Guidebook to Invasive Nonnative Plants of the Elwha Watershed Restoration

Olympic National Park, Washington

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A project submitted in partial fulfillment of the

requirements for the degree of

Master of Environmental Horticulture

University of Washington

2013

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Program Authorized to Offer Degree:

School of Environmental and Forest Sciences

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University of Washington, Seattle
September 3, 2013

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Acknowledgements

It apparently takes a village to raise a master's student. The following villagers deserve my sincerest thanks.

Committee

Thanks to Joshua Chenoweth for being on my committee and to Linda Chalker-Scott for being its chair.

Special thanks go to Sarah Reichard, who was really supportive despite being department chair *and* executive director of the Washington Park Arboretum.

Extra-special thanks go to Kern Ewing, whose guidance, support, and espresso were critical to my finishing this degree.

Friendship, encouragement, plant expertise, and pictures

Arthur Lee Jacobson: Your contribution was unparalleled. I cannot thank you enough.

Generosity with knowledge, time, and materials

Many thanks to David Giblin and Ben Legler, in the Burke Herbarium. Also to Joseph DiTomaso, David Stokes, the Montana team of Susan Parkinson and Hilary Anderegg and so many other scientists and graphic artists who selflessly chipped in.

The beast tamers

Penny Hinke, Dan Comden: Thank you for herding my wild puppies.

The undersung heroes

The Miller Horticultural Library staff: Thank you.

Deepest thanks to my overeducated, sagacious, and radically supportive friends and family

Melissa A. Fleming, Michelle Elekonich, Val Pollet, Jude Rosenthal, Karin Gallagher, Vicki Holt, and Laurie Skandalis—to name a few.

Michael Volk, who said, "You finish what you start, that's why."

Most especially to Eve Riskin.

My #1 supporter (and editor) for life: Mom.

Introduction

"Keep your eyes open and your shovel handy. Knowing what species are problems and taking action against them are the best defenses against the spread of invasive species" –P.D. Boersma, in *Invasive Species of the Pacific Northwest* (2006)

In 2011 heavy machinery and explosives began chiseling concrete from an 86- and a 100-year-old dam on the Elwha River, Olympic Peninsula, Washington. As of August 2013, all that's left is a bit of the Glines Canyon Dam, scheduled for removal by the end of 2014 (Czuba *et al.* 2011). Although dams are starting to topple throughout the continent, removal of the Elwha and Glines Canyon dams is "the largest decommissioning in North America on record" (Czuba *et al.* 2011).

Held back for all these years, 7-8 of the nearly 19 million cubic yards of retained sediment—enough to fill a football field to the height of 11 Empire State Buildings—charged through the former Lake Aldwell and Lake Mills, depositing a Mars-scape of fine-clay-to-cobble landforms 20-60 ft. (6.1-18.3 m) deep.

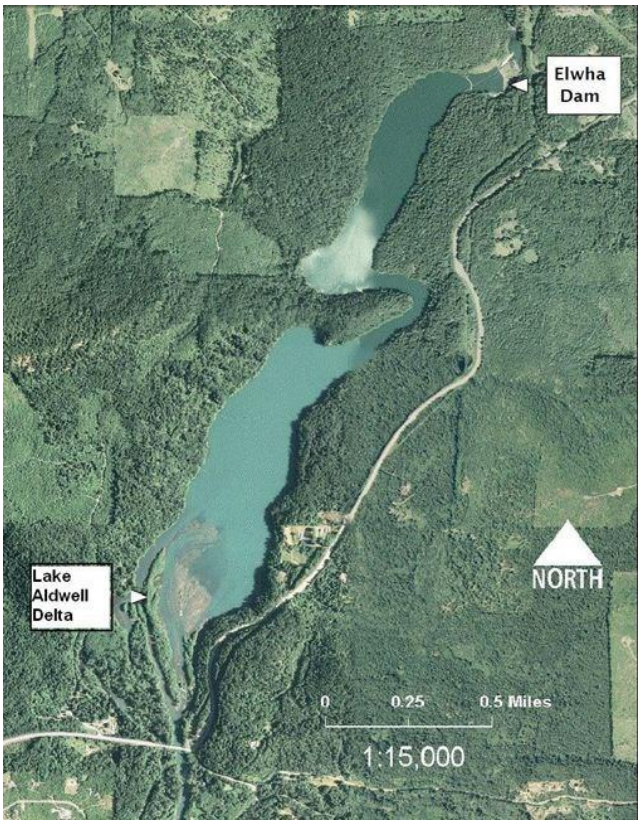

Figure 1: Lake Aldwell before Elwha Dam removal.

In a decision that led to destroying the dams, in 1992 the United States Congress authorized full restoration of the Elwha by passing the Elwha River Ecosystem and Fisheries Restoration Act (US Congress 1992). In response to years of lobbying by the Lower Elwha Klallam Tribe, the Sierra Club, and numerous other tribes and conservationists, this act authorized full restoration of the Elwha River and native anadromous fish populations—species, such as salmon (*Oncorhynchus* spp.), that spend most of their lives in saltwater but hatch in fresh water and return there to spawn.

Removing the dams was just the beginning. Restoring the Elwha requires reinstating a stable ecosystem, revegetating with native plant communities (Chenoweth, Acker & McHenry 2011); coaxing salmonids back to their historic home (Sadin & Vogel 2011); and renewing the salmon-centered culture of the Lower Elwha Klallam people. Since dam installation in the early 1900s, salmonid spawning dropped 93%—from an estimated 392,000 spawning fish to 3,000 a year (Final EIS 2005). Less than 5 months after the Elwha Dam fell, wild adult Chinook (king) salmon (*Oncorhynchus tshawytscha*) were spotted migrating up the river—the first time since 1913 (McKenna 2012). According to Klallam elder George Bolstrom, however, "It's not just about taking the dams out, or even just putting the fish back. It's about the whole picture….If the system is addressed, then maybe restoration will work" (LEKT [date unknown]).

Dam Weeds

To achieve a lasting restoration, crews are actively revegetating native plants on approximately 800 newly exposed acres (about 325 ha) of silt, clay, and cobbles. Central to the project's success is minimizing nonnative invasive plants that can derail a primary goal of this project: fostering the natural progression from early colonizing species to forests dominated by native species.

Invasive nonnative plants—for the purposes of the Elwha revegetation project—are plants that can potentially dominate an ecosystem and cause serious environmental harm. Minimizing invasive nonnative species "is arguably the most important goal of the project," write Chenoweth, Acker, and McHenry (2011). "Invasive, exotic species could disrupt restoration at any time."

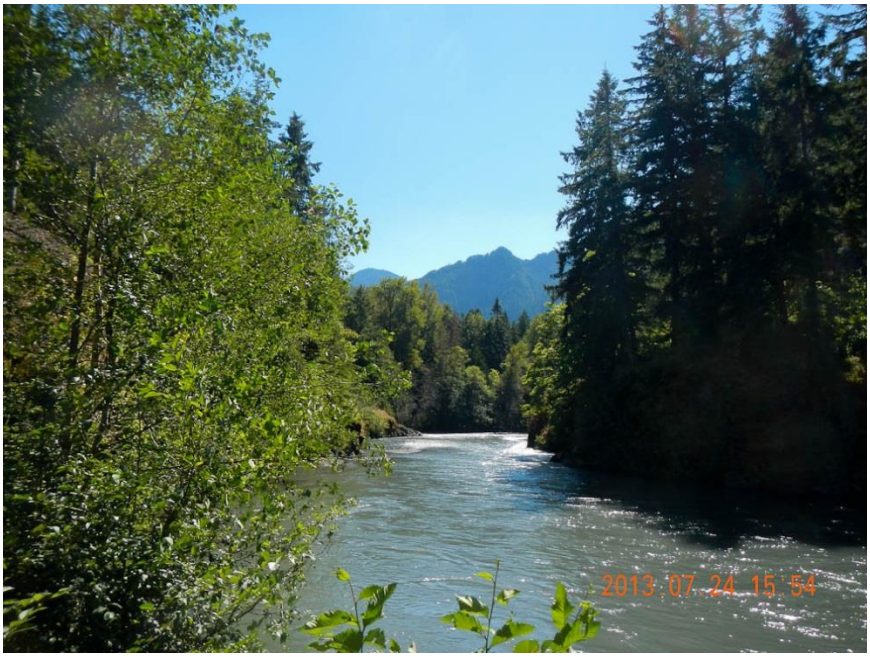

Figure 2: At the border of Olympic National Park, near Madison Falls, Elwha River.
(Courtesy of Luke McGuff, NatureIntrudes.net, ©2013.)

Invasive species management is therefore the highest-funded activity in the park's $4.1 million revegetation budget, garnering 21%, or $878,966 of the funds (followed closely by the technical lead and preparation and planting crews) (Chenoweth, Acker & McHenry 2011).

If areas where humans have disturbed vegetation or soil are more prone to invasions than intact ones, as is commonly thought (Bossard, Randall & Hoshovsky 2000), the Elwha is doubly susceptible. Riparian habitats are especially vulnerable because of water flow shifts, high moisture, and propagules introduced by water (Hood & Naiman 1999). The mostly barren Elwha basins, continually plowed up as the river gradually carves its ultimate floodplain, are practically a welcome mat for invaders. With so many invasive nonnatives already in the Elwha, these species can alter or even derail the succession to healthy, native-plant-dominated communities.

Healthy habitat is critical for salmonids and 22 other wildlife species that depend on them (Final EIS 2005). That's probably why weed control here began in 2002, long before the dams came down, with crews from the Lower Elwha Klallam Tribe (LEKT). In 2008, the LEKT workers joined with Olympic National Park crews to begin herbicide treatments (ONP restoration botanist Joshua Chenoweth, personal communication Aug 2013). It was critical to remove weeds from the projected floodplain before the Elwha River was released. The waters could disperse weed propagules (rhizomes, stem fragments, seeds—anything that could grow into a plant) down the river and out of control.

Figure 3: A female Chinook salmon excavates a nest in the Elwha River—
among the first to colonize the river in 100 years. (U.S. Geological Survey/photo 2012 by Jeff Duda.)

Treatments are ongoing for 20 species already in the park that managers have identified as severe environmental threats (Table 1) (Chenoweth, Acker & McHenry 2011). Crews are treating these priority species with herbicides throughout the watershed during all stages of the project.

Table 1: Top-priority invasive nonnative plants already being treated with herbicides.

Scientific name[1]	**Common name**	**Growth habit**	**Noxious weed designation**[2]
Bromus tectorum	cheatgrass	Graminoid	None
Centaurea jacea	brown knapweed	Forb	Class B-designate
Cirsium arvense	Canadian thistle	Forb	Class C
Cytisus scoparius	Scot's broom	Shrub	Select
Digitalis purpurea	purple foxglove	Forb	None
Geranium robertianum	herb Robert	Forb	Select
Hedera hibernica, *H. helix* (and cultivars)	English Ivy, Atlantic ivy	Vines	*H. hibernica* and *H. helix:* Class C
Hypericum perforatum	Klamath weed, common St. John's-wort	Forb	Class C
Ilex aquifolium	English holly	Tree	None
Lathyrus latifolius	perennial pea, everlasting-pea	Vine, forb	None
Lathyrus sylvestris	small everlasting peavine, narrow-leaf pea	Vine, forb	None
Linaria vulgaris	Greater butter-and-eggs, yellow toadflax	Forb	Class C
Phalaris arundinacea	reed canarygrass	Graminoid	Class C
Polygonum cuspidatum	Japanese knotweed	Shrub	Select
Polygonum sachalinense	giant knotweed	Shrub	Select
Polygonum x*bohemicum*	Bohemian knotweed	Shrub	Select
Potentilla recta	sulfur cinquefoil	Forb	Class B-designate

Prunus laurocerasus	Laurel cherry, cherry-laurel	Tree, shrub	None
Rubus armeniacus	Himalayan blackberry	Subshrub	Class C
Rubus laciniatus	evergreen blackberry	Vine, subshrub	Class C
Senecio jacobaea	tansy ragwort	Forb	Select

[1]*Binomials and common names are per the University of Washington Burke Herbarium's Washington Flora Checklist, at* http://biology.burke.washington.edu/herbarium/waflora/checklist.php.
[2]*Noxious weed listing is per the 2013 Clallam County Noxious Weed List, at* http://www.clallam.net/weed/doc/WeedList2013.pdf. *"Select" plants are Class B and C noxious weeds selected for extra measures to control spread.*

An additional 22 plants are on the watch list (Table 2). They can potentially do great environmental harm but have not yet been spotted in the Elwha or are present far from the former reservoirs. Crews will aggressively treat these plants, too, if they are discovered at any point in the project. Many already occur in Clallam County, and several are designated as noxious weeds on the 2013 Clallam County Noxious Weed List (CCNWCB 2013).

