Recap of Knotweed Control Studies

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(1) Overview: Knotweed control can be accomplished with herbicides. To date, most efforts have centered on foliar applications of glyphosate. On terrestrial sites, mixes of up to 2% product in water carrier may be used for spray-to-wet applications to perennial weed foliage, while low-volume applications may use mixes of 5 to 10% product in water carrier (as per Monsanto's Roundup Pro label). Glyphosate applied to perennial weeds on wet sites (as per Monsanto's Aquamaster label) may include mixes of up to 1.6% product in water carrier for spray-to-wet applications, while mixes of 5 to 8% product in water carrier may be used for low-volume applications. Remember that aquatic glyphosate products require the addition of a surfactant at 0.25 to 0.5% v/v prior to application. The application of herbicides to wet sites also requires an aquatic endorsement on your applicator's license and additional licensing from Department of Ecology. Although several glyphosate products are labeled for use on non-cropland sites, it is important to recognize that these knotweeds may not be mentioned on these labels! Consequently, control recommendations for knotweed is based on results from supplemental research efforts performed by county, state, and federal agency personnel as well as private organizations and landowners.

Glyphosate products registered for aquatic use in WA include Aquamaster (Monsanto), Rodeo, Accord, and Glypro (Dow AgriSciences), Glyphosate VMF (DuPont), Fireball and HM-2028 (Helena), Glyfos (Cheminova), Glyphosate 5.4 (Alligare), Pondmaster (PBI/Gordon), Kill-Zall (Hi-Yield), Terminator (Mid-American Research Chem), Trailblazer Maxx (Check-Mark), Aquaneat and Foresters' (Nufarm), Touchdown Pro (Syngenta), Cinco (UAP Loveland), Aquapro (SePRO), Eagre (Griffin LLC), Shoreklear Puls (Applied Biochememist), and Cattplex (Sanco).

There is a general consensus in the Pacific Northwest that a minimum of 2.5 to 3% glyphosate product is necessary to adequately control knotweed and that, at that rate, repeat applications to re-growth will be necessary over the subsequent two growing seasons.

Other herbicides that have shown good foliar activity on knotweed species include triclopyr and imazapyr. Aquatic labels for triclopyr are Renovate (SePRO), Agristar (Albaugh), Kraken (Phoenix Environmental), Tahoe (Nufarm), and Ecotriclopyr (Vegetation Management LLC). Aquatic labels for imazapyr include Habitat (BASF), Lineage (DuPont), Gullwing (Phoenix Environmental), E-Pro2 (Etigra LLC), Polaris AQ (Nufarm), Aquapier (SePRO), and Ecomazapyr (Vegetation Management LLC).

There is general consensus in the Pacific Northwest that Habitat is best applied at 0.5% when used in tank mixture with glyphosate, and that 0.75 to 1% is a good rate when Habitat is used alone. Always add surfactant when using imazapyr products. No consensus exists for use of triclopyr on knotweed, however. While it does show activity, control is usually inadequate when the product is used alone.

(2) Results from my tests with foliar-applied glyphosate, triclopyr, and imazapyr on Bohemian, giant, and Himalayan knotweed transplants in the greenhouse (2003-04) indicate that triclopyr resulted in symptom expression, usually within 48 hours, and defoliation within two weeks. Plants treated with glyphosate and imazapyr did not show symptoms until about a week after treatment, and defoliation had only progressed to about 50% by three weeks. At three weeks after treatment, plants were clipped and knotweed re-growth was monitored for the next eight weeks. Relative susceptibility to these products did not differ much by species, although Bohemian transplants were most tolerant to herbicides applied at 0.5 to 1% product in water. It appears that imazapyr is the most active product on knotweed, as knotweed transplants did not re-grow when treated with imazapyr at 0.5% or greater, either applied alone or tank-mixed with glyphosate or triclopyr. Bohemian knotweed control 11 weeks after treatment with 1% glyphosate mix was 90% (compared to re-growth of untreated plants), while triclopyr at 1% gave 96% control. While knotweed in the field will likely require higher dosages of herbicide to achieve similar levels of control, it appears that all three of these herbicides alone or in combination will aid in the control of these species.

