and to begin restoration of native riparian vegetation.

Weighing down fabric at a covering site

Restoration and replanting

Oxbow's restoration and replanting strategy focused on establishing native vegetation first around knotweed patches as treatment was initiated (years 2, 3, and 4 of chemical treatment), then moved to planting within controlled patches as height and stem density became suitable for spot-spraying (mostly year 4).

Restoration planting peripheral to knotweed patch

Approximately 3,000 native plants were installed over 3 years and 1.7 acres spread along 2500 linear feet of riverbank. The timing of blackberry removal and replanting of native trees was influenced by the pace and success of knotweed control efforts in each area. Plantings in grass or in incompletely controlled knotweed patches were fitted with plant-protection tubes to shield them from accidental string-trimmer injuries and herbicide overspray.

Results

Foliar herbicide application

Over the course of 4 years of treatment (2017-2021), average knotweed percent cover was reduced from 100% to 8.2% (Fig. 1). From 2018 to 2021 density reduced from 78.5 to 22.0 stems per 5m^2 plot. Canopy height (average height of tallest 5 canes) was reduced from 11.0 to 2.1 feet. In one out of the 10 monitoring plots, knotweed was eradicated after the 2nd year of treatment, and a second plot had only a single stem after a third treatment year.

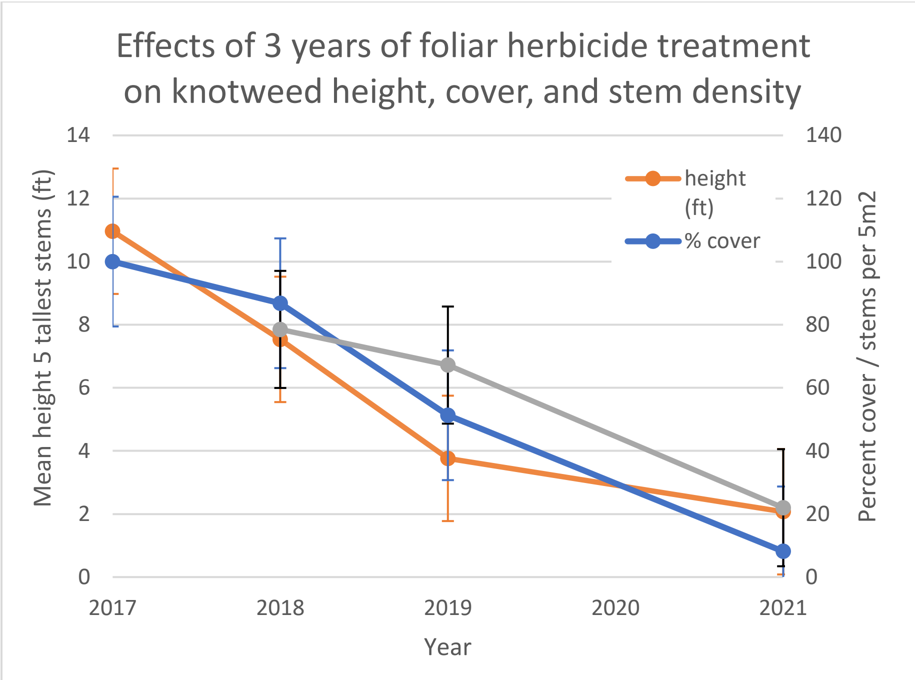

Figure 1: Effects of 3 years of foliar herbicide treatment on knotweed height, cover, and stem density

We did not see statistically significant differences in efficacy (as measured by stem density or height) between Imazapyr-based and glyphosate-based foliar herbicide mixes (N=5 for each) after 2 or 4 seasons (Student's t, $p>0.26$). Stem density was widely variable after both treatments, as some knotweed rootstocks resprouted thickly with epinastic growth and others did not. Both treatments led to significantly reduced height, density, and estimated biomass (Student's t, $p<0.025$).