Table 2: Watch-list plants—invasive nonnative species not yet seen in the Elwha or present but far from the former reservoirs.

Scientific name[1]	**Common name**	**Growth habit**	**Noxious weed designation**[2]
Acer platanoides	Norway maple	Tree	None
Ailanthus altissima	Tree-of-heaven	Tree	None
Buddleja davidii	Orange-eye butterfly-bush	Shrub	Class B
Centaurea solstitialis	Yellow star thistle	Forb	Class B-designate
Centaurea montana	Montane star thistle	Forb	None
Centaurium erythraea	Common centaury	Forb	None
Clematis vitalba[3]	Old man's beard	Vine	Class C
Conium maculatum	Poison-hemlock	Forb	Class B-designate

Daphne laureola	Spurge-laurel	Shrub	Class B
Echium vulgare	Common viper's-bugloss	Forb	Class B-designate
Heracleum mantegazzianum	Giant hogweed	Forb	Class A
Hieracium aurantiacum	Orange hawkweed	Forb	Class B-designate
Iris pseudacorus	Yellow iris	Forb	Class C
Leucanthemum maximum	Shasta daisy	Forb	None
Linaria dalmatica ssp. *dalmatica*	Dalmatian toadflax	Forb	Class B-designate
Lythrum salicaria	Purple loosestrife	Forb	Class B-designate
Petasites japonicus	Japanese butter-bur, Japanese sweet coltsfoot	Forb	None
Persicaria wallichii (syn. *Polygonum polystachyum*)	Himalayan knotweed	Forb	Class B-designate
Rubus odoratus	Purple flowering raspberry	Subshrub	None
Rubus vestitus	European blackberry	Subshrub	None
Silene latifolia	White campion	Forb	Class C
Ulex europaeus	Common gorse	Shrub	Class B-designate

[1]*Binomials and common names are per the University of Washington Burke Herbarium's Washington Flora Checklist, at* http://biology.burke.washington.edu/herbarium/waflora/checklist.php.

[2]*Noxious weed listing is per the 2013 Clallam County Noxious Weed List, at* http://www.clallam.net/weed/doc/WeedList2013.pdf. *"Select" plants are Class B and C noxious weeds selected for extra measures to control spread.*

[3]Clematis vitalba *is in the watershed but not considered a direct threat to the reservoirs.*

Second-priority invasives (Table 3) are so common in the watershed that it's impractical to treat them on a large scale unless they start dominating plant communities or growing near the drained reservoirs. They will be treated only in the reservoirs during and after dam removal to try to prevent them from becoming dominant (Chenoweth, Acker & McHenry 2011). Not all

nonnative plants in the Elwha are considered an imminent threat: the appendix lists all nonnative plants recorded in the watershed as of 2011 (Chenoweth, Acker & McHenry 2011).

Table 3: Secondary invasive nonnative plants that are common in the lower watershed, to be treated (1) in priority treatment sites and in the reservoirs during and after dam removal or (2) if they later start to dominate plant communities.

Scientific name[1]	**Common name(s)**	**Growth habit**[2]	**Noxious weed designation**[3]
Agrostis gigantia	giant bentgrass, black bent	Graminoid	None
Agrostis stolonifera	creeping bentgrass, spreading bent	Graminoid	None
Dactylis glomerata	orchard grass	Graminoid	None
Elymus repens	quackgrass, blue wildrye	Graminoid	None
Holcus lanatus	common velvet grass	Graminoid	None
Leucanthemum vulgare	oxeye daisy	Forb	Class C
Schedonorus arundinaceus	tall fescue	Graminoid	None
Phleum pratense	common timothy	Graminoid	None
Ranunculus repens	creeping buttercup	Forb	None
Rumex acetosella	common sheep sorrel	Forb	None

[1]*Binomials and common names are per the University of Washington Burke Herbarium's Washington Flora Checklist, at* http://biology.burke.washington.edu/herbarium/waflora/checklist.php.
[2]*Noxious weed listing is per the 2013 Clallam County Noxious Weed List,* at http://www.clallam.net/weed/doc/WeedList2013.pdf. "Select" plants are Class B and C noxious weeds selected for extra measures to control spread.

Success Strategies

Invasive nonnative plants can seriously harm habitats or species. They can alter ecosystem structures; displace native species; provide refuge and resources for other nonnative organisms; and change genetic fitness of natives (Bossard, Randall & Hoshovsky 2000). According to Boersma, Reichard, and Van Buren (2006), "We are only beginning to understand the impacts of these harmful introduced species, but we know that they may alter relationships

among species and change community characteristics. They do this by… introducing diseases, altering sedimentation or erosion, changing soil chemistry, altering the frequency or intensity of fires, modifying hydrology, and changing the survival, reproductive success, and growth of other species."

Examples of all these impacts and more are discussed for every species herein. Dominating part of the community structure can itself cause grave effects. For example, *Geranium robertianum* (regionally known as "Stinky Bob"), a flimsy and malodorous perennial, can invade undisturbed forest and quickly elbow out native, herbaceous understory plants that provide food and shelter for a host of creatures (CCNWCB 2013). A less-sophisticated competitive technique is to simply smother other plants. *Hedera helix* (English ivy) and *Hedera hibernica* (Atlantic ivy) do just that, clambering over other vegetation and reducing photosynthesis. When winter comes, the ivies' evergreen leaves add so much weight that the supporting trees sometimes snap in storms.

Other invasive plants have multiple deleterious effects. *Phalaris arundinacea* (reed canarygrass), for example, can change hydrology, cause erosion and sedimentation, locally decrease certain arthropods, and reduce in-stream shade—all of which severely damage habitat for salmon (*Oncorhynchus* spp.) and trout (*Salmo* spp.). In-stream shade, clear water, cover, and food are examples of ecosystem services that native species provide and this usurper does not (Seebacher & Reichard 2008).

Other species, such as *Bromus tectorum* (cheatgrass), can (among other effects) increase the frequency and intensity of fires by leaving dead grass stalks for fuel. Fire usually benefits such species by stimulating regrowth, and it further reduces competition because our native plants are not fire adapted. Other dirty tricks of nonnative invasive plants include monopolizing water; preventing succession by suppressing native plant propagation; emitting secondary compounds, called "allelopaths," that block nearby species from growing; altering trophic structures (who eats what and who eats whom); changing nutrient cycling; and altering soil

properties (Bossard, Randall & Hoshovsky 2000; Boersma 2006; Boersma, Reichard & Van Buren 2006a).

Simply killing or removing the offending species doesn't always correct the situation. It can take years or longer for natives to grow there again. "Invasive species may alter the delivery of ecosystem services and in some cases completely disrupt them through changes in nutrients or disturbances such as fire. The changes may last forever" (Boersma, Reichard & Van Buren 2006).

The Science of Prediction

Even when initial colonizers don't forever alter an ecosystem, they can still influence future plant composition for a long time (Mansfield 1993; Shafroth *et al.* 2002). Initial colonizers in the bottoms of former reservoirs—which are typically bare, moist, high in nutrients, and lacking a native seed bank—"tend to be weedy plants with typical ruderal traits such as rapid growth, high levels of seed production, and effective dispersal mechanisms" (Shafroth *et al.* 2002). Comprising clay, silt, sand, gravel, cobble, and boulders chipped from mineral bedrock and glacial deposits high in the mountains (FINAL EIS 1995), the soils lining the old Lake Aldwell and Lake Mills might favor our native seral species, which thrive in low-nutrient systems. But plenty of nonnative plants are already lining the shores, armed with adaptive traits and carrying fully loaded seedpods (metaphorically speaking).

Figure 4: Former Lake Aldwell, October 22, 2012. (Photo courtesy of Arthur Lee Jacobson ©2012.)

Plants great at reproducing and good at tolerating stress are often the best invaders (Reichard 2011). Plants that produce lots of seeds or that excel at dispersing—such as by packaging its seeds in bird-attracting fruits—can

become invasive (Reichard 2011). Alternatively, the capacity to rapidly spread through vegetative means, such as rhizomes, stolons, bulblets, and tip layering, can predict invasibility. Such plants often sail through such stressors as foliage damage (for example, by browsing or trampling) and reproduce from fragments if separated from the clonal parent. Other stress-tolerating strategies include fixing nitrogen through root nodules, which improve success in low-nutrient, post-disturbance habitats; the ability to photosynthesize year-round via evergreen leaves or stems; and long survival of seeds banked in the soil, enabling them to wait for favorable conditions in which to germinate (Reichard 2011). Many invasive species can establish in a wide range of climates, soil types and textures, and hydrologic situations, from drought to flood.

Still, predicting where they'll grow is a challenge because the bare sediments in the Elwha have differing textures, structures, and moisture levels; likely lack beneficial mycorrhizae; and are exposed to harsh conditions, such as sun, wind, and rainwash. Predicting which nonnative plants will invade and where is confounded by the complexities of seed recruitment patterns

and unknowns about the growing properties of the soils.

Figure 5: Drained Lake Aldwell—a difficult place to grow plants. (Courtesy of Luke McGuff, NatureIntrudes.net, ©2013.)

Chenoweth's (2007) study on how to predict *Alnus rubra* (red alder) and *Elymus glaucus* (blue wildrye) recruitment and germination in Elwha sediments motivated Michel, Helfield, and Hooper (2011) to try to further predict (1) patterns of native seed rain and (2) germinability of three native and two nonnative species in Elwha substrates. The authors collected so few seeds in the 3-month seed-rain experiment that they could conclude only that summer colonization via seed rain was likely to be slow. In the 12-week germination experiment, the authors sowed seeds pretreated to break dormancy in alluvial sand, in a 50-50 mix of alluvial sand and reservoir sediment, and in 100% reservoir sediment. Although they published their results, I did not use them in this guidebook because conditions vary dramatically between the greenhouse trial and field conditions. Thus predicting which species will succeed—and where—in the biotically scrubbed, harsh conditions of the Elwha sediments is as much an art as a science.

What scientists have learned is that few legacy propagules remain from before the dams (Chenoweth 2007), and most of the exposed areas are too far from forest-edge seed rain to naturally regenerate anytime soon (Chenoweth, Acker & McHenry 2011).

Knowing the Enemy

This guide can help scientists predict where new infestations will occur—one of the bigger problems that Mack *et al.* (2000) identify in managing invasive nonnatives. But catching these dangerous pests requires everyone in the watershed—not only scientists and staff but volunteers, visitors, tribal members, and students—to be able to quickly identify new nonnative species and new invasions, before they establish roots and/or start banking seeds. “Effective control will require awareness and active participation of the public as well as natural resource managers and specialists” (Bossard, Randall & Hoshovsky 2000).

Early detection is key to preventing new infestations and cheaper than controlling them after they establish (Mack *et al.* (2000) because once they establish, the damage they do to the environment and its denizens can’t necessarily be undone. “Preventing or stopping just one new invasive weed would be of greater conservation benefit in the long run than far most costly and difficult efforts to control an already widespread pest” (Bossard, Randall, and Hoshovsky (2000). Next, information herein may help inform scientists studying this landmark restoration. Although the Elwha itself is ecologically unique, some of this knowledge may be applicable to future dam removals. Also, environmentalists, recreationists, native plant enthusiasts, and students of all kinds may use this information to learn about native plant restorations and the many ways invasive nonnative plants can interfere with them. Perhaps even a legislator or two, reading these descriptions, will more-fully appreciate the dangers invasive nonnative plants pose to our unique flora and fauna—and support future noxious weed legislation. “Our first line of defense is knowledge, followed by political action to slow their spread, and finally control” (Boersma 2006).

Where to Go from Here

Controlling invasives was a first step in revegetating the Elwha, and some kind of monitoring will occur in perpetuity (Chenoweth personal communication, 18 Aug 2013). The Lower Elwha is not an isolated area. It is near the city of Port Angeles, cut by Washington State Route 112 and US 101 and accessible by road and by trail. Humans, other animals, wind, and other dispersers can introduce new invasive nonnative species at any time—either those already infesting Clallam County or plants that have yet to be introduced. Trusted nonnative plant species can also change their invasiveness over time or in unusual circumstances. "Any exotic plant species can become invasive in the unique conditions associated with the dewatered reservoirs," write Chenoweth, Acker, and McHenry (2011), who wrote the Elwha revegetation plan.

Often, invasive species go through a lag period, up to decades long, before they start to rapidly spread and dominate plant communities. One example might be *Ilex aquifolium* (English holly), whose glossy foliage and ruby berries signify Christmas to so many celebrants. Slow to germinate, slow to mature, and extremely long lived—up to 300 years—this species has been laying low in the Pacific Northwest since its introduction to Portland, Oregon, possibly in 1878 (Wieman 1961). Many of its traits are atypical for an invader; however, land managers are starting to notice its rapid population expansion in urban parks. Further research is needed to determine whether *I. aquifolium* is expanding its invasion into natural ecosystems and if so, where.

