ABSTRACT

Invasive knotweed (*Polygonum L.* [Polygonaceae]) species are a significant threat to native ecological communities that occur in riparian areas and other vulnerable habitats. This project applied practical methods to control Bohemian knotweed (*Polygonum* x *bohemicum*). This species was controlled for 2 y prior to restoring appropriate native species for the Chehalis River Surge Plain Natural Area Preserve in Washington State (US). The invasive species Himalayan blackberry (*Rubus discolor* Weihe & Nees [Rosaceae]), scotsbroom (*Cytisus scoparius* (L.) Link [Fabaceae]), and reed canarygrass (*Phalaris arundinacea* L. Raeush [Poaceae]) were also controlled.

Davenport R. 2006. Control of knotweed and other invasive species and experiences restoring native species in the Pacific Northwest US. Native Plants Journal 7(1):20–26.

KEY WORDS

Bohemian knotweed, *Polygonum* x *bohemicum,* Chehalis River Surge Plain, reed canarygrass, invasive species control

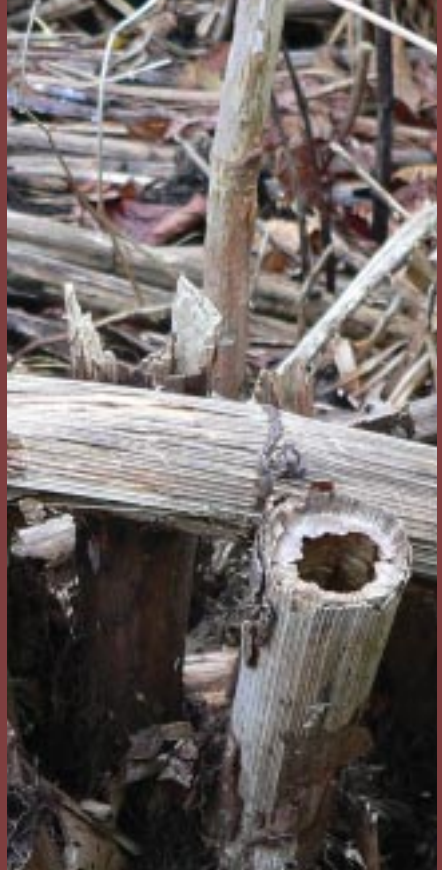
NOMENCLATURE

USDA NRCS (2005)

Dead knotweed (foreground) at Preacher's Slough will be replaced with native shrubs and trees like those growing in tree shelters in the background. Photo by Roberta Davenport

Control of Knotweed and other invasive species and experiences restoring native species in the Pacific Northwest US

| Roberta Davenport



The Washington Department of Natural Resources manages the Chehalis River Surge Plain Natural Area Preserve, which is part of a statewide system of natural areas. This 1200-ha (3000-ac) preserve is designed to protect a large freshwater tidal surge plain wetland, listed as Priority 2 in the Washington Natural Heritage Plan (WDNR 2003). The primary ecological community of the surge plain occurs in tidal wetlands dominated by Sitka spruce (*Picea sitchensis* (Bong.) Carr [Pinaceae]), with a typical understory of common lady fern (*Athryrium felix-femina* (L.) Roth [Dryopteridaceae]), redosier dogwood (*Cornus sericea* L. [Cornaceae]), salmonberry (*Rubus spectabilis* Pursh. [Rosaceae]), and twinberry honeysuckle (*Lonicera involucrata* Bank ex Spreng [Caprifoliaceae]). The wetland complex includes highly sinuous sloughs, palustrine emergent, scrub-shrub, and forested wetlands. It is the largest, highest quality occurrence of this type of wetland community in the Pacific Northwest US.

Preacher's Slough, entirely within the preserve, is approximately 8 km (5 mi) long and is a major side channel of the Chehalis River. Invasive species surveys indicated that the slough is in extraordinarily good ecological condition, but one area, covering about 6.5 ha (16 ac), was significantly invaded by knotweed and other weeds (Figure 1). In this paper I describe how we have reduced the serious threat of Bohemian knotweed (*Polygonum* x *bohemicum* (J. Chrtek & Chrtkovß) Zika & Jacobson [Polygonaceae]) invasion and re-established native plants.

THE PROBLEM: KNOTWEED

Invasive knotweed species in the Northwestern US include giant knotweed (*Polygonum sachalinense* F. Schmidt ex Maxim), Japanese knotweed (*Polygonum cuspidatum* Sieb & Zucc.), Bohemian knotweed (*Polygonum* x *bohemicum*), and Himalayan knotweed (*Polygonum polystachyum* Wallich ex Meisn.). We believe the hybrid dubbed "Bohemian knotweed" is the species that infests this site and many other riparian areas (Zika and Jacobson 2003). It is an extremely durable plant that relies on a woody root system composed of a knotty crown and rhizomes that appear to extend in every direction. The root system has great reserves, and shoots emerging from the root system are known to push through asphalt (Shaw and Seiger 2002). This hybrid is extremely difficult to control with manual methods such as covering, mowing, digging, and so on unless a very small area is all that needs treatment. Virtually all parts of the plant can generate new roots if separated from the mother plant. Stem sections need a node to generate rooting; very small sections of the crown and rhizomes are capable of regenerating (Miller 2004). Landowners grow frustrated with the landscape-dominating plants and are likely to dump excavated roots along roadsides or nearby waters, where a new population soon takes root. Rivers with exposed sand and gravel bars are extremely vulnerable when flooding hastens the spread of these species (Soll 2004).

