STATEWIDE KNOTWEED CONTROL PROGRAM

2017 Progress Report

Washington State Department of Agriculture

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Cover Photo: knotweed infestation on Skagit River, the largest and most biologically important river draining to Puget Sound, in Skagit County, Washington (WSDA).

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Executive Summary

The Washington State Department of Agriculture (WSDA) Knotweed Control Program is a key component of the intergovernmental effort to protect and restore watersheds in Washington State. Knotweed includes four closely related noxious weeds that invade riparian corridors and displace native vegetation. This program provides funding, coordination, specialized equipment, and field expertise to invasive knotweed control projects. The program works with tribal governments, local governments, non-governmental organizations, and other state agencies. The program supports green jobs, benefiting the environment and economy of Washington.

WSDA works with groups throughout Washington to identify knotweed infestations, develop control projects, and secure grant funding. In order to minimize duplication of effort, WSDA fulfills state-level environmental review requirements, coordinates Federal Clean Water Act permit compliance, provides public notification, produces educational materials and publishes required notices.

WSDA has received approximately $7.5 million for knotweed control since 2004. State funding allows program cooperators to secure additional resources that require state-origin matching funds. For the 2017-2019 biennium the WSDA Knotweed Control Program budget is $950,484, which allows for the support of project activities in watersheds of 20 counties.

For the 2017-2019 biennium cooperators submitted to WSDA, 29 proposals requesting a total of almost $1.4 million. WSDA furnished support to 24 of these projects and one biological control development project, providing a total of $623,000 for agreements and contracts. In 2017, over 285 solid acres of knotweed were treated with integrated pest management techniques, and project work occurred in nearly 840 river miles. These projects assisted more than 5,300 landowners.

WSDA will continue to support knotweed control as program funding allows. Elimination of control projects would jeopardize ongoing watershed and salmon habitat restoration efforts. In contrast, knotweed projects that have received stable funding have shown a vast decrease in knotweed presence.

Introduction

This is a progress report for the Washington State Department of Agriculture's Statewide Knotweed Control Program. This report describes the program framework, survey methods, treatment methods, project selection process, budget for the 2017-2019 biennium, and results for calendar year 2017.

The results are divided into a programmatic summary to describe the general activity level of program cooperators, and monitoring results that describe the changes at infested sites. Three program measures are used to describe the activity level of program cooperators.

- *Solid Acres Treated* = A measure of how many acres a dispersed population would occupy if all knotweed plants were grouped together.
- *River Miles* = Total amount of river miles within project area(s) receiving any survey, treatment, and /or monitoring activities. River miles are measured once down the middle, not both shorelines.
- *Landowners Assisted* = Number of landowners receiving survey, treatment, and /or monitoring activities within project area(s).

Analyzing the total acreage surveyed, monitored, or treated by program cooperators on an annual basis is a reasonable method to describe the amount of area affected by knotweed, but is not a precise way to detect the change that occurs within infested sites following herbicide applications. For a better understanding, monitoring plots were used to detect the within-site change of knotweed populations following annual treatment activities. Results show that knotweed populations persisting in project areas have fewer stems per acre and exhibit reduced stem height, stem diameter, and overall vigor. This has lead to native plants, including tree and shrub species, reestablishing in areas where they had previously been displaced by knotweed.

After treatment, follow-up activities at project sites are important. If left untreated, there is evidence that the small amount of live knotweed present at treatment sites can return to the original infestation level in as little as three seasons, eventually surpassing the infestation level present prior to any investments in knotweed control. This would result in the loss of progress toward long-term knotweed control, increased future control costs, degradation of environmental quality, and the alteration of the sustainable ecological services of invaded sites.

The Problem

The invasive knotweeds are non-native plants that have been introduced to Washington State without the factors that keep their populations under control in their native range. Knotweed alters riparian vegetation communities, disrupts nutrient cycling, negates riparian restoration efforts, negatively affects the recreational use of watercourses, and decreases property values. Knotweed has been reported in all 39 counties of Washington State. These plants are pioneer species that quickly colonize disturbed areas. Once knotweed becomes established, it is very difficult to remove, and single patches can persist for more than 100 years.