Careful monitoring must continue indefinitely to identify changes in ecological patterns, as described in the revegetation plan: "Even if a species is not considered invasive in the literature, known populations will be monitored in order to observe the growth patterns and changes in number of patches and patch sizes. If a species increases in number of patches, vigorous growth rates, abundant seed production, and/or creates monocultures, the species would be considered invasive and appropriate actions taken" (Chenoweth, Acker & McHenry 2007).

Among priorities for further funding are long-term monitoring, maintenance, and invasive species management.

At any time, one or more plants either in this guidebook or suggested as additions in the following paragraphs could seriously threaten the revegetation and restoration of the Lower Elwha Watershed. The best way to protect the Elwha—and any other treasured natural area—is for as many people as possible to learn as much as possible about both native and nonnative plant species and to alert the gatekeepers if ecological patterns seem to change. "Understanding the biology and ecology of each weed provides insights into how to manage the infestation effectively within a dynamic plant community" (Sheley, Petroff & Borman 1999).

In the interest of educating potential gatekeepers, writing this guidebook should continue with the watch-list species—those nonnative invasive species not currently in the Elwha—as listed in Table 2. Two-thirds of these plants are not only present but designated as noxious weeds in Clallam County, so this task is urgent. The next priority for this guidebook should be including photographs of the species in Table 3 and in the appendix along with a brief note about their identification and ecology, even if only in brief, as in the print book *Weeds of the West* (Whitson 2004). Any photographs that ONP staff, LEKT, or volunteers could contribute would immeasurably speed writing and gathering permissions for the next phases of this book. Appeals could be made to the Washington Native Plant Society and to hobbyist photographers—for instance, on the Elwha restoration web site or in print materials.

In addition, the Burke Herbarium plant collection lacks many native and noxious nonnative species from Olympic National Park. Arrangements could be made with Herbarium Collections Manager David Giblin for samples to be properly collected, notated, and delivered for processing.

Sharp and educated eyes are needed to spot new invasions or to notice existing plants starting to dominate a plant community. The revegetation plan states, "The most effective way to identify pioneering exotic species will be to train monitoring and planting crews to identify all

species that are common in the Elwha." I would argue that the more people who can identify these species, the better control project managers will have over potential invasions.

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Family: Poaceae

Bromus tectorum L. (BROTEC)

Synonym: *Anisantha tectorum* (L.) Nevski

Common name: cheatgrass (downy brome, downy chess)

Cheatgrass is the most widespread and successful annual brome grass introduced from Eurasia (Hulbert 1955), densely monoculturing millions of acres around the world. Usually a winter annual, *B. tectorum* emerges before native plants, outcompeting them for early spring water (Jones 2006). Its dense growth—as many as approximately 11,000 plants/yd^2 (13,000 plants per m^2) producing more than 1 billion seeds/acre (2.6 billion seeds/ha) (Mosley, Bunting & Manoukian 1999)—displaces native plants, including as many as 10-15 species of native grass (Jones 2006). In addition, it increases fire frequency, promoting its own growth but killing many native plants (Jones 2006). Its physical and genetic variability within populations also contributes to its success in almost all habitats (Mosley, Bunting & Manoukian 1999).

Distribution

Cheatgrass is present on the berms adjacent to the Glines Canyon and on the canyon walls. Although NatureServe (2012) lists its environmental impact as "high," Clallam County does not list cheatgrass as a noxious weed, probably because it is so rare there (Chenoweth, personal communication 2013). Washington State and the federal government also do not list it as a noxious invasive (APHIS 2012; WSNWCB 2013).

Figure 6: *B. tectorum* infestation. (Leslie J. Mehrhoff, University of Connecticut, Bugwood.org.)

Description

B. tectorum is a fairly short, cool-season annual grass, 2.0-23.6 in. (5.0–60.0 cm) tall, which can complete a full life cycle in as little as 2-3 months (Hulburt 1955). Its small, pale green flowers are arranged in many-branched clusters (panicles) to 7.9 in. (20.0 cm) that droop at maturity. Awns are diagnostically straight and 0.4-0.8 in. (10.0-15.0 mm). Arising from a branching base, the grass often leans later in the season. At maturity, it turns from light green to shiny purple before fading to tan in summer.

Figure 7: *B. tectorum* seeds showing long, straight awns. (Steve Hurst, USDA-NRCS PLANTS Database, plants.usda.gov.)

Note: Grasses are notoriously difficult to identify, and the terminology is specialized. See the glossary at the end of this book or get a good reference on grasses, such as *How to Identify Grasses & Grasslike Plants* (Harrington 1977), for line drawings and more-precise details.

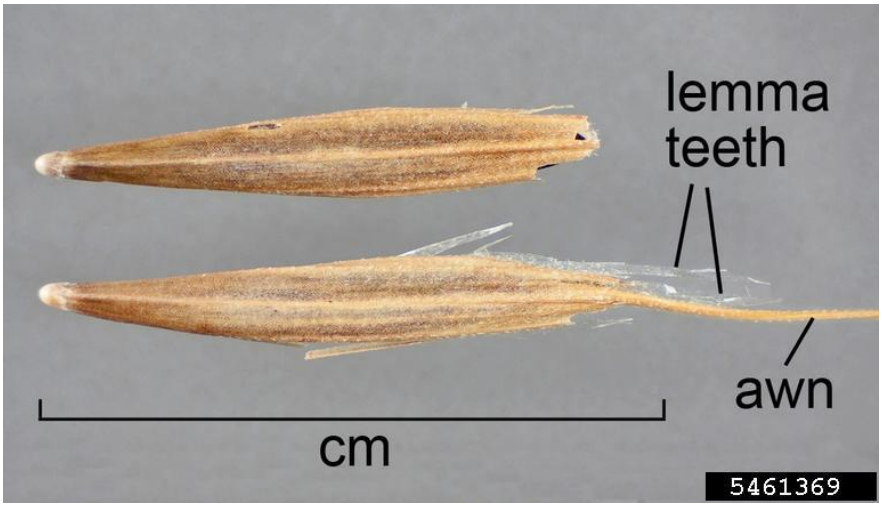

Figure 8: *B. tectorum* lemma, awn. (D. Walters and C. Southwick, CPHST, Bugwood.org.)

Similar Plants

Several other *Bromus* spp. may occur in the Elwha, including native bromes—*B. sitchensis* (Alaska brome), *B. carinatus* (California brome), *B. pacificus* (Pacific brome), and *B. vulgaris* (Columbia brome)—and nonnative bromes—*B. commutatus* (hairy brome), *B. diandrus* (ripgut brome), and *B. hordeaceus* ssp. *hordeaceus* (soft brome) (Buckingham *et al.* 1995).

All the Clallam County bromes except *B. sitchensis, B. vulgaris,* and *B. tectorum* are upright, much taller than *B. tectorum*, and have open, upright or spreading (not drooping) panicles (Chenoweth, personal communication Aug 2013).

Figure 9: Ligule fringed, sheath closed only at bottom. (Joseph M. DiTomaso, University of California - Davis, Bugwood.org.)

Table 4: Comparison of selected traits of drooping bromes.

Species	**Native status**	**Duration**	**Distinguishing features**[1]	**Elwha status**	**Habitat**
B. tectorum (cheatgrass)	Nonnative	Winter annual	• *Usually* 8-20 in. tall • Blades very narrow, ~0.1 in. wide, flat • Blooms mid-April • ***Mature panicles* open, loose, drooping (often to 1 side),** 2-8 in. • Primary branches usually with 4-8 **small spikelets** <1 in. • **Sharp floret bases** • **Awns straight, 0.4 in. or longer** • Lemma, narrow; body ~0.4-0.5 in. long	Present at Glines Canyon	Waste and disturbed areas

			• Lower glumes with 3 nerves • Green or purple; brown by summer • **Note:** Panicles can start as tight and narrow but relax and droop over time.		
B. sitchensis	Native	Perennial	• Stout to 6 ft. tall • Blades flat, 0.3-0.6 in. wide • Panicle 4-14 in., erect, spreading, or drooping • Spikelets (4-10) towards branch ends, 0.8-1.6 in. long • Glumes shorter than lemmas • Lemmas hairy, keeled, with 0.2-0.5 in. awns	Present (though uncommon) in the Elwha estuary and throughout the lower Elwha watershed. Part of the *Bromus* complex seeded in the drained reservoirs.	Woods; meadow and subalpine stream banks; talus slopes
B. vulgaris	Native	Perennial	• 2-4 ft. tall • Stem nodes often hairy • Leaves lax, flat, 0.2-0.4 in. wide • Panicle open, drooping • Ligules ~0.1-0.2 in. • Spikelets with few flowers • Lemmas hairy only on margins • Awns ≥0.2 in.	Very common in the lower watershed, along trails, in meadows, and in the forests. Tolerates shade.	Shaded to open forest, openings, thickets, moist and dry banks, subalpine meadows, dry rocky slopes

[1] See "Glossary" for grass terminology.

B. sitchensis holds its large, open panicles 3.9-13.8 in. (10.0-35.0 cm) long either upright or drooping, but it grows 20.0-60.0 in. (50.0-150.0 cm) tall—up to 3 times taller than *B. tectorum* (2013). *B. vulgaris* has drooping panicles and turns purple, but at 23.6-39.4 in. (60.0-100.0 cm), it is significantly taller than *B. tectorum* (Chenoweth, personal communication 2013), and its

leaf blades are lax and wider 0.2-0.4 in. (5-10 mm) than those of *B. tectorum*. See a good grass book to better distinguish the drooping bromes.

QUICK ID

- Short compared to other bromes—usually <2 ft.—with leaning stems
- Drooping panicles, often to 1 side, 2-8 in. at maturity
- Sharp florets
- Straight awns usually 0.4 in. or longer
- Turns purple June to July, tan-brown late summer
- Soft-hairy, long and narrow leaves ~2-5 in. long, ~0.1 in. wide
- Sheaths soft-hairy at bottom of plant but often hairless at top
- Sheaths fused only at their bases

Roots

Fibrous, branching roots grow as deep as 6.6 ft. (2.0 m) (Hulburt 1955) but are mostly in the top 11.8 in. (30.0 cm) of the soil (Jones 2006).

Figure 10: *B. tectorum* roots. (Leslie J. Mehrhoff, University of Connecticut, Bugwood.org.)

Seedlings

B. tectorum plants usually spend the winter as small, bright green seedlings, growing primary roots (Young 2000; DiTomaso & Healy 2007). They resume growth early spring (Mosley, Bunting & Manoukian 1999), extending long lateral roots that are key to its success. They continue growing roots until soil moisture is gone (Young 2000).

Distinguishing features of seedlings include bright green color, hairy leaves, and, at the base of the plant, hairy sheaths, which wrap the stems at the bases of the leaves (Mosley, Bunting & Manoukian 1999). Sheaths are often hairless at the top of the plant.

Leaves

Leaves are narrow, soft-hairy, and flat, 2.0-4.7 in. (5.0–12.0 cm) long and 0.08-0.16 in. (2.0–4.0 mm) wide. At their bases, the leaves sheath the stem for more than half their length (DiTomaso & Healy 2007).

Flowers

Cheatgrass flowers from mid-April through June (Knoke, Giblin & Legler 2005+) in open, multibranched clusters (panicles) to 2.8-7.9 in. (7.0–20.0 cm) long. As they mature, panicles droop and change from light green to purple. Each spikelet, which is up to 0.8 (2.0 cm) long, contains 2-8 florets topped with long, straight awns. The awns are usually 0.4 in. (1.0 cm) or longer. Glumes and lemmas, awns are hairy.

Fruits

Fruits are single-seeded and do not split open.

Reproduction

Cheatgrass reproduces exclusively by seed, producing 25-5,000 per plant (Jones 2006), depending on density (Mosley, Bunting & Manoukian 1999). Plants only 1-2 in. (2.5-5.1 cm) tall can produce viable seed (Mosley, Bunting & Manoukian 1999).

Maturing in June and July, most seeds germinate in fall of their first year (Jones 2006), although they can also germinate in winter and spring (DiTomaso & Healy 2007). Some seeds mature before the flowers turn purple (Hulbert 1955). Although germination rate is extremely high, most seeds do not germinate immediately after dispersing in summer, requiring several weeks of cooler temperatures (Hulburt 1955). Any remaining seeds form a bank that lasts 2-3 years (Jones 2006) or possibly as long as 5 years (DiTomaso & Healy 2007). Late spring rains can stimulate a second seed crop in fall (Zouhar 2003).

Figure 11: Plant turns purple at maturity. (Joseph M. DiTomaso, University of California - Davis, Bugwood.org)

B. tectorum seeds travel short distances in wind (Hulburt 1955) and by rodents caching them for food (DiTomaso & Healy 2007). They can travel long distances in water or stuck to animals and vehicles. Upland birds and other small mammals eat and disperse the seeds as well (DiTomaso & Healy 2007).