Effort

Herbicide applicators in the Pacific Northwest have reported time expenditures of 2.8 staff-hours/acre (**0.06 hours per 1000 ft^2 per year**) for foliar treatment of knotweed (McClure 2014).

Repeated cutting

Capacity for spring regrowth, measured over a 14-day period after the first spring cutting, showed a strong negative relationship with the number of cutting treatments applied the year before (Fig. 2, $R^2=0.87$). Plots with more frequent cutting treatments showed decreased capacity for resprouting the following year. By the beginning of year 3, the capacity for spring regrowth (over 14 days) was 5% (125 ± 137g) of regrowth in previously uncut plots (2437 ± 811g). In 2021, Elk movement along the transect of plots with 3, 6, and 9x cutting frequencies may have had some influence on regrowth through trampling. 12x frequency plots were not impacted by elk.

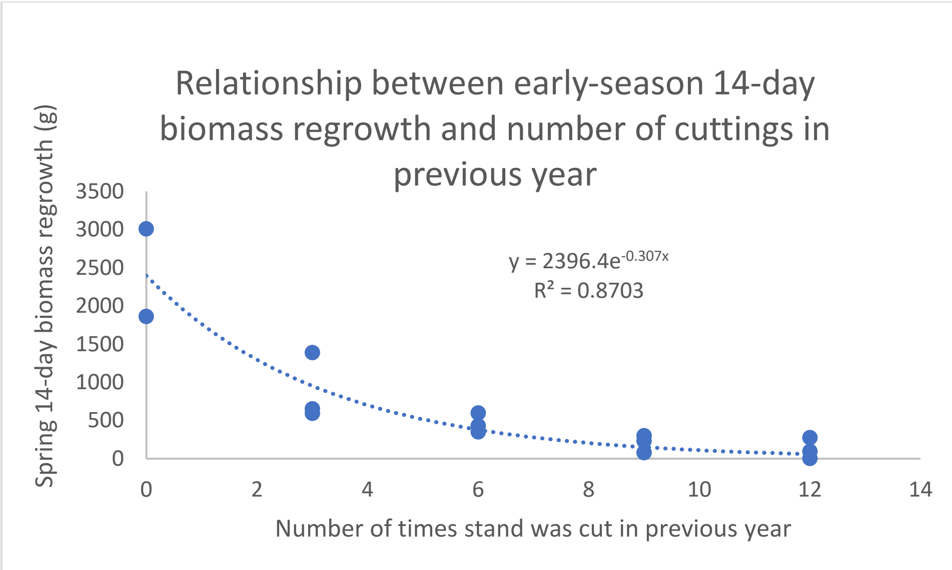

Figure 2: Relationship between early-season 14-day biomass regrowth and number of cuttings in previous year

Effort

Cutting with a hedge-trimmer blade took 20-45 minutes per 1000 ft^2, plus time to gather materials and access site. Annual time expenditure for maintaining cutting treatments was approximately **9 hours per 1000 ft^2 per year**. (Labor for collecting biomass and other measurements for these experimental data are not included in that estimate). Larger-scale mowing equipment and even string-trimmer machinery with a nylon string head could decrease this time, but at the risk of spreading fragments greater distances. Note that these estimates of effort do not include travel time.

Cutting equipment

In our single trial, the standard heavy-duty nylon line attachment for the FS240 Stihl brush cutter ("string trimmer head") threw a substantially greater number and mass (128 g) of stem fragments up to 15.8 feet from the cutting location (Fig. 3). The hedge-trimmer attachment threw fewer, smaller fragments (12 g) to a maximum of 5.0 feet.