In the Pacific Northwest, knotweed spreads when roots and stems are moved by natural means or human activities. Human activities include moving soil that contains knotweed plant material, mowing or cutting knotweed, or discarding knotweed plant material in vulnerable habitats.

Figure 1. Gravel bar in the Washougal River during summer flow (left) and winter flow (right) levels.

Figure 2. Knotweed plants sprouting from plant fragments deposited by flood water.

In river corridors, knotweed reproduces from fragments and seeds that travel downstream, affecting the gravel bars and riparian forests of entire river systems. Figure 1 shows natural flooding of a knotweed-infested gravel bar. This site served as a source for new infestations as knotweed stem and root fragments were transported downstream by the flowing water. Root and stem fragments as small as one inch can produce a new plant. As a result, one patch can be the source of many downstream populations.

Figure 2 shows knotweed sprouting from fragments deposited by floodwaters in the Skagit River valley. If left untreated, these small plants will form multi-stemmed patches. When these patches coalesce, they exclude all other vegetation. Figure 3 shows a knotweed-infested watershed in Pacific County.

Knotweed had displaced most of the understory plants at this site and occupied any opening created by natural disturbance.

Figure 3. Watershed in Pacific County infested by Bohemian knotweed.

Riparian areas are transitional habitats located between terrestrial and aquatic ecosystems such as lakes or rivers. Riparian areas provide shade, nutrients, and large woody debris to both aquatic and terrestrial ecosystems. Over time, riparian areas that are occupied by early-successional native species such as alder, willow, and other shrubs, move toward a plant assemblage dominated by conifers. These functions take many decades to recover once impacted by any disturbance.

Substantial resources have been applied to the protection or restoration of riparian areas in Washington State for the benefit of fish, wildlife, and recreation. Many of these projects seek to reintroduce or protect riparian vegetation that is critical to self-sustaining ecological services of forests and streams. However, many of these projects are located in areas vulnerable to knotweed invasion. Knotweed infestations can ruin the sustainable benefits of these projects by

out-competing the offspring of the native plantings and dominating the vegetation community in the long-term.

When sites are heavily infested by knotweed, there are fewer juvenile trees available to replace mature trees removed by natural disturbances such as wind, flood, or fire. Instead, the knotweed present in the understory fills any gaps that are created. Failure to control knotweed at these sites will result in a monoculture of knotweed that excludes beneficial riparian vegetation in the future.

The lack of juvenile tree species in knotweed-infested riparian forests could also result in a decrease in large trees available to fall into stream channels. These large pieces of wood, also known as large woody debris are important to the rivers and streams of the Pacific Northwest. Large woody debris creates pool habitats, retains spawning gravels, and provides cover for juvenile salmonids. The loss of large woody debris can disrupt natural processes, leading to a down-cutting of the stream bed, loss of side channel fish habitat, loss of pool habitat, decreased retention of spawning gravels, and decreased cover for juvenile salmonids and their prey. Depending on the time of year and salmon species, a decrease in the number of pieces and volume of large woody debris has been shown to decrease the number of salmon that utilize the section of stream lacking large woody debris. This could negatively impact efforts to restore salmon populations.

Knotweed can also have a negative effect on aquatic invertebrates that are the basis of the aquatic food chain by disrupting or altering the quality and timing of leaf litter inputs. This lowers the species diversity of invertebrates and negatively affects the organisms and processes that depend on them. Invertebrates are the primary food source of juvenile fish species.

Knotweed often negatively affects residential property and transportation infrastructure (Figure 4). Along right-of-ways, knotweed can grow through materials used for roadways, causing the need for expensive repairs. Knotweed patches also pose potential sight-distance hazards to vehicle operators due to rapid growth, affecting public safety on roadways.

Figure 4. Negative impact of knotweed on transportation in King County.

Habitat modeling performed by WSDA indicates that knotweed currently occupies a small fraction of its potential habitat in Washington. However, there is evidence that knotweed populations outside of current project areas will continue to expand, and will eventually invade these suitable areas.