Successional Status

Ecosystem disturbance accelerates cheatgrass invasions, but *B. tectorum* can also invade intact habitats, such as undisturbed grassland and shrub grassland (Jones 2006). It dominates disturbed sites, but with sufficient moisture, it can remain present as a minor component in older forests (Mosley, Bunting & Manoukian 1999).

Cheatgrass can also occur as a climax dominant species on sites previously bearing forbs and grasses. Although deep shade limits its invasion, it can grow beneath shrubs. In the Intermountain West, it does not thrive in mature forests, such as those dominated by Western hemlock (*Tsuga heterophylla*), grand fir (*Abies grandis*), Western redcedar (*Thuja plicata*), or Douglas-fir *(Pseudotsuga menziesii)* except in dry, sunny openings or disturbed areas (Hulburt 1955).

Ecology

B. tectorum tolerates most soils and a huge range of climatic and growing conditions (Mosley, Bunting & Manoukian 1999). Growth continues just above freezing. It is extremely competitive in drier areas (Mosley, Bunting & Manoukian 1999), preferring regions with summer drought and average annual rainfall of at least 6-22 in. (15-56 cm) (Skinner *et al.* 2008). It frequently grows in coarse-textured (Young 2000) and sandy soils (DiTomaso & Healy 2007). Growth starts at temperatures just above freezing and ceases at 60˚ F (15˚ C) (Young 2000).

Impacts

Outcompeting native plants and preventing their establishment (Mosley, Bunting & Manoukian 1999), cheatgrass interferes with successional change and reduces biodiversity. It changes soil hydrology and nutrient dynamics, and increases fire frequency, facilitates invasion by other nonnative plants). It also changes vascular arbuscular mycorrhizal fungal communities, reducing their number and diversity (Goodwin 1992).

B. tectorum sucks moisture out of soil to 28 in. (70 cm), killing adjacent plants and reducing competition (Hulburt 1955; Young 2000). With populations varying greatly year to year, it invades in "pulses," taking over in years when other plants are stressed by drought, by fire, or by browsing (Mosley, Bunting & Manoukian). *B. tectorum* increases the intensity and frequency of fires, which favors its own life cycle and encourages other nonnative, fire-adapted invasive plants. In general, Elwha native plants are not adapted to frequent fires and may be killed.

Although deer, elk, and Canada geese eat *B. tectorum* in late winter and early spring, when it is the only tender green on the menu, it rapidly becomes unpalatable (Skinner *et al.* 2008). Soon, the barbed cheatgrass awns stiffen, causing infections and eye damage to animals that feed on it (Mosley, Bunting & Manoukian 1999).

Management

Elwha teams are treating cheatgrass with Plateau (imazapic), Milestone (aminopyralid), and Roundup Pro (glyphosate) in early spring, before plants produce seed (Chenoweth, McHenry & Acker 2011).

Eradicating *B. tectorum* is often not feasible, as applying chemicals for only 1 year increases seed production (Mosley, Bunting & Manoukian 1999). As plant density decreases, seed production increases, bolstering the seed bank, so plants that regenerate from the seed bank

will need to be treated for several years (Jones 2006). Efforts to control it must include establishing native plants (Mosley, Bunting & Manoukian 1999).

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Family: Asteraceae

Cirsium arvense (L.) Scop. (CIRARV)

Common name: Canada thistle (creeping thistle, California thistle, field thistle)

"Canada thistle is one of the world's worst weeds," state Townsend and Groom in *Invasive Species of the Pacific Northwest* (2006). Reproducing both sexually and vegetatively, its roots can spread 13.1-16.4 ft. (4.0-5.0 m) and 3.3-6.6 ft. (1.0-2.0 m) a year (Bayer 2000), quickly forming dense clonal patches (Jacobs, Sciegienka & Menalled 2006).

Figure 12: *C. arvense.* (Courtesy of Luke McGuff, NatureIntrudes.net, ©2013.)

Its copious seeds can disperse over long distances (Townsend & Groom 2006). Already extremely difficult to control (Townsend & Groom 2006), *C. arvense* management in Clallam County is further complicated by the presence of three other *Cirsium* spp., including two natives.

Distribution

The greatest concentration of *C. arvense* is upstream of the roads in Geyser Valley, including Humes Ranch. It occurs along roads, in reservoir deltas, and in open, disturbed sites, such as fields, forest openings, and on river banks. Washington State (WSNWCB 2010) has declared it a Class C noxious weed. NatureServe (2012) ranks its impact (I-Rank) as "high/medium."

Figure 13: Hairless stems lack wings. (Leslie J. Mehrhoff, University of Connecticut, Bugwood.)

Description

Although physical characteristics may vary, *C. arvense* is a 1.0-4.0 ft. (0.3-1.2 m) herbaceous perennial with small, purple to white flowerheads; male and female flowers usually on separate plants (subdioecious); and spiny but hairless stems that lack conspicuous wings.

Its leaves are prickly and deeply incised. It takes some practice to correctly identify nonflowering *C. arvense*, especially the seedlings (Chenoweth 2012, personal communication).

Figure 14: Rosette (juvenile) stage. (Robert Vidéki, Doronicum Kft., Bugwood.org.)

Similar Plants

Other *Cirsium* spp. in the Elwha—such as nonnative *C. vulgare* (bull thistle) and native *C. brevistylum* (clustered or short-style thistle) and *C. edule* (edible or Indian thistle) (Knoke, Giblin & Legler 2005+)—don't have the characteristic *C. arvense* combination (Pojar & MacKinnon 1994):

- Small, almost spineless flowerheads
- Male and female flowers on separate plants
- Green stems without spiny wings
- Creeping rhizomes

Also a common noxious weed in the Elwha, *C. vulgare* is not as harmful as *C. arvense* because it grows only from seed, does not spread as aggressively (Townsend & Groom 2006), and is not perennial (Woodward *et al.* 2011).

Quick ID

- Herbaceous plant with slender, spiny (but hairless) stems to 4' tall
- Clustered 1" purple (to white) flowerheads, almost spineless
- Male and female flowerheads usually on separate plants
- Leaves prickly but not spiny (Townsend & Groom 2006)
- Green stems without spiny wings
- Creeping, rhizomatous roots

Roots

The key to the species' success are its three types of root—taproots, laterally spreading roots, and aerial roots that can form anywhere along stem. A seedling first grows a slender taproot and starts vigorously producing horizontal roots within weeks of germination. Roots can grow 6.0-15.0 ft. (1.8-4.6 m) deep (Jacobs, Sciegienka & Menalled 2006). They are associated with mycorrhizal fungi.

Seedlings

Seedlings emerge as irregularly lobed, spiny rosettes, with leaves mostly 0.2-0.6 in. (5.0-14.0 mm) long by 0.1-0.2 in. (3-6 mm) wide. Leaves are alternate, narrowly oval, and have stiff hairs on top and a few soft hairs beneath, where the midvein is shiny. Leaf margins are wavy or unevenly toothed, with each tooth ending in a small prickle. Bases taper into long, winged stalks (DiTomaso & Healy 2007).

Figure 15: First true leaves. (Ohio State Weed Lab Archive, Ohio State University, Bugwood.org.)

If seedlings emerge in spring, they can elongate and flower in one season. If they emerge in late summer or fall, they remain rosettes until they die back in a hard frost (Jacobs, Sciegienka & Menalled 2006).

Figure 16: Leaves are densely white-hairy beneath. (©2004 Ben Legler.)

Leaves

Leaves are lance-shape, light to dark green, and deeply incised with prickly margins and dense, white hairs on the underside. Alternately arranged, they are 1.2-7.0 in. (3.0-18.0 cm) long and 0.2-2.4 in. (0.5-6.0 cm) wide. Bases of the leaves clasp the stem or even run down it a little (Bayer 2000).

Flowers

In the Asteraceae family, *C. arvense* flowerheads may each comprise hundreds of flowers. Appearing July to September (Townsend & Groom 2006), flowerheads are nonspiny and small, at 0.4-0.7 in. (1.0-2.0 cm) diameter and 1.0 in. (2.5 cm) tall (Bayer 2000). Many-branched seed

bristles (pappi) make ripe female flowerheads look fluffy and cottony when flowers mature. Insects, especially bees, pollinate them.

Fruits

Fruits are tan, single-seeded seeds, each with a plume (pappus) for wind dispersal.

Reproduction

C. arvense reproduces both sexually and vegetatively. A female plant can produce 1,500-5,000 seeds per stem (Jacobs, Sciegienka & Menalled 2006), which germinate easily and can live as long as 20 years (Townsend & Groom 2006). Most seeds fall near the parent (Bayer 2000). Hikers, machinery, and pack-animals can carry seed in mud. In the Elwha, seeds and root fragments travel long distances by water (Woodward *et al.* 2011). Plumes, however, are only weakly attached, so wind disperses seed poorly (Jacobs, Sciegienka & Menalled 2006).

Figure 17: Fluffy white pappi help disperse seed in wind. (Leslie J. Mehrhoff, University of Connecticut, Bugwood.org.)

C. arvense spreads vegetatively by root growth and chunks of stem and roots. Roots can grow laterally 13–20 ft. (4–6 m) in one season, and they grow year-round. Buds can form anywhere along the roots at any time, producing new plants and forming clonal patches more than 115 ft. (35 m) in diameter. Root fragments as small as 0.3 in. (0.8 cm) long can generate new plants (Jacobs, Sciegienka & Menalled 2006).

Successional Status

An early successional species, *C. arvense* can resprout after the most severe disturbances. It was a common weed on Mount St. Helens soon after the volcano erupted in 1980 (Wood & del Moral).

Ecology

C. arvense grows best in disturbed, open, moist sites and in dry, sandy soils. Occurring at the edges of forests, it can tolerate light shade, although deep shade of forests and other dense plant communities prevent seedling growth. Hardpan, gravel, and sand also limit spread. saturated soils (Bayer 2000).

Impacts

Forming clonal stands that can spread indefinitely, *C. arvense* displaces native plants through shading, resource competition, and allelopathy. It alters community structures, reduces species diversity, threatens rare species, and stabs hikers (Bayer 2000).

Management

Effective management starts with positively identifying *Cirsium* thistles to avoid killing natives (Bayer 2000). In the Elwha, park personnel are treating *C. arvense* foliage before budbreak with Milestone (aminopyralid) (Chenoweth *et al.* 2011).

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Family: Fabaceae

Cytisus scoparius (L.) Link (CYTSCO)

Common names: Scotch broom, Scot's broom, common broom

Cytisus scoparius is a deciduous shrub so successful in the Pacific Northwest that "it has endangered much of our region's distinctive rain shadow flora" (Pojar and McKinnon 2004). Although not common in the Elwha, *C. scoparius* is a threat because it is highly adaptable, has photosynthetic stems, seeds prolifically, fixes nitrogen, and matures quickly (Peterson and Prasad 1998; Bossard 2000; Dougherty 2003). Furthermore, it makes soil properties hostile to native plants, an effect that lasts for years after removal (Reichard 2011).

Distribution

In the Elwha, *C. scoparius* is growing on the berms formerly surrounding the Glines Canyon Dam (Woodward *et al.* 2011). Clallam County has designated *C. scoparius* as a Class B-select weed to prioritize its control (CCNWB 2013).

Washington State—where *C. scoparius* is common along roadways—has listed it as Class B noxious weed (WS Legis. 2012) and has prevented its sale through quarantine since 2010 (WSDOA 2010). The NatureServe rank for *C. scoparius* is "high" (NatureServe 2012).

Figure 18: *C. scoparius* invading roadside strip. (Courtesy of Luke McGuff, NatureIntrudes.net, ©2013.)

Description

Bountiful bright-yellow flowers, sometimes tinged red or purple, announce *C. scoparius* in spring. When it is not in bloom, its twiggy, photosynthetic branches and small, sparse leaves make this 3.0-10.0 ft. (0.9-3.0 m) shrub look mostly green (Dougherty 2003).

Figure 19: Its year-round green stems makes *C. scoparius* look green overall when not in bloom. (©2013 Cynthia Lee Riskin.)

It is both early and stress deciduous (Oneto *et al.* 2009), but its green stems enable it to continue growing after midsummer leaf drop and adapt to stressors such as herbivory, drought, and both low and high temperatures (Bossard and Rejmanek 1992). Green stems may help it grow year-round, although research conflicts (Bossard and Rejmanek 1992; Wheeler *et al.* 1997). Branches are strongly five-angled when young (star-shaped in cross-section), becoming smooth and brown with age (Bossard 2000; Oneto *et al.* 2009).

Individual plants usually live 10 to 15 years (CCNWB 2000), although some live much longer (Smith and Harlan 1991; Bossard 2000; Oneto 2009).

Similar Plants

Also bearing bright-yellow pea flowers, *Ulex europaeus* (common gorse) is easily distinguished by its mighty spines and hairy stems and seed pods. It is evergreen (Oneto *et al.* 2009).