(3) A novel method of knotweed control evaluated in the Pacific Northwest involves injection of herbicide directly into the hollow knotweed stem. Aquatic formulations of glyphosate [Aquamaster (Monsanto) and Glypro (Dow)] and Roundup Pro are registered for this use on supplemental product labels in selected states. Up to 5 ml of undiluted product (6 ml for Roundup) is injected into knotweed stems using a syringe, about 6 inches from the ground. An awl may be used to first punch a hole into the stem just below a node, or a specially-designed injection gun may be purchased (www.jkinjectiontools.com) which performs both functions in the same operation. A second method is to cut the stem just below a node and to place 10 ml of 50% solution in the hollow "well" that is created in the stem section. Note that these labels stipulate the maximum number of stems which may be treated per acre using this method.

(4) Results from my field tests with injection techniques on giant and Bohemian knotweed (2003-05) showed that 2.5 or 5 ml of glyphosate, triclopyr, and imazapyr gave 91 to 100% control of stems and crowns by eight weeks after treatment. **Please note that neither triclopyr nor imazapyr are currently registered for knotweed injection (and probably never will be).** I also tested wiping the lower three feet of knotweed stems with 33% herbicide solutions using a sponge paintbrush (Aquamaster, Garlon, or Arsenal at 1 part product plus 2 parts water; I also added surfactant at about 0.25%, v/v). Wiping uncut canes resulted in 63 to 80% stem control by eight weeks after treatment, while wiping canes whose tops had been cut off at a height of three feet resulted in 97 to 100% stem control. Knotweed control at one year after treatment was similar for all treatments, however. While knotweed "knockdown" was quicker if herbicides were applied at early flowering compared to post-flowering, there was no difference in control the following season, indicating that knotweed can be adequately controlled over a fairly wide application window. **Note that only glyphosate is registered for injections at this time!**

(5) Herbicide symptoms from these field trials were apparent on knotweed the following season up to four feet away from where the treatments occurred, with the symptoms being more obvious in August than in April. There were no correlations between injury level and type of application (so injection did not result in more symptomolgy than wiping, for example). There were also visible symptoms on other plant species (salmonberry, thimbleberry, snowberry, blackberry, and

reed canarygrass) the year after application; in fact, non-target symptomology was apparent in 22 cases out of a possible 144 (15%). Most of these cases involved imazapyr—not surprising given that herbicide's soil activity and longevity. Glyphosate injury on salmonberry was seen, however, as was triclopyr injury on snowberry. These observations were also noted in several locations where glyphosate injection was used for knotweed control.

(6) A second greenhouse study was conducted in 2005 to verify these observations of glyphosate uptake by non-target vegetation. Knotweed plants were transplanted into pots with either salmonberry or thimbleberry and grown together for two months. Aquamaster was then sprayed over the entire pot (2% in water, with added surfactant), wiped on knotweed leaves (33% in water, with added surfactant), or injected (full strength, as much as possible into a single internode: 2.8 mls). Damage to knotweed from the overspray averaged 81% (98 to 100% control of Himalayan or giant, and 68% control of Bohemian), with berry plants sustaining 68% injury. Leaf wipes resulted in 89% knotweed control (83% Bohemian control and 98% of Himalayan and giant) and about 13% berry plant injury. Injection gave 88% knotweed control (88% of Bohemian and 100% of giant). While I was not able to inject Himalayan knotweed (stems too small), just the drop of glyphosate on the outside of the stem was enough to cause 63% injury of those plants. Thimble- and salmonberry injury from knotweed injection was 26%. Therefore, knotweed injection resulted in about twice as much non-target injury as did leaf wipes, but non-target damage was 2.6 to 5.2 times greater, respectively, than using a foliar spray.

(7) Results of glyphosate treatments made to southwestern Washington knotweed sites in 2004 (WSDA funded program) was monitored in June, 2005. I monitored six sites to determine the relative effectiveness of the knotweed control strategies being conducted by the project managers at each location. Sites and treatments included the following:

Overview of project sites and knotweed control strategies.