The Plants

The invasive knotweed complex is comprised of four herbaceous perennial plant species from the buckwheat family (Polygonaceae) that are native to Asia. They are broadleaf plants that have green stems and reddish nodes (Figure 5). The plants were introduced to the United Kingdom and the United States as garden ornamentals in the early part of the 20th century. The four species are commonly referred to as Japanese, Giant, Bohemian, and Himalayan knotweed. All four species occupy similar habitats and cause similar negative impacts. They are collectively referred to as knotweed in this report. The four species are alternatively placed in either *Polygonum* or *Fallopia* genus.

- **Japanese knotweed** (*Polygonum cuspidatum* Sieb. & Zucc.) The leaves of this plant are blunt at the base and sharply tapered at the tip (Figure 6). The stems of this plant usually grow to 7 feet tall. Stem diameters range from one-half to one inch.

- **Giant knotweed** (*P. sachalinense* Schmidt) This is the largest of the four invasive knotweed species. It has large heart shaped leaves (Figure 6), stems that can grow up to 12 feet tall, and stem diameters up to two inches.

- **Bohemian knotweed** (*P. x bohemicum* Chrtek & Chrtkova) This is the hybrid produced by giant and Japanese knotweed. Leaf shape, stem diameter, and stem heights are variable, but are usually within the range of the smaller Japanese knotweed and larger giant knotweed. It is the most common invasive knotweed species in Washington State.

Figure 6. Leaves of three species of knotweed. From left to right are the leaves of giant, Japanese, and Himalayan knotweed.

- **Himalayan knotweed** (*P. polystachyum* Wall) has lance-shaped leaves that make it readily identifiable when compared to the other species (Figure 6). The stems of this plant usually reach one half inch in diameter, and four to five feet in height. It is most common in the coastal areas of southwest Washington.

All four species are listed as Class B noxious weeds on the Washington State Noxious Weed List (WAC 16-750-011). Class B noxious weeds are designated for control in regions of Washington State where they are not yet widespread. In regions where Class B noxious weeds are abundant, mandatory control is decided at the county level. In addition, all four species are included in the Washington State noxious weed seed and plant quarantine list (WAC 16-752-610). Under this rule, it is illegal to transport, buy, sell, or trade any of the invasive knotweed species.

Figure 7. Flowering knotweed in Skamania County.

Invasive knotweeds have extensive underground rhizome and root systems. They thrive in moist soil or river cobble, in full or partial sunlight, and are most common along rivers, creeks, beaches, and disturbed areas.

The aerial stems of knotweed emerge in spring and reach full height by early summer. The plants flower in late summer or early fall (Figure 7), and the aerial shoots die after the first frost leaving living underground root systems. The dead shoots persist through the winter, and can remain standing for several years (Figure 8).

Figure 8. Dead aerial stems of knotweed on unstable bank of Wynoochie River in Grays Harbor County.

WSDA Knotweed Control Program

Since 2004, the Washington State Department of Agriculture has partnered with multiple organizations to locate and control knotweed in select watersheds across the state. Implementing annual field surveys and targeted herbicide applications has proven to be a very effective means of controlling knotweed. Program cooperators survey for knotweed by wading or boating streams and driving right-of-ways in each project area. The location of knotweed is documented, and this information is used to identify the ownership of affected parcels. Figure 9 shows the location of a knotweed plant being recorded in the Skagit River. Program cooperators provide educational materials and notification to each landowner prior to the performance of any control activities. Most landowners are familiar with the negative impacts of knotweed and welcome the assistance provided by program cooperators.

Treatment methods are selected based on site and infestation characteristics according to integrated pest management (IPM) principles. An important IPM consideration for the program is the treatment of all known knotweed populations in the selected river corridor, starting at the upstream source of the infestation and working in a downstream direction. This strategy helps to ensure that untreated knotweed plant material will not re-infest treatment sites as it moves downstream.

Treatments are conducted when the knotweed plants are actively growing. Figure 10 shows a crewmember evaluating a site for treatment in Grays Harbor County. Program cooperators apply formulations of the systemic herbicides imazapyr or glyphosate, alone or in combination. Foliar delivery of herbicide was the primary treatment method used by project cooperators in 2017. The use of herbicide has been proven to be the most effective treatment method.