Quick ID

- Deciduous shrub to 10 ft.
- Yellow pea flowers (sometimes with red or purple)
- Stiff green branches without spines or hairs
- Small, sparse, mostly trifoliate leaves
- Fruit a flattened pod, hairy on edges

Roots

C. scoparius roots are deep, with a forked taproot. Nitrogen-fixing bacteria on root nodes enable the plant to invade nutrient-poor systems (Hulting *et al.* 2008).

Seedlings

Seedling leaves are palmately compound, having three leaflets with entire margins.

Leaves

Leaves are alternate, ovate, and entire (Knoke, Giblin & Legler 2005+), with short or no stalks (Pojar & McKinnon 2004). They are trifoliate at the bases of branches, becoming simple farther out (Pojar & McKinnon 2004; Knoke, Giblin & Legler 2005+).

Flowers

Bright yellow flowers 0.8-1.2 in. (2-3 cm) form in leaf axils from early spring through June (Peterson & Prasad 1998; Bossard 2000; CCNWCB 2000;Hulting *et al.* 2008)

Figure 20: Bilabiate--two-lipped flower. (Leslie J. Mehrhoff, University of Connecticut, Bugwood.org.)

They are 2-lipped, with two upper and three lower lobes (Knoke, Giblin & Legler 2005+). C. scoparius has a mutualistic relationship with honey bees (Apis mellifera) and an obligatory one with native bees (Bonner and Karrfalt 2008).

Fruits

Fruits are flattened, dehiscent pods 1.0-3.0 in. (2.5-7 cm) long and 0.3-0.5 in. (8.0-13.0 mm) wide. They are hairy along the edges and turn black when mature. Each contains 3-12 bearing seeds, each bearing an eliasome, a small structure containing oil to attract pollinators such as ants.

Figure 21: Pods are green, with hairy edges, turning brown in summer. (Eric Coombs, Oregon Department of Agriculture, Bugwood.org.)

Reproduction

Reproducing by seed at 2-3 years (Bossard 2000), *C. scoparius* can resprout from root tissue (Bossard & Rejmanek 1994). A medium-size shrub can produce 12,000 seeds a year (Bossard 2000). With a hard coat that requires scarification to germinate, the seeds are viable for at least 5 and possibly as long as 50 years (Oneto 2009). The resulting seed bank can contain as many as 2,000 seeds/ft^2 (21,400/m^2) (Bossard 2000).

In summer to early fall (Zouhar 2005a), pods open with a pop (Bossard 2000), hurling seeds up to 10 ft. (3 m) (Jones 2006). Seeds disperse primarily through human activity, although water transport is also important (Woodward *et al.* 2011). Debris flows (Woodward *et al.* 2011), animals passing contaminated feed, birds (Zouhar 2005a), and ants (Bonner and Karrfalt 2008)—play a lesser role in distribution.

After fire or other damage, *C. scoparius* can regrow from crowns or stumps. Resprouting occurs at a higher rate during the rainy than the dry season (Bossard & Rejmanek 2004) and depends in part on the severity of the damage.

Successional Status

C. scoparius is an early successional species, growing best on disturbed soils in full sunshine. Although intolerant of deep shade, it can grow in open woodland and in open patches in forests. Bossard (2000) reports, however, that seedlings can tolerate up to 90 percent shade.

Impacts

C. scoparius changes trophic relationships, impedes succession, increases fire hazards, and modifies soils. Forming monospecific stands, broom decreases biodiversity, crowds out native seedlings, and inhibits wildlife (Zouhar 2005a; Woodward *et al.* 2011).

Figure 22: Monocultures are common. (Eric Coombs, Oregon Department of Agriculture, Bugwood.org.)

It is also changes soil chemistry, lowering pH and increasing soil organic matter, nitrate, and carbon (Dougherty 2003; Caldwell 2004; Reichard 2011). These effects persist for years after the weed is removed (Reichard 2011).

Management

Seed production needs to be decreased 95 percent for long-term control (Coombs *et al.* 2008). In the Elwha, some *C. scoparius* infestations are growing where the landscape is too steep or precarious to treat (Allen 2013). Where possible, crews are treating *C. scoparius* with time-independent foliar applications of Milestone (aminopyralid) and Garlon 3A (triclopyramine), with Roundup Pro (glyphosate) for cut stumps. Killing new seedlings and quickly revegetating are critical to controlling the plant (CCNWCB 2000; Hulting 2008).

The Clallam County Noxious Weed board (2000) suggests:

- Hand pulling young plants before they seed, when the soil is moist
- Cutting plants in summer, when soils may be too dry to permit resprouting, and chemically treating remaining stumps within 5–20 minutes
- Pulling older plants using a Weed Wrench
- Girdling plants using a torch

Clallam County is trying to reduce populations using biocontrols such as *Lecoptera spartifoliella* (twig-mining moth) and *Exapion (Apion) fuscirostre* (seed weevil), but it is too soon to determine their effectiveness (CCNWB 2000). *Bruchidius villosus* (broom seed beetle) is being studied for *C. scoparius* control.

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Family: Plantaginaceae (Scrophulariaceae, Veronicaceae)

Digitalis purpurea L. (DIGPUR)

Common names: foxglove, purple foxglove

Digitalis purpurea is a common sight in the Pacific Northwest—1 of 15 most-common weeds found in a 2001-2005 survey in Oregon and Washington (Gray 2006). This escaped garden favorite rapidly spreads in disturbed sites, reseeding copiously and displacing native plants that provide wildlife forage.

Containing the toxic cardiac glycosides used to manufacture the heart drugs *Digitalis* and digitoxin, a dosage of only a few hundredths of 1% of an animal's body weight can be lethal (DiTomaso & Healy 2007).

Figure 23: Foxglove is so common that many think it's native to the Pacific Northwest. (Photo courtesy of Arthur Lee Jacobson ©2013.)

Distribution

Clallam County has a huge population of *D. purpurea* (PNW Herbaria 2013). In the lower Elwha, *D. purpurea* is listed as a secondary species of concern (Chenoweth, Acker & McHenry 2011). With a NatureServe I-Rank of medium/insignificant (NatureServe 2013), it is not listed as a noxious weed by Clallam County, Washington State, or the federal government (CCNWCB 2013; WSNWCB 2013; APHIS 2012), perhaps because it is too rampant to eradicate. In the lower Elwha, *D. purpurea* is common along the Olympic Hot Springs Road and near the former site of the Glines Canyon Dam. In 2013, 6-10 flowering *D.*

purpurea plants were found near Boulder Creek at the south end of the former Lake Mills. Its I-rank is "medium/insignificant," but the NatureServe site (2012) states that "Given its propensity to escape cultivation, it is likely that *Digitalis purpurea* could become much more widespread."

Description

A biennial to short-lived perennial, *D. purpurea* spends its first year as a rosette of fuzzy gray-green leaves with toothed margins and a tap root. In early spring of its second year, it sends up a tall, leafy spike to 6.5 ft. (2.0 m) with large, bell-shape, purple to white flowers on one side.

Similar Plants

In flower, *D. purpurea* is unmistakable. In its vegetative stage, however, it can be confused with similarly fuzzy rosettes of nonnative *Verbascum thapsus* (common mullein) or *Symphytum officianale* (common comfrey) (DiTomaso & Healy 2007).

Figure 24: In the rosette stage, toxic *D. purpurea* is easily confused with other plants. (Courtesy of Arthur Lee Jacobson ©2013.)

Caution: Difficulty distinguishing rosettes of comfrey, mullein, and foxglove has led to poisonings in people who mistakenly drank foxglove infusions as tea (DiTomaso & Healy 2007).

Symphytum spp. have smooth-edged leaves with no teeth, unlike *D. purpurea*, which has rounded teeth on its leaf margins (DiTomaso & Healy 2007). The hair*s* on *V. thapsus* are star-shape (stellate)—although this characteristic may be difficult to determine in the field. In the former Lake Aldwell reservoir, common mullein is abundant on the high terraces at the south end.

Quick ID

- (Juvenile) Fuzzy rosette of oval leaves with small, rounded teeth
- Numerous, large, bell-shape purple to white flowers with dark spots inside, drooping along one side of the top of the flower stalk
- Fuzzy, alternate leaves decreasing eth to 20 in long
- (Reproductive) Herbaceous plant with flower stalk to 6.5 ft. in size up the stalk

Seedlings

D. purpurea spends its first year as a rosette, sending up a flowering stalk its second year. The stalk dies back in winter (Harris 2000).

Roots

The taproots on *D. purpurea* grow to a minimum of 6.0 in. (15.2 cm) (USDA [date unknown]).

Leaves

Leaves are grayish green-woolly above and gray-woolly below, with small, rounded teeth on the margins. Arranged alternately on the stem, leaves at the base are 5.9-19.7 in. (15-50 cm) long and 11.8-4.7 in. (3-12 cm) wide, decreasing in size upward.

Flowers

In its second year, *D. purpurea* sends up a spike to 3.3-6.6 ft. (1-2 m) tall. Its showy flowers in May through July are 1.6-2.4 in. (4-6 cm) long; drooping; purple, pink, and/or white; tubular to bell-shape blooms; with dark spots on the lower petal. Sometimes all three colors appear on one flowering stem (Reichard 1996). They are pollinated by insects.

Figure 25: Drooping flowers have spots inside. (Tom Heutte, USDA Forest Service, Bugwood.org)

Fruits

Fruits are capsules that split open in summer, releasing numerous minute seeds.

Reproduction

D. purpurea reproduces entirely by seed, which it disperses throughout the summer (Harris 2000). Each plant can produce up to 500,000 innately dormant seeds (Salisbury 1942; van Baalen 1982) A modest-size plant in the garden of H.N. Ridley (1930) produced nearly 100,000 seeds.

Although most seeds fall close to the parent, some disperse by wind and rain (Ridley 1930), in mud clinging to mobile objects and in water (Watterson & Jones 2006). Seeds can float for hours

and germinate while floating or after sinking (Watterson & Jones 2006). Typical invasions begin along roads, where human activities carry the seeds, and then along the river, especially on previously flooded bars and banks, along secondary water flows, and in low-gradient reaches (Watterson & Jones 2006).

Seed viability is high (Watterson & Jones 2006; RBG 2008), and ungerminated seeds form a large seed bank (van Baalen 1982). Buried seed viability scarcely decreases in the first 2 years, and they are not eaten, likely because of their toxicity (van Baalen 1982). Although germination decreased substantially after being tumbled with very coarse or fine sand or gravel in studies by Watterson & Jones (2006), viability was still 33.3%. Germination was best in moderately coarse materials, such as very fine gravel and medium sand. Seeds also germinated in fines and in a sand/gravel mix but did not germinate in very coarse or medium gravel. Increasing percentage of plant cover also decreases germination (Watterson & Jones 2006).

Successional Status

D. purpurea is a pioneer species, speedily populating disturbed habitats and forest openings. Seedlings can't push their roots through turf, so they require disturbed soil to establish (Harris 2000). Although USDA ([date unknown]) states that the weed is intolerant of shade, it tolerates partial shade well enough to persist into mid-successional forests (van Baalen 1982). Growth, seed production, and germination substantially decrease in mid-successional habitats, although small but stable populations—the result of seed banking—can persist into later stages (van Baalen & Prins 1983), awaiting a toppled tree or other disturbance to reinvade.

Ecology

This weed thrives in moist, moderately fertile substrates and is not drought tolerant (USDA [date unknown]). Nonetheless, its massive distribution throughout North America testifies to its broad tolerance of many conditions.

Impacts

D. purpurea can vigorously reproduce, displacing groundcover plants in both disturbed areas and in undisturbed forests. Wildlife has died after eating it (Reichard 1996).

Management

In the Elwha, staff is treating *D. purpurea* before flowering with foliar applications of Garlon 3A (triclopyr) and Roundup Pro (glyphosate) (Chenoweth, Acker & McHenry 2011). Herbicides may work on large infestations, although early spring and late summer herbicide trials with triclopyr and metsulfuron methyl on *D. lanata* in Kansas did not kill all the plants (Harris 2000).

Pulling stalks by hand is effective, particularly during spring of the plant's first year, when the soil is moist and the entire root will come out. Cutting the tops before seeds ripen can stimulate a second flowering in mid- to late summer. Active control needs to continue for 5 years and monitoring up to 10 years (Harris 2000).

Caution: Workers handling *D. purpurea* toxic leaves must protect themselves from extended contact. Smoke from burning the plant is toxic (Harris 2000).

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Family: Geraniaceae

Geranium robertianum L. (GERROB)

Common names: herb Robert, Robert geranium, stinky Bob

Geranium robertianum is a deceptively delicate herb that is easy to pull but difficult to eradicate. Unlike many invasive nonnative plants, it grows in full shade to full sun so can invade both intact and disturbed ecosystems. It forms vast, high-density, monospecific tracts, often outcompeting native plants.