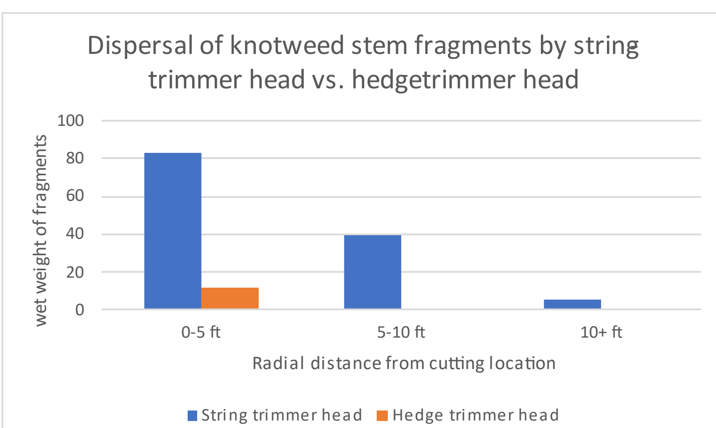

Figure 3: Dispersal of knotweed stem fragments by string trimmer head vs. hedge trimmer head

Covering

Covering knotweed with landscape fabric was promising in several ways:

1. The approach substantially reduced regrowth of knotweed over the 2 years of observation
2. The approach reduced maintenance time and travel time as compared to repeated cutting treatments (which must be done very frequently to be successful).
3. Covering field-side portions of larger stands served to increase the required buffer zone between chemically-treated knotweed areas and organic-certified fields in cases when portions of knotweed stands were too close to fields to treat them with herbicide.
4. Live stakes (or other plantings) could be installed through fabric while maintaining some level of non-chemical knotweed control. (Simultaneous establishment of native plants and control of knotweed would be extremely difficult using a cutting/mowing approach).

Covering treatments also posed limitations and challenges:

1. Sprouts continue to come up on margins and through punctures in fabric (including planting holes).
1. Live staking increases the numbers of holes for re-emergence
2. Because control is achieved very slowly by this method and removing the fabric is labor-intensive, it is difficult to assess when control is complete and fabric should be removed
3. Flood waters can pull up or bury fabric under sediment. Layers of sediment on fabric allow stems that push through to root into the sediment above fabric, making maintenance removal more difficult.

Effort

Knocking down and installing fabric over knotweed required approximately 4-7 person-hours per 1000 ft^2, and maintenance through hand-pulling at puncture points and cutting around edges has required about 4 hours per year per 1000 ft^2, for a total expenditure of **5-8 hours per 1,000 ft^2 per year** (spreading installation hours over 4 years of treatment). As noted before, these effort estimates do not include travel time. Furthermore, this estimate applies to a covering site where the fabric is compromised by planting-holes which would require more maintenance than a cover site where the fabric was not punctured. Woven polypropylene ground (geotextile) fabric can be purchased at about $70/1000 ft^2.

Restoration and replanting

Blackberry removal around knotweed patches facilitated access. Native plantings were largely successfully established (~90% survival). Live stakes were installed primarily on steep, moist banks where digging would cause destabilization of banks and/or knotweed rhizome systems. Some of the sandier, more well-drained mid-bank staking areas had lower live-stake survivorship (~50%) due to rapid drying of sandy surface soils. Stakes and poles on low benches appeared to have higher survival rates, though these were not assessed quantitatively.

There appear to have been some cases of off-target herbicide damage where plants were interplanted with persistent knotweed patches, but these were relatively infrequent.

Discussion

Integrating chemical and mechanical control methods

Both herbicide and mechanical control methods were able to substantially reduce knotweed cover, biomass, and capacity for regrowth over 3 seasons at Oxbow and Carnation Farm sites in the Snoqualmie Valley. Mechanical treatments are labor intensive, require multiple maintenance visits per year, and are therefore mostly feasible only for small stands that require relatively little travel per visit. They are, however, necessary parts of a whole-property strategy on organic farms or other places where the use of herbicide is limited. At Oxbow, we have used mechanical methods to treat:

1. Small, isolated stands that are easily accessible or that are within the organic-certified farm field area and buffer
2. Portions of larger stands that are within the organic-certified area and buffer. Fabric cover in these areas created a sufficient buffer for other portions of the stand to be treated with herbicides

Herbicides are much more cost effective and feasible for large stands outside of organic-certified areas and buffers. Treatment near streams and wetlands should be done by professionals holding relevant pesticide licenses (WSDA pesticide applicator license in Washington) and NPDES (National Pollutant Discharge Elimination System) permits for treatment near aquatic systems.