Project	Site	Knotweed Type	Treatment
Clark	Upper East Fork Lewis River	Bohemian	Injection, 5 mls Aquamaster per stem
Clark	Lower East Fork Lewis River	Bohemian	Foliar, 1.5% Habitat
Lewis	Upper Cowlitz River	Bohemian	Foliar, 1.5% Aquamaster + 0.75% Habitat
Pacific	Willapa River	Bohemian	Foliar, 2% Aquamaster + 0.5% Habitat
Skamania	Washougal River	Japanese (?)	Injection, 5 mls Aquamaster per stem
State Parks	Beacon Rock	Japanese (?)	Injection, 5 mls Aquamaster per stem

Visual knotweed control ranged from 88 to 94% with no significant differences between sites. There was a trend toward better control when imazapyr was used, however. Stem numbers were reduced from 63 to 80%, and estimated 17,000 to 33,500 stems per acre before treatment compared to 4,600 to 10,800 after treatment. Similarly, stem height ranged from 10 to 20 inches tall compared to an expected height 72 inches (72 to 86% reduction). Injury to non-target vegetation among all treatments was <10%, with no apparent correlation between injury and application type or herbicide choice. All new knotweed shoots in treated areas were from rhizomes/crown (no seedlings). It was also obvious that very little plant growth occurred in any

plot once the knotweed was killed. This response probably speaks more to the competitive ability of these knotweeds prior to treatment than resulting from herbicides killing other species.

(8) I conducted initial tests (2005-06) with aminopyralid (Milestone, Dow AgroSciences) on Bohemian knotweed at two separate sites near Mount Vernon. Fully grown knotweed plants at one site were treated at full bloom, while knotweed plants at a second site were mowed in mid-summer and the re-growth treated when about 3 to 4 feet tall. Aminopyralid alone showed only slight activity on knotweed at the 3 to 7 fl.oz/acre rate at ten months after treatment, although treatment was improved by some 35% by mowing and treating regrowth. By comparison, treatment with 3% Aquamaster resulted in 80 or 96% control of uncut or re-grown knotweed, respectively, while 0.75% Habitat resulted in 85 or 99% control, respectively.

(9) A second Milestone trial conducted in 2006-07 controlled Bohemian knotweed much better. Applications were made at 0.5, 1, and 1.5% Milestone with or without glyphosate at 1.5%. All treatments resulted in 91 to 100% control at nine months after treatment. Bending stalks about, one week prior to treatment improved control by about 5%. A third Milestone trial is currently underway (2007-08) on Bohemian and giant knotweed. In this trial, knotweed plants were bent or cut about one month prior to treatment, and control will be compared to uncut knotweed plants this summer.

(10) A third Milestone trial was conducted in 2007-08 with applications at 0.5 and 1% Milestone, 0.5% Milestone with either 0.5% Garlon or 1% Rodeo, or 0.75% Habitat. Applications were made to cut, bent, or intact giant knotweed (cut/bent July 26, treated August 31, 2007) or to cut or intact Bohemian knotweed (cut July 27, treated August 24, 2007). At one year after treatment, Bohemian knotweed control was 10 to 20% better by treating intact stems, regardless of treatment. Control from treatment of intact stems ranged from 89% with Habitat to 99 or 100% for the other treatments, compared to treatment of re-growth from cut stems (control was 56% for Habitat, 61% for Milestone + Garlon, 79% for Milestone + Rodeo, and 99 or 100% for Milestone at 0.5 and 1% (respectively). Giant knotweed control was generally enhanced by cutting and bending and then treating re-growth (about 10% improvement on average). Milestone effectiveness was particularly improved by cutting/bending, with 60 or 30% improvement at 0.5 and 1%, respectively. The opposite effect was seen with Habitat, with cutting/bending reducing control by 40 or 30%, respectively.

(11) The current season trial (2008-09) is a symptomatic knotweed trial, in which plants treated with glyphosate or combination glyphosate + imazapyr by TNC for the last two seasons (the cooperator thought it had been sprayed every year for the last five years—we're checking on that…). Symptomatic plants (6 to 8 inches tall, about 5% leaf yellowing at the time of treatment) were treated October 1, 2008 with broadcast applications of Milestone, Rodeo, Habitat, Garlon, Milestone + Rodeo, Habitat + Rodeo, or Garlon + Rodeo. Re-growth will be monitored next spring to see if any of these applications had a good result on these plants.