Figure 26: *G. robertianum* can grow just about anywhere. (Courtesy of Arthur Lee Jacobson ©2013.)

"Herb Robert is a severe threat to forest understory habits by displacing small native plants" (CCNWCB 2013). Its life cycle gives it an additional edge over most native forbs: *G. robertianum* can be a spring or a fall annual (WSNWCB 1997), a biennial (Jones & Reichard 2009), or a perennial (Barndt 2006).

Distribution

G. robertianum is one of the most-common weeds in the Elwha, especially in Geyser Valley; on the Lake Aldwell Delta and other deltas; and along the river, trails, and roads (Woodward *et al.* 2011). Clallam County has designated it as Class B-select, requiring control in potential pathways to habitats where *G. robertianum* is a controlled or priority plant

(CCNWCB 2013). A Class B weed in Washington, it is spreading rapidly in forest understories (WSNWCB 1997).

Description

Variable in form, the juvenile can be a small rosette, and the reproductive plant can be lax or upright, with many branches to 10 in. (25.4 cm)—or as tall as 23.6 in. (60 cm). Its doubly dissected leaves, its brittle joints, and the soft, glandular white hairs on its stems are diagnostic. Flowers are usually 5-petaled, upright, and pink. Both stems and leaves often turn red in sun or cold.

Crushed leaves emit an unpleasant scent that Sarah Reichard likens to rancid peanut butter (personal communication, 2013) and Arthur Lee Jacobson (2008) describes as reminiscent of ginger or cilantro, earning it the nickname "stinky Bob." An unsubstantiated report suggests that the odor can trigger asthma attacks (WSNWCB 1997).

Figure 27: Red foliage on exposure to sun or cold. (Courtesy Arthur Lee Jacobson ©2013.)

Figure 28: The rounded, lobed foliage and 5-petaled flower of *G. robertianum.* (Rob Routledge, Sault College, Bugwood.org.)

Similar Plants

Dicentra formosa (Haw.) Walp. ssp. *formosa* (Pacific bleeding heart), which can intermingle with *G. robertianum* in partial to full shade, also has finely dissected leaves. Its stems, however, are hairless (glabrous) and unjointed, and its pink-and-white flowers face downward in an urn or a bell shape (CCNWCB 2013). Its leaflets are longer, narrower, and more sharply and deeply dissected than those of *G. robertianum*, which are deeply lobed. *D. formosa* ssp. *formosa* leaves have a light, fresh scent when crushed. Above-ground foliage of *D. formosa* does not take on a red tinge, and unlike *G. robertianum*, *D. formosa* dies back in mid- to late summer.

Figure 29: *Dicentra formosa.*

Seedlings

Most *G. robertianum* seeds germinate in fall or spring (Barndt 2006), although they can germinate almost any time (CCNWCB

2000). Spring-germinated plants emerge with kidney-shape seed leaves (cotyledons) attached to a hairy stem. Seeds that germinate in fall may overwinter as small rosettes, elongating in spring (WSNWCB 1997).

Figure 30: *G. robertianum* seedlings, just outgrowing their kidney-shape.
(Joseph DiTomaso, University of California - Davis, Bugwood.org.)

The rosette stage has several leaves on long petioles arising from a short stem. Approximately three weeks after germinating, deeply lobed true leaves form (Tofts 2004). Plants neither branch nor flower in this juvenile stage (Barndt 2006). Those that germinate in spring can flower and set fruit in their first year (WSNWCB 1997).

Quick ID

- Foul smell when crushed
- Herb generally to 10 in. or more, often growing in shade
- Finely dissected, rounded leaves
- 5-petaled pink flowers
- Soft-hairy stems, sometimes red
- Branches easily broken at joints

Roots

Small, fibrous roots make *G. robertianum* easy to pull, although disturbing the soil CAN improve soil conditions for the weed (WSNWCB 1997) and expose its seed bank. The roots occasionally form associations with arbuscular mycorrhizae (Boerner 1990; Fitter and Peat 1994).

Leaves

Leaves and stems may be green to red—the latter especially in winter or in the sun (CCNWCB 2000).

Figure 31: *G. robertianum* stems are hairy. (http://bruxellanatura.files.wordpress.com/2013/05/geranium-robertianum.jpg.)

Leaves are compound and polygonal in outline, with three to five deeply cut, rounded lobes that are dissected again (Tofts 2004).

Flowers

In the lower Elwha and in Clallam County, *G. robertianum* can flower and produce seed all year (CCNWCB 2000). It bears 5-petaled, pink (sometimes striped or rarely white) flowers in pairs, on long stalks coming from angle where the leaf meets the stem (axillary pedicels) (Tofts 2004). Flowers average 0.6 in. (15 mm) across (Barndt 2006). With unspecialized pollination requirements, they are pollinated by at least three species of small bees and flies (WSNWCB 1997), although they can self-pollinate more than 90% of the time (Barndt 2006).

Fruit

Fruit is a beaked capsule (WSNWCB 1997).

Figure 32: Beaked *G. robertianum* fruits. (Rob Routledge, Sault College, Bugwood.org.)

Reproduction

G. robertianum can produce seed in its first year and flower more than once in 12 months (Woodward *et al.* 2011). In Washington, under an open canopy, a population can produce 3,100 seeds/m^2; it produces fewer under a dense canopy (WSNWCB 1997). Because they prolifically produce seed that is viable for 6 (Barndt 2006) or more years, *G. robertianum* forms a large seed bank. One Royal Botanical Gardens study at Kew (2008) found that seed was 81% viable after 15 years in controlled storage.

Seeds ripen within 3 weeks (Barndt 2006) and launch as far as 21.3 ft. (6.5 m) from the parent plant (Jones & Reichard 2009). They bear a sticky strand at one end, adhering to almost anything: other plants, animals (including hikers and elk), and vehicles (Woodward *et al.* 2011). They also disperse by water (Jones & Reichard 2009). Seeds are not likely to disperse by water, sinking in less than 1 minute (Praeger 1913). Seeds can germinate soon after dispersal if moisture is sufficient (WSNWCB 1997). Most germinate in spring or fall (Barndt 2006).

Successional Status

Although it prefers partial to full shade (Bertin 2001), *G. robertianum* can tolerate full sun, forming vast monospecific tracts in dense forest and open, rocky outcrops. Reproduction is low under a heavy canopy, however (WSNWCB 1997).

Ecology

G. robertianum grows best in moderate- to high-nutrient, somewhat basic soils (Bertin 2001). It can grow almost anywhere, however, in railway ballast and on river banks, in forests or as an epiphyte on trees or shrubs. It does seem to be limited by climates with severe hot and cold temperatures; where annual rainfall is less than 0.82 in. (25 cm); or where soil pH is less than 4.5 (Tofts 2004). In Olympic National Park, it has overwintered under snow (WSNWCB 1997). (For more information on ecological tolerance, please see "Ecological Flora of the British Isles," at http://www.ecoflora.co.uk/search_species2.php?plant_no=830010370.)

Impacts

G. robertianum displaces native understory plants, disrupting succession and reducing biodiversity (WSNWCB 1997). Photosynthesizing year round, it gains an edge over native herbs by starting to grow earlier in spring, giving it an advantage. In the Pacific Northwest, it rapidly attains 50%-100% cover (Jones & Reichard 2009), shading out native understory plants and intercepting their seeds before they touch soil. They might also be allelopathic—that is, emit secondary compounds that keep neighboring plants from growing (Barndt 2006).

Management

In the Elwha, staff are treating infestations with preflowering foliar applications of Garlon 3A (triclopyramine) and Roundup Pro (glyphosate) (Chenoweth, Acker & McHenry 2011). The Washington Park Arboretum, in Seattle, has had success with four preemergent herbicides—Devrinol (napropamide), Ronstar (oxadiazon), Treflan (trifluralin and naphthalene), and Rout (oxyfluorfen and oryzalin) (WSNWCB 1997). A thick layer of mulch, renewed as it breaks down, might help suppress germination from the seed bank. Pull seedlings as they emerge (Barndt 2006).

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Family: Araliaceae

Hedera helix L. ssp. *helix* (Stace 1997) (HEDHEL)

Synonyms: *Hedera helix* L. in part [H&C]

Common names: English ivy, common ivy

Hedera helix L. ssp. *hibernica* (Stace 1997) (HEDHIB)

Synonyms: *Hedera helix* L. in part [H+C], *Hedera hibernica* (G. Kirschn.) Bean

Common names: Atlantic ivy, Irish ivy

The name "English ivy" is commonly misused for several invasive cultivars of nonnative *Hedera helix* and *H. hibernica* (Irish or Atlantic ivy). Genetic studies in the Pacific Northwest revealed that 83 percent the invaders were *H. hibernica* 'Hibernica,' and the remaining 17 percent were mostly *H. helix* cultivars, especially 'Baltica,' 'Pittsburgh,' and 'Star' (Clark, Reichard & Hamilton 2006).

Figure 33: Invasive ivy infesting a forest understory. (Courtesy of Luke McGuff, NatureIntrudes.net, ©2013.)

Thriving under most conditions, *Hedera* spp. rapidly form monocultures, toppling trees, displacing forest understories, and disrupting ecosystems.

Although most of the 14 species (500 cultivars) (American Ivy Society 2012) of *Hedera* are not invasive, we will refer these invasive ivies as "*Hedera* spp." or "invasive ivy" for the rest of this description.

Distribution

Hedera spp. in the Elwha are relatively rare, but most of what's out there is probably *H. hibernica* var. 'Hibernica' (Reichard, personal communication 2013). Clallam County and the State of Washington have designated *H. helix* 'Baltica,' 'Pittsburgh,' and 'Star' and *H. hibernica*

'Hibernica' as Class C noxious weeds (CCNWCB 2013, WSNWCB 2013). They have a NatureServe I-rank of "high/medium" (2012).

Description

Hedera spp. have two forms: a juvenile vine and a mature shrub. Both have woody bases and evergreen leaves.

Taking 10 or more years to mature, juvenile vines can grow densely as a groundcover to 8.0 in. (20.3 cm) tall or climb to more than 99.0 ft. (30.2 m) (Reichard 2006).

In general, only vertically growing plants mature to produce flowers and berries (Robbins 1960; Hitchcock and Cronquist 1973; Clarke *et al.* 2006; Reichard 2006), although mature trailing plants in sunshine occasionally reproduce.

Vines often climb deciduous trees reach sunlight when leaves drop in fall. Plants can continue to grow, albeit slowly, throughout winter (Reichard 2006).

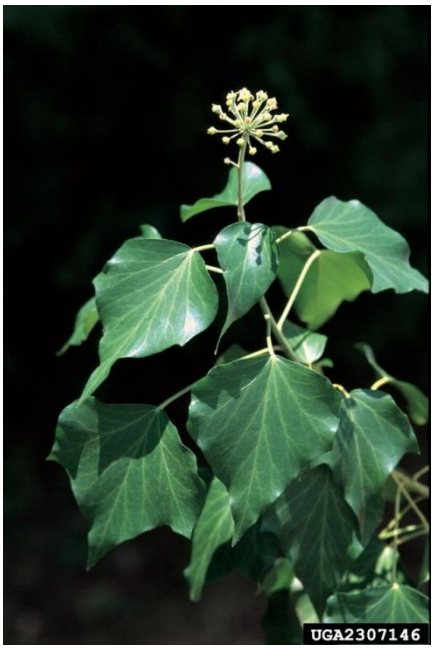

Figure 34: Mature, shrub form. (James H. Miller, USDA Forest Service, Bugwood.org.)

Seedlings

The first seed leaves are leathery, elongated ovals 0.6-0.8 in. (1.5-2.0 cm) long, with rounded tips and bases and leaf stalks 0.08-0.1 in. (2.0-3.0 mm) long. The first true leaves are leathery and wavy-edged, and oval with 3 vague lobes. Star-shape hairs adorn these leaves and their stalks (DiTomaso & Healy 2007) as well as young shoots and leaves (Reichard 2000).

Similar Species

No similar species are native to Washington.

Quick ID

- Evergreen glossy, leathery leaves
- Leaf veins lighter than leaf
- Petioles approximately as long as leaves

Juvenile vine:

- Leaves 3–5 lobed, alternate
- Creeping or climbing
- Small aerial roots; no tendrils

Mature shrub:

- Erect, nonclimbing
- Leaves entire, broadly ovate to diamond-shape or triangular, spirally arranged
- Inflorescences (in fall) globose, greenish to white flower clusters at stem ends
- Small, dark-blue to purple-black, fruits (in spring)

Roots

Seedlings are shallowly rooted, with many fine branches and lateral roots. Juvenile roots form on aboveground nodes, climbing as soon as they contact a vertical

Figure 35: Modest-size roots being removed. (Courtesy of Luke McGuff, NatureIntrudes.net, ©2013.)

surface. Aerial roots do not penetrate tree bark (Reichard 2000) but are powerfully adhesive, often remaining after the vine itself is removed.