Working with herbicide applicators at an organic farm requires clear demarcation of mechanical treatment areas and clear and detailed communication with the applicators to avoid accidental application within the organic-certified areas and buffers.

Herbicides and organic buffers

From an organic certification perspective, it is important to leave a buffer between organically certified crop fields and non-organic-certified pesticides if they are to be applied for knotweed control. This buffer is evaluated in conversation between a farmer and their organic certification inspectors. The effectiveness of the buffer may be evaluated by several attributes (Coleman, 2012; Erin Coyle, pers comm.):

1) Distance over which any overspray/drift can dissipate. 25' or 50' are often-cited rules-of-thumb, but the acceptable distance is affected by many other factors, below (Erin Coyle, Pers Comm).
2) The presence of barriers to drift or overspray (such as a slope, trees, shrubs, buildings, etc.). Substantial vegetation between application and organic areas helps a buffer to be more effective.
3) The mode of application. Application through injection, hand application, or large-droplet sprays may reduce the potential for unintended spread of pesticides.

Mechanical treatments, such as cutting or covering, can help to create sufficient buffer space when knotweed grows near organic-certified areas (Fig. 4, and see section on "covering" below).

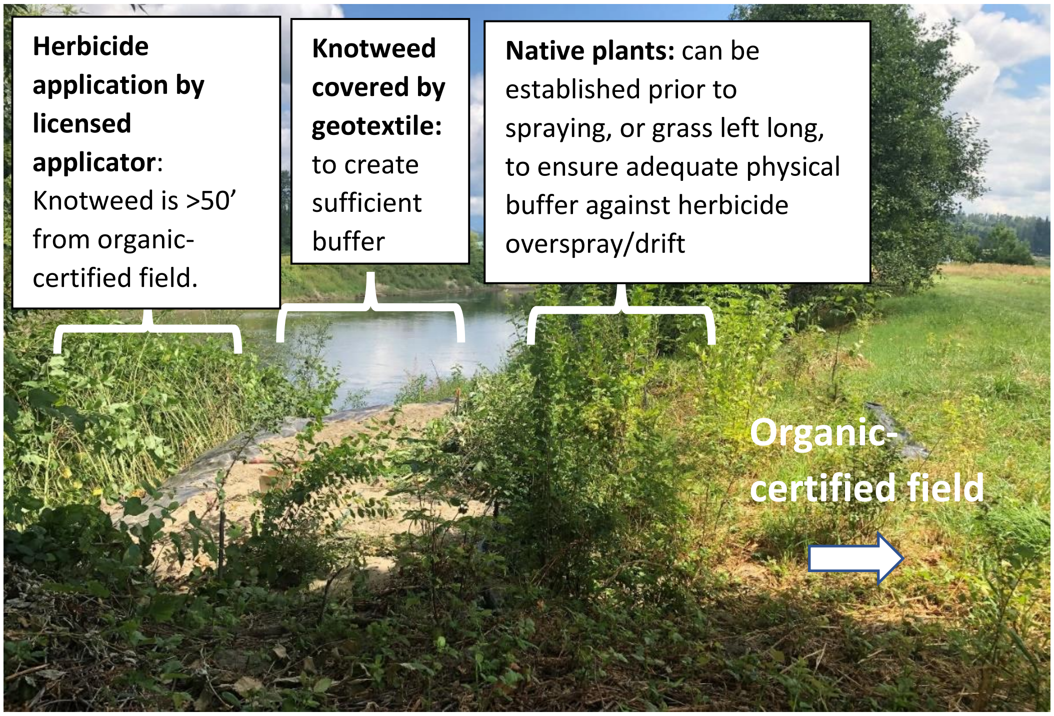

Figure 4: Example of using fabric covering to help create sufficient herbicide buffer width

Foliar herbicide application monitoring

Our monitoring suggests that either 1% imazapyr or 5% glyphosate are effective in knotweed control, causing substantial reductions in cover, height, and estimated biomass. This study was limited by a small number of monitoring plots, and it is possible that a larger number of comparison plots might elucidate more subtle differences in effectiveness between these treatments. That it required 4 years of treatment to achieve ~90% decrease in cover at Oxbow supports other observations that several years of treatment are often necessary for complete control, though in some circumstances knotweed can be controlled more quickly (pers. comm. Justin Brooks).