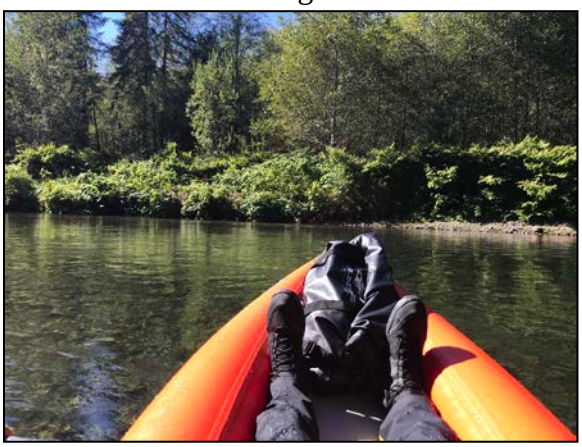

Figure 10. Actively growing knotweed on the Wynoochee River in Grays Harbor County.

Program cooperators use herbicides that are registered in Washington State for use in or near water. WSDA requires that all aquatic herbicide applications be made under the supervision of a licensed applicator. Funding to support the WSDA knotweed program helps to ensure that licensed and trained professionals make herbicide applications near water.

Project Selection

The organizations that implement knotweed control projects in Washington State are growing in both numbers and type. Many cooperative weed management groups have formed to combat invasive knotweed, bringing together landowners, land management agencies, tribal governments, county noxious weed control boards, fisheries enhancement groups, conservation districts, and other conservation organizations and citizen groups. With the increase in organizations involved in knotweed control comes an increase in need for funding to support cross-jurisdictional projects on the scale of whole river systems.

For the 2017-2019 biennium, WSDA prioritized and supported projects that:

- protected previous accomplishments;
- cost-effectively controlled knotweed populations; and
- protected large, ecologically important areas.

WSDA also considers the project area's current infestation level, health of riparian areas, use by salmon, prior crew performance and the extent that requested funds would be used to leverage additional funding to rank proposals and develop a list of projects that would be supported.

For the 2017-2019 biennium, 29 proposals requesting a total of $1,422,948 were submitted. WSDA furnished support to 24 of these projects and one biological control development project, allocating a total of $623,00 for agreements and contracts. Figure 11 shows the counties with supported projects.

Figure 11. Map depicting the counties where WSDA supports knotweed control projects.

Budget

The Washington State Department of Agriculture has administered a knotweed control program since 2004. In total, WSDA has received $7.5 million to control knotweed. This funding has been critical for the ability of our program cooperators to secure additional resources by providing them with state-origin matching funds.

For the 2017-2019 biennium, the WSDA knotweed control program budget is $950,484 (Table 1). WSDA coordination expenses include agency administration costs, permitting and environmental compliance, salaries and benefits for coordination, legal and clerical support, equipment costs, printing, and other goods and services.

Table 1. Estimated budget activity for the 2017-2019 biennium.

Activity			Expenditure
Purchased services			$623,000
	10,000 Years Institute	$30,000	
	Chelan County	$35,000	
	Clallam/Jefferson County	$30,000	
	Clark County	$30,000	
	Cowlitz County	$20,000	
	Ferry County	$5,000	
	Hood Canal Salmon Enhancement Group	$40,000	
	King Conservation District	$10,000	
	King County	$25,000	
	Kooskooskie Commons	$7,000	
	Lewis County	$20,000	
	Mason Conservation District	$15,000	
	Mason County	$15,000	
	Mountains to Sound Greenway Trust	$20,000	
	North Olympic Salmon Coalition	$20,000	
	Oregon State University	$25,000	
	Pacific County	$40,000	
	Pierce Conservation District	$30,000	
	Skagit County	$20,000	
	Skagit Fisheries Enhancement Group	$35,000	
	Skamania/Klickitat County	$25,000	
	Snohomish County	$35,000	
	Sound Salmon Solutions	$10,000	
	Thurston County	$25,000	
	Washington State University	$5,000	
	Yakima County	$10,000	
	Unobligated Purchased Services*	$41,000	
Herbicide/Equipment			$30,000
Coordination			$297,484
Total Biennial Expenditures			**$950,484**
*appropriated for second year of biennium (FY19)			

Results

In addition to a biological control development project with Oregon State University and Washington State University (see *Appendix A*), in 2017 WSDA provided resources to the entities listed in Table 2 below. These cooperators implemented knotweed control projects in watersheds of 20 counties.