Figure 36: Unusual situation of mature form growing prostrate with juvenile form (the latter with lobed leaves).(Cynthia Lee Riskin.)

Leaves

Hedera spp. have waxy, leathery, deep-green leaves arranged spirally and held on long leaf stalks. Juvenile leaves have 3-5 deep lobes. Adult leaves are oval to triangle shape, 1.6-4.0 in. (4.0-10.0 cm) long by 2.5-5.1 in. (6.4-13 cm) wide, and narrowing to a sharp tip.

Flowers

In fall, plants produce 8 to 20 clusters of greenish to white, globose clumps of small flowers at branch tips. Flowers are 0.2-0.3 in. (5-7 mm) across.

Fruits

In April and May, *Hedera* spp. produce dark-blue to black, berrylike fruits approximately 0.24-0.35 in. (6.0-9.0 mm) in diameter. Each contains 2-5 seeds.

Reproduction

Although reproduction is primarily vegetative, prolific seed production and high germination rates contribute to its success (Reichard 2000; Biggerstaff & Beck 2007). Each adult produces tens of thousands of fruits each year (DiTomaso & Healy 2007).

Seeds ripen a year after plants bear fruit, in spring (DiTomaso & Healy 2007). They are 70-100% viable after scarification in bird digestive systems (Reichard 2000; Biggerstaff & Beck 2007). Within a couple of weeks of dispersal (Biggerstaff & Beck 2007), they germinate in either light or darkness (Baskin & Baskin 1998).

Figure 37: Mature leaves, flowers, and fruit. (Forest & Kim Starr, Starr Environmental, Bugwood.org)

Birds, such as America robin (*Turdus migratorius*) and European starling (*Sturnus vulgaris*), disperse *Hedera* spp. seeds. In the Elwha, they drop them along the former reservoirs and in woodland openings.

Juvenile *Hedera* spp. spread vigorously, primarily by vegetative reproduction (Reichard 2000; Biggerstaff & Beck 2007). Stem and root fragments and cut stumps readily generate new plants. Growing up to 30 ft. (9.1 m) a year (Soll 2010), vines can rapidly engulf tall trees (Reichard 2006). *H. helix* ssp. *helix*, in particular, can scale conifers as high as 300 ft. (91.4 m) (Soll 2010).

Successional Status

Hedera spp. tolerate shade but thrive at 65-68% of full sunlight (Reichard 2000), suggesting they can establish and persist throughout successional stages (Waggy 2010). Once they invade an ecosystem, plants can last a long time. One specimen lived 433 years, as dated by annual rings (Reichard 2006).

Ecology

Hedera spp. thrive in a wide range of climates, soil textures (coarse to fine), and pH values, although they prefer a slightly acid soil. They tolerate drought once established (Soll 2010) and all but the most water-logged soils (Swearingen & Diedrich 2006; USDA 2013).

Impacts

When *Hedera* spp. dominate an ecosystem, they can block succession by preventing understory and shrub-layer regeneration and creating gaps in the forest canopy (see "Impacts," below).

Figure 38: Invasive ivy killing a deciduous tree. (Courtesy of Luke McGuff, NatureIntrudes.net, ©2013.)

Hedera spp. can dominate a secondary woodland within 30 years (Biggerstaff & Beck 2007). Forming large monocultures, *Hedera* spp. create "ivy deserts" in natural areas (Bugwood [date unknown]), killing trees and destroying habitat. Containing the toxic glycoside hederin, *Hedera* spp. have little forage value (USDA 2013), reducing animal diversity and providing habitat only for invasive rats (Soll 2010).

The evergreen vines weaken and kill trees by blocking photosynthesis from the ground to the canopy. The added weight increases the likelihood of damage in storms (Swearingen 2000), especially when vines are snowy or wet. One study estimated that 1 acre of heavy infestation weighs 10 tons (Reichard 2006).

Hedera spp. disrupt soils by increasing soil nitrogen from dying leaves (Sulgrove 2004) and through allelopathy, which does not seem to persist after plants are removed (Biggerstaff & Beck 2007). Their shallow roots also leave soils susceptible to erosion (Soll 2010), which can in turn lower water quality and encourage invasion by other noxious nonnative plants.

Management

Hedera spp. may require repeated treatments because its waxy cuticle resists many herbicides and because it tends to resprout (Peachey 2012; Swearingen & Diedrich 2006).

In the Elwha, the goal is to eliminate the as-yet disparate patches by applying Roundup Pro (glyphosate) on foliage and on cut stumps (Chenoweth, Acker & McHenry 2011). Garlon 4 (triclopyramine) is also slated for use on cut stumps at any time (Chenoweth, Acker & McHenry 2011).

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Family: Araliaceae

Ilex aquifolium L. (ILEAQU)

Common name: English holly

In Washington State, *Ilex aquifolium* is as much a contentious political issue as an environmental problem. As holly growers and weed boards clash in the state legislature over whether to legally declare English holly—a commercial crop serving mostly the Christmas trade—a noxious weed, at least one thing is clear. This thicket-forming small tree, with glossy evergreen leaves and ruby winter berries, could become more of a problem in the Elwha. The largest holly grower in Washington is 50 miles to the east and two more growers less than 25 miles to the north, in Victoria, British Columbia, Canada (Northwest Holly Growers Association [date unknown]).

Although the species is slow to germinate and slow to mature, a single 15.0 ft. (4.6 m) tall tree in the UK was estimated to produce 30,000 berries—potentially 120,000 seeds—in a 1965 study (Peterken & Lloyd 1967). It is difficult to eradicate because it resprouts readily.

Distribution

Mapped in the Elwha in 2001 and 2008, *I. aquifolium*, although rare, is a plant of high concern for its potential to cause great environmental harm (Woodward *et al.* 2011), despite claims of the Northwest Holly Growers Association to the contrary ([date unknown]).

Figure 39: *Ilex aquifolium.* (Courtesy of Joe DiTomaso ©Regents of CA.)

Attempts to list *I. aquifolium* as a Class C noxious weed have failed, leaving it on the Washington State monitor list (WSNWCB 2011). Although it's listed as a weed species in "Weed Species Reported on Forest Service Land in Clallam or Jefferson Counties, 2002-2012," with information on how to kill it, *I. aquifolium* is not on the 2013 Clallam County Noxious Weed List (CCNWCB 2012; CCNWCB 2013).

Peter Zika (2010) found *I. aquifolium* to be naturalized in hundreds of low-elevation Pacific Northwest forests, both old growth or disturbed, including those dominated by *Acer macrophyllum* (bigleaf maple), *Alnus rubra* (red alder), *Picea sitchensis* (Sitka spruce), *Pseudotsuga menziesii* (Douglas-fir), or *Populus balsamifera* (black cottonwood).

Description

This broadleaved evergreen tree has a dense, pyramidal form and grows 30-50 ft. (9.1-15.2 m). Leaves are glossy, thick-leathery, and dark green above, lighter beneath. Leaf edges range from untoothed (entire) to painfully spiny and everything in between—all on the same plant. Male and female flowers are mostly on separate plants and are white and small, giving rise (on female plants) to bright-red winter berries. Berries and leaves are toxic yet rarely deadly in humans (Levy & Primack 1984).

Similar Plants

Berberis aquifolium (tall Oregon-grape)—formerly called "*Mahonia aquifolium*"—may look similar when it is not flowering or fruiting. *Berberis aquifolium* is a stiff-branched, evergreen shrub to 15.0 ft. (4.6 m). Its leaves are *thin*, however, compound (multiple leaflets along one main stem, or rachis), and variably glossy and spiny, sometimes turning purplish in winter.

Figure 40: *Berberis aquifolium* yellow flowers. (Courtesy Luke McGuff, NatureIntrudes.net, ©2013.)

Blooming February through May (not May through June, like English holly), it bears 3 in. (7.6 cm) clusters of sweet-smelling, bright yellow flowers (not clusters of small, dull-white flowers); and its dark blue (not red) berries ripen late June (not late summer to early fall) (Jacobson 2008).

Table 5: Comparison of *I. aquifolium* and *B. aquifolium*

Ilex aquifolium	***Berberis aquifolium***
English holly	Tall Oregon-grape
15-50 ft.	3-15 ft.
Thick, single leaves; dark green year round	Thin, *compound* leaves (7-9 leaflets); green to purplish in winter
Flowers dull-white, May-June	Flowers in erect 3-in., bright yellow clusters, February-May
Berries bright red, late summer to early fall, lasting all winter; poisonous	Berries ripening from green to dark blue in June; edible

Figure 41: *Berberis aquifolium* compound leaves, blue berries. (©2013 Cynthia Lee Riskin.)

Quick ID

- Broadleaved evergreen shrub or small tree to 50 ft.
- Glossy, thick, dark green leaves, lighter beneath
- Leaf shape variable, from wavy-edged and spiny to egg-shape with mostly smooth edges
- Bright red berries in winter
- Small, 4-petaled, dull-white flowers May-June

Seedlings

Seed leaves are shiny and leathery, oblong to about 0.4-0.-0.6 in. (1.0-1.6 cm). The first true leaves are slightly larger, alternate, and narrowly oval, with prickly teeth on their edges (DiTomaso & Healy 2007).

Figure 42: Seedlings look similar to adults. (©2013 Cynthia Lee Riskin)

Roots

Primary roots are woody (DiTomaso & Healy 2007) and grow deeply.

Leaves

Leaves are polished dark green and leathery, paler beneath, from 1.0-2.4 in. (2.5-6.0 cm) long. They can vary in shape on the same tree. Mature leaves and leaves of plants grown in shade may be egg-shape and a polished dark green above, lighter and duller beneath, with smooth (entire) margins.

Juvenile leaves are similarly colored, but edges may be wavy (undulate) and armed with several triangular, stiff, spiny teeth. Leaves of intermediate shape and spininess can occur on the same plant.

Figure 43: Upper leaf shiny; lower paler, duller. (©2013 Cynthia Lee Riskin.)

Flowers

Male and female flowers occur mostly on separate plants in May through June. The bee-pollinated clusters of fragrant, dull-white flowers each have four petals approximately 0.2 in. (6.0 mm) long. They grow in clusters on year-old twigs.

Figure 44: Worthy ornamental or forest menace? (Photograph courtesy of G. D. Carr, ©2002.)

Fruits

Fruits are bright-red, stalked berries approximately 0.3 in. (7.0-8.0 mm) in diameter, ripening late summer to early fall (DiTomaso & Healy 2007) and remaining attached throughout winter (Olmsted 2006). Each fruit contains 4 (2-8) bony, hard seeds (DiTomaso & Healy 2007).

Reproduction

Sexual regeneration is slow and sparse, although that's what introduces *I. aquifolium* into new sites (David Stokes, prepublished personal communication 2013). Vegetative regeneration is not an effective means of dispersal, although *I. aquifolium* suckers readily and occasionally spreads vegetatively when a branch—even one that's broken off—touches the ground and roots. By doing so, however, a plant can form dense, unisex clumps (Peterken & Lloyd 1967). University of Washington Professor David Stokes and his students found that 80% of *I. aquifolium* in his St. Edward Park, Kenmore, Washington, study site is a result of vegetative spread, and 20% is from seed (2013), although he cautions that his findings might not apply to other sites, including the Elwha.

I. aquifolium bears seeds at 5-12 years (Young & Young 1992; DiTomaso & Healy 2007), although it can produce berries as early as 2 years (Olmsted 2006). Germination occurs in the second or third spring (Young & Young 1992; RFS 2013). Seeds are viable more than 3 years in the soil (DiTomaso & Healy).

Plant growth is also slow for the first four years, at 0.4 in. (1 cm) a year. It makes up for lost time, however, by then growing up to 19.7 in. (50 cm) a year (Peterken & Lloyd 1967) and spreading rapidly once established (DiTomaso 2004). Living 250-300 years (Olmsted 2006), a single female can produce hundreds of berries each year.

Figure 45: Prolific reproducer. (©2013 Cynthia Lee Riskin)

Birds are primary dispersers of seeds during winter and spring (Young & Young 1992). Zika (2010) observed 7 species of bird dispersing the seeds west of the Cascades, with the two top dispersers being American robins (*Turdus migratorius*), at 96%, and European starlings (*Sturnus vulgaris*), at 3.2%. None of the remaining species exceeded 0.5%. In Ridley's Kew Gardens observations, birds don't eat *I. aquifolium* fruit until winter, when food is scarce (1930). Peter

Zika (2010) observed flocks of American robins potentially removing more than 106 seeds/minute, with some moving seeds 546.8 yd. (500 m) before regurgitating them.

The ability of English holly propagules to disperse by water is debated. In Praeger's buoyancy experiments (1913), fresh *I. aquifolium* fruit floated up to 2 days, dry fruit 10 days, dry seeds 10 days, a fresh branch 14 days, and a dry branch 4 days. Ridley's *I. aquifolium* seeds sank immediately, however, and he doubts that streams or rivers disperse them (1930).