Poor accessibility can substantially slow treatment efforts where topography is challenging or surrounding and intermingled vegetation hampers movement. Establishing clear access to all knotweed in an area will lead to a more successful treatment

Repeated cutting

Cutting treatments may be a useful part of a long-term knotweed control plan on an organic farm, although at Oxbow we were not able to demonstrate complete control of knotweed patches by cutting during this 3-year project. Nevertheless our observations indicate that these points are critical to keep in mind:

1) **Cutting must be diligently kept up at least twice a month** from April to October for 3 or more years. Therefore, this approach is best for sites where travel time to the target stand is minimal or where mowing can be done as part of a regular management regime). Additionally, cut stems

must be bagged and landfilled or dried when there is any chance of flooding or other mechanisms moving/spreading cut canes.

2) **Be sure you can budget time for this approach**, as twice-monthly hedge-trimming takes approximately 9 person-hours/year/1000 ft^2, substantially more than herbicide application. This could be much reduced if large mowing equipment can safely be used at the site (and cleaned to avoid spreading fragments).
3) **Be sure the equipment used does not cause fragments to be thrown into waterways** (see “cutting equipment” below).
4) **Dispose of cut stems carefully.** If there is no danger of flooding or fragments moving to re-establish elsewhere, canes can be dried at the treatment site until completely brittle and allowed to compost onsite. Crushing/stomping facilitates drying and decomposition.

Cutting is best used for small stands (especially those that are too close to organic-certified fields to safely spray) and patches that are easily incorporated into an existing mowing regime.

Cutting equipment

Hedge-trimmers or hedge-trimmer attachments for brush cutting equipment cut knotweed somewhat slowly than some other attachments but throw fewer and smaller fragments a shorter distance (<5’) than standard nylon string attachments, which cut knotweed relatively efficiently but throw more fragments further (> 15’) from the cutting area. If using hand-held brush cutter/string trimmer equipment near open water or vulnerable wet soils where fragments may root and establish, it is advisable to use a hedge-trimmer attachment for cutting.

Larger mowing equipment may cut still more rapidly, but it is important to consider the risk of spreading fragments and establishing new invasions with such equipment, either through throwing fragments or by moving fragments that may adhere to the wheels or mowing decks of the mowing equipment. Mowing equipment wheels and cutting decks should be cleaned and inspected after using mowers to control knotweed.

Covering

Our observations of covering treatments at Oxbow (based on 2 years of work) suggests that covering small stands with woven polypropylene landscape fabric can work as part of a larger knotweed control strategy, especially following these guidelines:

1. **Weigh down, not stake, if possible**. Punctures in the fabric, even small ones, allow knotweed sprouts to grow through and maintain rhizome reserves. Use heavy rocks and corner-tucking to weigh down fabric (in lieu of staking) where possible. Do not pull fabric tight, as knotweed may more easily puncture and re-emerge.
2. **Maintain regularly.** Knotweed will continue to resprout beneath, around, and through holes in fabric. Continued (~monthly) pulling and crushing (stomping) stems beneath the fabric or seasonal spot-spraying are necessary to continue to starve rhizome reserves and maintain the integrity of the cover.
3. **Areas of flooding require extra maintenance and stabilization**. Flooding poses challenges to covering treatments. If treatments are to be applied in floodplains, extra rock, stakes, and

maintenance will be required to keep the treatment stable. If sites can only be visited on the order of once a season, covering may not be a viable option where there is active flooding.