Photo by Roberta Davenport

Figure 1. Bohemian knotweed growing in Preacher's Slough.

THE SOLUTION

Knotweed and Other Weed Control

After several years of consistent effort on the old pasture site at Preacher's Slough (described below), we achieved significant control of Bohemian knotweed, Himalayan blackberry (*Rubus discolor* Weihe & Nees [Rosaceae]), scotsbroom (*Cytisus scoparius* (L.) Link [Fabaceae]), and reed canarygrass (*Phalaris arundinacea* L. Raeush [Poaceae]). These weeds were persistent and tenacious, but as sections were cleared of them outplanting of native species was completed in phases.

2001

The Preacher's Slough treatment began with mowing about 75% of the site in July with a tractor-mounted brush-hog mower and hand-held brush cutters. We flagged native species and used care to mow around the few existing native trees and shrubs. Small hidden channels, holes, and half-buried debris that created hazards for the crew were marked when discovered. Knotweed and other weed species were allowed to re-grow for about 5 to 6 wk and then treated with a foliar spray of glyphosate (Rodeo plus surfactant) at a rate of 5% concentrate in water. The herbicide results were mixed; some knotweed appeared nearly unaffected, while other patches showed damage. A follow-up treatment of surviving stems, using the same herbicide rate, was completed near the end of the growing season. Re-growth of larger blackberry patches was successfully treated with Garlon 4, following the label application rate.

2002

The site manager re-treated knotweed areas with foliar glyphosate spray (rate 5% concentrate) when new growth became apparent in June. These re-sprouting crowns, covered with masses of stunted shoots, proved difficult to eliminate. In spite of regular mowing and the use of landscape fabric along planted rows, vast numbers of seedlings of blackberry and scotsbroom had to be managed by pulling, mowing, and spot spraying, using the labeled herbicide rate or the lowest rate with efficacy on seedlings. Dense areas of regenerating reed canarygrass were mowed early in the growing season and treated once in June or July with 2% glyphosate spray.

2003

By 2003, new information on knotweed control methods indicated promise for injecting the hollow stems with herbicide, or applying herbicide to the well of a cut stem. The recommended injection application is 5 ml of undiluted glyphosate concentrate per stem (Crockett and Burgess 2002). The only herbicide currently labeled for this use is Aquamaster, a glyphosate formulation designed for use near water. Studies conducted by The Nature Conservancy showed efficacy with lower rates, such as

TABLE 1

Native trees and shrubs planted to replace Bohemian knotweed and other invasive species at Preacher's Slough.

Trees		**Stocktype**
western red alder	*Alnus rubra* Bong. (Betulaceae)	Bareroot
black cottonwood	*Populus balsamifera* L. ssp. *trichocarpa* Torr & Gray ex Hook (Salicaceae)	Cutting
Douglas-fir	*Pseudotsuga mensiezii* (Mirbel) Franco (Pinaceae)	Bareroot
Oregon ash	*Fraxinus latifolia* Benth. (Oleaceae)	Bareroot
western crabapple	*Malus fusca* (Raf.) Schneid. (Rosaceae)	Bareroot
Sitka willow	*Salix sitchensis* Sanson ex Bong (Salicaceae)	Cutting
western redcedar	*Thuja plicata* Donn ex D. Don (Cupressaceae)	Bareroot
Sitka spruce	*Picea sitchensis* (Bong.) Carr (Pinaceae)	Bareroot
Shrubs		
nootka rose	*Rosa nutkana* K. Presl (Rosaceae)	Bareroot
salmonberry	*Rubus spectabilis* Pursh. (Rosaceae)	Bareroot
thimbleberry	*Rubus parviflorus* Nutt. (Rosaceae)	Bareroot
red elderberry	*Sambucus racemosa* L. Caprifoliaceae)	Bareroot
redosier dogwood	*Cornus sericea* L. (Cornaceae	Bareroot

Photo by Roberta Davenport

Figure 2. Effective control of knotweed was attained by cutting stems and filling the hollow stems with glyphosate solutions.

2.5 ml per stem (Soll 2004). We attempted injection with large hypodermic needles but this was not practical. We did, however, have success with the cut-stem method and tried various concentrations between 1:1 (v:v) glyphosate:water and 1:5 (v:v) glyphosate:water (Figure 2). The lower rate (1:5) is effective provided the stem is large enough (at least 3 cm [1.2 in] diameter) to hold sufficient herbicide mixture. Other workers report that smaller stems are treated with a foliar spray, at a rate of up to 8% glyphosate, rather than attempting to inject or treat cut stems (Soll 2004).