WSDA uses three metrics to track the progress of each project. *Solid Acres Treated* is a measure of how many acres a dispersed population would occupy if all knotweed plants were grouped together. *River Miles* and *Landowners Assisted* include any survey, treatment, and/or monitoring activities. In cases where our projects are focused on the treatment of upland knotweed populations in order to prevent the infestation of the shorelines of rivers, the river miles measured does not apply. Table 2 shows a summary of the work performed by program cooperators in 2017.

Table 2. Results by program cooperator for the 2017 control season.

Organization	Solid Acres Treated	River Miles	Landowners Assisted
10,000 Years Institute	0.045	45	18
Chelan County	0.66	63.7	855
Clallam/Jefferson County*	35.6	21.3	28
Clark County	7.05	40.8	1036
Cowlitz County	7.87	62.86	103
Ferry County	0.4	5	15
Hood Canal Salmon Enhancement Group	5.15	21.59	260
King Conservation District	1	2	7
King County	10.58	91.2	1161
Kooskooskie Commons	3.4	109	32
Lewis County	6.4	37	132
Mason Conservation District	25	30.2	398
Mason County	1.3	4.92	123
Mountains to Sound Greenway Trust	2.7	6	118
Pacific County	29.08	65.05	346
Pierce Conservation District	81	27	74
Skagit County	5.8	8.7	52
Skagit Fisheries Enhancement Group	0.36	39.7	36
Skamania/Klickitat County*	26.38	37.52	43
Snohomish County	33.5	17.66	45
Sound Salmon Solutions	0.7	1	1
Thurston County	1.85	25	167
Yakima County	1.26	73	330
Total	**287.085**	**835.2**	**5380**

*These groups worked in a shared project area with a combined crew

Outlook

WSDA continues to work with program cooperators to develop sustainable knotweed control strategies. As in the past, state resources were utilized to leverage additional funding. Combining funding and resources from multiple sources allows program cooperators to implement projects on the scale of entire watersheds. In 2018, program cooperators will continue to place emphasis on landowner participation and education. This provides landowners and land managers with the knowledge and experience to be the long-term stewards of their respective project areas.

WSDA will continue to support the development of biological control methods for knotweed. Typically, biocontrol agents do not reduce the populations of invasive plants as much as other control techniques. However, if self-sustaining populations of biocontrol agents can be developed in the future, this may constitute a cost-effective and self-sustaining suppression strategy for sites heavily infested by knotweed.

WSDA will continue to support knotweed control as program funding allows. The funding outlook in 2018 appears stable. In the past, funding reductions have led to the abandonment of projects and reduced support for ongoing initiatives. Eliminating projects would impact the habitat and restoration efforts of salmon bearing streams. In contrast, knotweed projects that have received stable funding have shown a vast decrease in knotweed presence.

Appendix A

Annual Progress Report 2017 Biological Control for Knotweeds 2017-2019

Submitted by Fritzi Grevstad, Oregon State University

Introduction

After extensive testing and review, the knotweed psyllid (Aphalara itadori) is in the final stages of federal permitting for release as a biological control agent for Japanese and giant knotweeds. In November of 2013, this insect, native to Japan, was recommended for release into North America by the multi-agency Technical Advisory Group for Biological Control of Weeds (TAG). Since that time, the proposed biological control introduction has been under review by the USDA Animal and Plant Health Inspection Service (APHIS) and the U.S. Fish and Wildlife Service.

Two biotypes of the psyllid are proposed as biocontrol agents. Colonies of both biotypes are maintained in the Oregon State University Quarantine facility in Corvallis, Oregon. The northern biotype from the Island of Hokkaido performs best against giant knotweed and some genotypes of hybrid knotweed. The southern biotype from the Island of Kyushu is most effective against Japanese knotweed and most genotypes of hybrids. Both are needed to control the varied knotweed species complex that is invasive in North America. We propose activities to facilitate the permitting process and begin to implement the biocontrol program.