In our experience, the advantages of the fabric cover approach are that it **allows for less frequent maintenance visits** and lower maintenance effort than repeated cutting, it **can be used to control portions of stands too close to organic fields** to treat chemically (creating a buffer area after coverage), and it **allows for simultaneous establishment of native plants** (especially live stakes) while undertaking knotweed control.

Restoration and replanting

After 4 years of treatment and 3 years of measurement and restoration, installed plantings are increasing their cover and height, which literature and ecological theory suggests will reduce the chance of re-invasion or resurgence of knotweed where it is being controlled (though we have not been able to test this quantitatively as part of this project).

Oxbow staff have not yet been able to evaluate whether shade from live-staking in fabric treatment areas has increased efficacy or speed of knotweed control over the longer-term, but in the short term it has required some additional maintenance as knotweed sprouted through live stake holes. If replanting is attempted in fabric over knotweed, consider that live stakes require a smaller hole (as compared to container or bare root plantings) and therefore create less opportunities for knotweed re-emergence.

Some of the knotweed treatment areas have not yet reached the level of control where we have felt comfortable planting within the densest knotweed areas. These areas will be planted in future years as knotweed density and vigor continues to be reduced.

Other observations on restoring recent and ongoing knotweed control areas:

- **Late winter/early spring (March) mowing** can allow better access for herbicide or other treatments where knotweed and Himalayan blackberry are intermixed.
- **Herbicide treatment can make sites vulnerable to establishment of other ruderal/invasive species.**
    - This seems especially true of imazapyr, which remains active in the soil longer than glyphosate.
    - In our experience, common colonizers are: Canada thistle (*Cirsium arvense*), tansy ragwort (*Senecio jacobaea*), touch-me-not (*Impatiens capensis*), and Himalayan blackberry. Ongoing weed-removal is often necessary where knotweed has been sprayed, and establishing native plants can help (see below).
- **Replanting knotweed-control areas is best viewed as a long-term and iterative process**.
    - <u>Native plants may be established early-on in degraded areas surrounding knotweed patches</u>, decreasing chances that knotweed will spread, impeding the colonization and spread of new weeds, and helping to stabilize soil as knotweed rhizomes die back.
    - <u>Later, native plants may be established within dwindling knotweed stands</u> (after 1-3 years of herbicide treatment, when knotweed canopy is thin enough not to compete with seedlings and widely spread enough to allow for herbicide application without hitting plantings).

    - These initial plantings will help shade out remaining knotweed and stabilize soil, though some herbicide mortality may occur.
    - Fitting plants with plastic seedling protectors ("blue tubes") can help herbicide applicators avoid off-target damage by both increasing seedlings' visibility and physically shielding seedlings from spray.
  - Follow-up plantings may be necessary to fill gaps from herbicide mortality or where knotweed clumps precluded planting in previous years.
  - If attempting control through mowing, seeding mowed areas with grasses after a few mowings may stabilize soil and compete with resprouting knotweed.
- **Carefully choosing plant materials and planting stock is important** for restoring the many landscape positions where knotweed occurs.
  - Container stock can often be acquired earlier in the season and therefore planted before low areas become inaccessible due to flooding. Bare root stock is cost-effective and easier to transport. Live stakes are useful for staking steep banks where digging planting holes would compromise bank stability, disrupt rhizomes, and increase permitting complexity.
  - Larger willow and cottonwood poles (6-8' cuttings) can be used in low bank areas where surface soils become too dry to establish shorter live stakes. Setting poles 3'+ depth may allow these cuttings to access deeper soil moisture and grow successfully.

Acknowledgments

This work was funded by King County Flood Control District through a Cooperative Watershed Management Grant administered by the Snoqualmie Watershed Forum/WRIA 7 (Grant number 4.7.18.008). We are also deeply grateful for the continuing assistance from King County Noxious Weed Control Program, who carried out all herbicide applications associated with this work. Thanks also to Carnation Farms for generously partnering on this and providing access and permissions to study knotweed on their property.

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