2004

In 2004 we used a new, patented injection tool to treat knotweed stems missed in 2003. The injector is made by JK International LLC and currently costs about US$ 220. It is calibrated to apply 5 ml of 100% glyphosate herbicide, such as Aquamaster (no surfactant is needed for this method). The ideal site for injection is the stem above the second node, because the lowest part of the stem is too woody to inject. Stems too small to inject were treated with foliar glyphosate spot spray, at the rate of 5% concentrate.

Our Preferred Techniques

When reflecting on the various methods used to control knotweed, we found the cut-stem method to be practical in a situation like this large restoration site. The cut stems are spread out to desiccate, which should avoid spreading the plant vegetatively. The herbicide is applied directly to the cut well in the stem above the second node, and it is effective if the dilution rate supplies 2 ml of glyphosate per stem. This rate should be no greater than 1:1 (v:v) glyphosate:water; however, the lowest rate we found effective was 1:5 (v:v) glyphosate:water. Stems less than 3 cm in diameter will be more difficult to treat. This method uses less herbicide than that required for stem injection, and large areas can be cut and treated. In riparian areas where access is limited to stream walking or a small boat, it is risky to leave cut stems where they could be transported by the stream and start new infestations. In this situation, we prefer the injection method because it is simple, effective, and relatively convenient for remote settings and isolated clumps; however, it is time consuming. A combination of methods may be necessary for thorough control, especially because follow-up treatments are usually required. The Skagit Knotweed Working Group developed a method that involves mechanically bending the growing knotweed stems, then applying a foliar herbicide to the regrowth (Rogers 2004). This reduces the height and vigor of plants while they are rapidly growing and produces a shorter stem that is treated later in the summer when knotweed is more susceptible to herbicide. Our test area with this method (using 5% glyphosate in water for the foliar spray) was nearly as effective as the cut-stem area. Mowing or bending over stems will result in small diameter stems that cannot be injected. It is apparent that all methods will require follow-up with foliar spot spray for at least an additional season.

Outplanting Native Species

Several sections of the restoration site were not planted the first year because knotweed had clearly survived the first treatments and posed a problem for native species establishment. The knotweed had persisted in a riparian area associated with a seasonal creek that bisects the site and a large rectangular area that fronted the slough edge. We laid out the mostly upland planting site and avoided the surviving knotweed areas in the first season of planting. Table 1 shows the species chosen to represent the surge plain best suited to meet the rapid growth, cover, and species-diversity goals. These species are frequently used in riparian restoration projects in the Pacific Northwest US (Bails and others 2001).

Landscape fabric was used around native plantings to suppress weeds, and solid tree protectors allowed us to mow around the trees without damaging them. A drip irrigation system was laid out in rows prior to planting. The site manager used the system during the driest weather of the summer but found that nonirri-

gated plants appeared to do almost as well. Wide rows allowed us to use a small tractor, riding mowers, and a walk-behind mower to control weeds around the plantings. Eventually, the tractor became too difficult to maneuver between planted rows and native-species volunteers.

The natural recruitment of native species in all parts of the project was a welcome development. The seedlings of elderberry, salmonberry, and red alder were found among surviving knotweed crowns that had a diminished competitive advantage. Solid plastic tree protectors were placed over these plants to allow them to be located later and to protect them from herbicide spot treatments. Intensive weed management can easily eliminate these native recruits, but they have proved to be an important component of the recovery of the site. Existing small deciduous trees and shrubs that were painstakingly extracted from blackberry thickets undoubtedly contributed to seed sources for these plants. These small trees also created pockets of shade where western redcedar trees have grown well. The project manager should weigh these considerable benefits when faced with the difficult task of recovering native species that are in a heavy cover of aggressive invasive species.

RECOMMENDATIONS

- Plan to treat knotweed species for at least 2 seasons before planting native species.
- Treatment methods that apply herbicide directly to the hollow stem appear to be the most effective, but all methods require meticulous follow-up. Stem injection can injure native shrubs, such as salmonberry, that have root contact with knotweed rhizomes.
- Ensure that cut stems are not left in riparian areas where they can root and that rhizomes are not transported to new locations.
- Check state permit requirements for herbicide application in riparian areas and follow label restrictions for application.
- Control methods discussed here are updated each year as new information is available to land managers and weed coordinators, so current methods should be investigated before starting a project.
- Landscape fabric and solid tree protectors can help protect new plantings from maintenance damage and competition.
- Choose native plant species that will ultimately create a diverse, competitive native community that is similar in species composition to nearby reference sites and can be maintained over a number of years until shade is established.

ACKNOWLEDGMENTS

Sound Ecological Services, Olympia, Washington, developed the restoration plan for the Preacher's Slough site (Alexander 2001) and completed a wetland delineation report for the trail that borders the area. Funding was provided through a partnership with The Nature Conservancy, the US Fish and Wildlife Service Chehalis Basin Fishery Restoration Program, and the Washington State Department of Natural Resources. University of Washington restoration ecology students helped with design and implementation. The Elma Middle School science program provided volunteer planters and Ron Rivera, Aberdeen, Washington, is the project volunteer steward. Research technicians Casey Gozart and Jeff Vanderpham implemented the project and helped refine methods.

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