Progress by Objective for 2017

Objective 1: Completion of the permitting process

In April of 2017, the principal investigator (F. Grevstad) attended the Annual Meeting of the Technical Advisory Group on Biological Control in Fort Collins, CO. She gave a presentation to update the TAG on the current research and permitting status of the knotweed psyllid. She met with regulatory officials from USDA-APHIS and USFWS to encourage them to move the permitting process forward. Soon after this meeting, the USFWS reviews were completed with all positive comments and USDA- APHIS proceeded with the Biological Assessment and the

NEPA review. APHIS requested some additional information regarding the status of knotweed psyllid releases in Canada and the United Kingdom, which was promptly provided by our collaborators in those countries. Currently, we are awaiting completion of the NEPA review and final release permitting by APHIS.

Objective 2: Maintain quarantine colonies and expand rearing

Throughout the reporting period, colonies of both biotypes of the knotweed psyllid were maintained in the Oregon State University Quarantine Facility. This involved periodic collection of knotweed rhizomes from field sites throughout the northwest, growing plants in the non-quarantine greenhouse, transferring plants to the rearing colonies, removing expended plants, and helping to maintain the quarantine facility.

One challenge that arose this year was an outbreak of spider mites on rearing plants in the quarantine. To eliminate spider mites, it was necessary to start brand new rearing cages with mite-free knotweed plants and carefully transfer individual adults (sorted to eliminate mites) from the old cages. Another challenge involved several incidents of quarantine overheating due to building renovation work and power outages. At least one of these overheating events killed off a large proportion of the insects, but the populations readily recovered.

In addition to colony maintenance, we carried out further testing of the photoperiod response of both biotypes of Aphalara itadori to supplement data that was obtained in a previous year. We now have good estimates of the critical photoperiod that cues the insects to end reproduction and enter diapause in the late summer. The northern biotype enters diapause when reared at day lengths shorter than 14.9 hours, while the southern biotype enters diapause when day lengths are shorter than 14.1 hours. Moreover, the southern biotype appears to have a more gradual threshold response (more individual variation) than the northern biotype. These results are currently being incorporated into a geo-climatic phenology model that will predict voltinism (number of generations) and degree of phenological match across the North American continent.

Objective 3: Coordinate and monitor releases

We visited new field sites to add to our growing list of potential biocontrol release sites. The new locations include Ten Mile Creek in the Oregon Coast Range, which is infested with Japanese knotweed (Fallopia japonica) and Molalla River State Park south of Portland, Oregon, which has both Japanese and hybrid knotweed (F. x bohemica). Molalla State Park has perhaps the largest contiguous stand of knotweed in the state of Oregon and therefore is especially suited to biological control (Fig. 1). As part of a separate, but related grant project, we are also planning releases of the knotweed psyllid at several military bases, including the Joint Base Lewis-McChord in Washington and Fort Drum and West Point in New York State.

Arrangements have been made to provide the two biotypes of the knotweed psyllid to collaborators on the East Coast. A starter population will be transferred to the North Carolina Department of Agriculture Quarantine Facility early in 2018 in anticipation of releases next summer. Once approved for release, the psyllid will be transferred to additional collaborators in Massachusetts, New York, Rhode Island, and New Jersey.

We are currently working on parameterizing a geo-climatic phenology model that will be used to predict and map voltinism and phenology match for newly introduced populations of the knotweed psyllid across the entire United States. A single site version of the phenology model for the knotweed psyllid is already available online at www.uspest.org. The improved version will include the photoperiod response and produce spatial output (maps). This model will help guide the selection of release locations where the psyllid will have the very best chances to establish and build robust populations.

We have made substantial progress toward completing a manuscript for a technology transfer publication entitled, “Biology and Biological Control of Knotweeds.” The manual is geared toward land managers and will be published by the Forest Health Technology Enterprise Team (U.S. Forest Service) early next year.

Figure 1. Japanese knotweed at Molalla River State Park, a potential release site for the knotweed psyllid Aphalara itadori.