Successional Status

I. aquifolium grows in sun to shade (Olmsted 2006), although shade reduces fruit production (Peterken & Lloyd 1967). It does not seem to need disturbance to invade, but it does establish in logged areas (DiTomaso 2004). In St. Edward Park, Stokes and his students (2013), however, found a very rapid invasion of *I. aquifolium* trees 10-50 years old thriving in heavy shade. Of his 150 study plants, only 1 showed any signs of ill health (yellowing leaves). No dead trees—easy to identify because they retain their distinctive leaves—were found. (Understory trees typically have low mortality rate, though, he says.) His study trees are early in their life spans and can persist another 100-300 years (Stokes 2013).

Ecology

In the Pacific Northwest, *I. aquifolium* grows in coastal forests, woodlands, riparian forests, and edges of wetlands (DiTomaso & Healy 2007). It performs best on well-drained, moist soils with a sandy base or gravelly loam, although it can tolerate nearly any soil (Olmsted 2006). In its native range, it grows in both acid and alkaline soils, from a pH of 3 to 9 and in permanently wet to shallow, dry soils (Peterken & Lloyd 1967). Its range is limited by its sensitivity to frost. Although *I. aquifolium* is characteristically an understory shrub in its native territory, it often forms nearly pure holly stands (Peterken & Lloyd 1967) and can grow in full sun.

Stokes (prepublished personal communication 2013) also found *I. aquifolium* growing in dense thickets, noting that it locally does the same in its region of origin. What's alarming, he says, is that in St. Edward Park, the invasion of English holly has increased exponentially since residences were built nearby in 1950-1960 and the species was planted for landscaping. (The incidence of plants 10-50 years old radically jumped around 1970.) With a population-doubling time of approximately 6-8 years, it could quickly dominate the park's forest. Biomass is also accelerating, and the trees are quickly getting too big to pull with a Weed Wrench™, and volunteers cannot be used to control the trees with pesticides. Although Stokes says he and his students have "conclusively" and "quantitatively" demonstrated the invasiveness of *I. aquifolium* in St. Edward Park, the question remains as to how applicable their results are to other sites (Stokes prepublished personal communication 2013).

Impacts

Ecological impacts of *I. aquifolium* are not well studied as yet. It is known to change the plant and animal species in forests by shading out native understory plants (Olmsted 2006) and reducing germination of native trees and shrubs (King County 2008). In our rare old-growth forests, it sometimes adds a tall shrub layer that doesn't naturally occur (Reichard 1996).

Its ability to vigorously resprout after top damage enables it to create dense mats of foliage useful for hedgerows (Peterken & Lloyd 1967) but perhaps impenetrable to wildlife. In addition, *I. aquifolium* is "thirsty" and can outcompete natives for water (King County 2008). It drops thick leaf litter on the forest floor (RFS 2013), which may further suppress native plant germination.

Management

Crews are treating *I. aquifolium* with cut-stump applications of RoundUp Pro (glyphosate) and Garlon 4 (triclopyr ester) any time of year. They are also applying Garlon 4 to the bark at the bases of the plants.

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Family: Fabaceae

Lathyrus latifolius L. (LATLAT)

Synonyms: *Lathyrus latifolius* var. *splendens* Groenl. & Rümpler

Common name: everlasting pea (perennial pea)

Lathyrus sylvestris L. (LATSYL)

Common name: narrow-leaf pea, small everlasting peavine, flat peavine

Lathyrus latifolius and *Lathyrus sylvestris* are not making any headlines—and only *L. latifolius* has even made a noxious weed list, in Oregon (ODA [date unknown]). But these herbaceous vines are widespread in the U.S. and Canada (Whitson [date unknown]). *L. sylvestris* is rapidly invading the Elwha. Not only is it one of the most common invasive plants in the Elwha, but it is coming back after previous removal treatments (Woodward *et al.* 2011). These "everlasting peas" are garden escapees with high potential to invade, covering all vegetation in their way. Bearing nitrogen-fixing nodules on their rhizomatous roots gives them competitive advantage in low-nitrogen soils (Bergersen 1982).

Figure 46: Asymmetric stipules and broadly winged stem of *Lathyrus latifolius.* (Courtesy of Ben Legler ©2004.)

Distribution

Genetically variable and tolerant of many habitats, the everlasting peas are widely spread in North America—especially *L. latifolius*, which is present in all states, except Florida and North Dakota, as well as in several Canadian provinces (USDA 2013). At present, it is not listed as a noxious invasive anywhere in Washington. *L. latifolius* has its claim to fame through a mug shot in a Whatcom County publication on plants toxic to livestock (WCNWCB [date unknown]). NatureServe (2012) has not yet ranked either species for its environmental impact.

Description

Everlasting peas are rhizomatous vines 31.5-79.0 in. (0.8-2.0 m) tall, with two-parted leaves, stems with broad, flat edges (wings), and long, showy, unbranched clusters of pea flowers (butterfly-shape, or papilionaceous). They climb using tendrils to wrap around other objects. At the base of each leaf stem is a 2-lobed, leaflike structure, called a *stipule*, which clasps the stem. When identifying the species, be sure to check the stipules toward the base of the plant. Stipules higher up are reduced in size and can appear quite different.

Figure 47: Winged stems; smaller, more evenly lobed stipules of *L. sylvestris.* (Courtesy of Ben Legler ©2004.)

Figure 48: *L. latifolius*—larger stipules, lobes quite asymmetrical. (Courtesy of Troy Evans, Great Smoky Mountains National Park, Bugwood.org.)

L. sylvestris has narrow (linear to lanceolate) leaflets; significantly flattened wings on both sides of the stem; and purplish pealike flowers. Its stipules are slender, and the lobes are nearly symmetrical. *L. latifolius* is altogether larger, with longer, broader, more oval-shape leaflets; wider stem wings; and larger flowers, varying from purplish to rosy pink, white, or striped. The stipules are large and asymmetrical, with one lobe 2-3 times longer than the other.

Quick ID

- Climbing, hairless (glabrous) vine with tendrils, to approximately 6.5 ft.
- 2-parted leaves, with additional leafy structures at the leaf-stem bases (stipules)
- Winged stems (see above)
- Rhizomatous roots

***L. sylvestris*:**

- All parts somewhat narrower, more linear or lanceolate than *L. latifolius.*
- Narrow, lance-shape leaflets 2.0-4.7 in. long
- Flowers purplish red, red
- Stipules 0.4-1.2 in. long, slender, and nearly symmetrical
- Pods 1.6-2.4 in. long by approximately 0.2 in. wide

***L. latifolius*:**

- All parts larger, broader, or more oval in shape
- Leaflets up to 5.5 in. long and 2.0 in. wide
- Flowers purplish red, pink, white, or striped
- Stipules 1.2-2.0 in. long, asymmetrical, with one lobe 2-3 times longer than the other
- Pods 2.4-3.9 in. long and 0.3-0.4 in. wide

Similar Plants

In the Elwha, other *Lathyrus* spp., generally occur in different habitats (such as tidal flats or on sandy beaches and dunes); have soft hairs on leaves, stems, or pods; or the stems lack true wings, although they may be angled (Knoke, Giblin & Legler 2005+). Several *Vicia* spp. (vetch) can be confused with *Lathyrus* spp., although their leaflets are often longer and narrower than in *Lathyrus* spp. (Jacobson, personal communication). To distinguish the genera, dissect a flower to see the styles. *Lathyrus* spp. styles (narrowed portions of the female pistil, or reproductive parts) have hairs on one side, like a toothbrush. *Vicia* styles have hairs clustered at the top (Pojar & MacKinnon 1994).

Figure 49: *Lathyrus* spp. styles have hairs on one side, like a toothbrush.

Figure 50: *Vicia* spp. styles have hairs clustered at the top.

(Photos courtesy of Russ Kleinman, Dale A. Zimmerman Herbarium, NM.)

Seedlings

Seed leaves (cotyledons) do not emerge from the soil. The first true leaves are alternate, scalelike, and very small, followed by a pair of stalked leaflets approximately 0.4-0.8 in. (1.0-2.0 cm) long (DiTomaso & Healy 2007).

Roots

Lathyrus spp. seedlings put down a taproot but are later rhizomatous. Rhizomes grow horizontally underground, periodically sending up clumps of new clonal plantlets (ramets) from buds on the rhizomes. These clumps sometimes create new taproots of their own. The clumps live only one year, but each connected mass—called a *genet*—can live indefinitely (Hossaert-McKey & Jarry 1992).

Leaves

Each leaf comprises 2 leaflets. At the base of each leaf, abutting the stem on both sides, is a leaflike structure called a *stipule*. Differences in leaflet and stipule size and shape help differentiate *L. latifolius* and *L. sylvestris*.

Leaflets on *L. sylvestris* are lance shape to a slightly oval–lance shape, 1.2-4.7 in. (5-12 cm) long by approximately 0.2 in. (0.6 cm) wide. Its stipules are slender, and its lobes are nearly equal in size, 0.4-1.2 in. (1-3 cm) long.

Figure 51: Two-part leaves, pea flower. (© 2013 Cynthia Lee Riskin.)

Leaflets on *L. latifolius* are longer and broader than on *L. sylvestris*—up to 5.5 in. (14 cm) long by 2.0 in. (5 cm) wide. The stipules are broadly lance-shape to oval-shape, 1.2-2.0 in. (3.0-5.0 cm) long, and obviously asymmetric: One lobe is 2-3 times longer than the other (Hitchcock *et al.* 1955-).

Flowers

Flowers are pealike—that is, butterfly shape—and are bee pollinated (Godt and Hamrick 1991). L. *sylvestris* has smaller, duller flowers, 0.6 in. (1.5 cm) long, and are purple (some say red). *L. latifolius* flowers are 0.6-0.8 in. (1.5-2.0 cm) and vary from purple (or red) to white, including pink or striped (Hitchcock *et al.* 1955-).

Figure 52: *Lathyrus sylvestris*, in Finland. (Courtesy of Antti Bilund, Creative Commons license.)

Fruits

Lathyrus spp. bear pods containing poisonous seeds. The pods of the 2 species vary in size—again, with *L. latifolius* being significantly larger. *L. sylvestris* pods are 1.6-2.4 in. long (4.1-6.1cm) long, with 10-20 seeds. *L. latifolius* pods are 2.4-3.9 in. (6.0-10.0 cm) long and 0.3-0.4 in. (0.7-1.0 cm) wide, with 10-25 seeds.

Reproduction

Everlasting peas reproduce primarily vegetatively, by extending their rhizomes and producing new clumps of plantlets from buds on the rhizomes. Both species can regenerate from those buds if damaged, but *L. sylvestris* excels in this department (Hossaert & Valéro 1988).

Both plants reproduce sexually as well. Seed production is low, however, and those that mature are often eaten by rodents (Hossaert & Valéro 1988). Ninety-five percent of seeds disperse within 3.3-65.6 ft. (1.0-20.0 m) of the center of parent plant by ejecting from the pod when it

snaps open at the seams (Hossaert-McKey & Jarry 1992). Because of differences in size and positioning in the pod, seeds of *L. latifolius* shoot farther than those of *L. sylvestris* (Hossaert & Valéro 1988). Given the dispersal pattern of *L. sylvestris* in the Elwha, water may also disperse everlasting pea seed (Godt & Hamrick 1991; Woodward *et al.* 2011). Experiments in Britain, however, found that seeds of both species sank in under 1 minute (Praeger 1913).

Successional Status

L. sylvestris tolerates shade, but *L. latifolius* does not (USDA [date unknown]). Their ability to fix nitrogen on mycorrhizae-bearing root nodules enables them to establish in low-nitrogen soils (Bergersen 1982), which disturbed sites are likely to have.

Ecology

Everlasting peas can be found in a variety of disturbed habitats, especially where there's sufficient moisture (Knoke, Giblin & Legler 2005+). They do, however, have a high tolerance for drought once they're established (USDA [date unknown]). In addition, they can adapt to a variety of soil textures, low pH, and low nutrient levels, although *L. sylvestris* is adapted to fine soils, and *L. latifolius* is not (USDA [date unknown]).

Impacts

L. latifolius grows densely over low plants, shrubs, and trees, smothering them and reducing native cover (ODA [date unknown]); likely, *L. sylvestris* does the same.

Management

L. sylvestris is recurring after herbicide treatments in the Elwha. The current control method is foliar applications of Milestone (aminopyralid) before flowering (Chenoweth, Acker & McHenry 2011).

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Family: Poaceae

Phalaris arundinacea L. (PHAARU)

Common names: reed canary grass, canarygrass

Phalaris arundinacea aggressively forms monocultures on vast tracts of wildland, reducing plant, insect, and arthropod diversity (Lavergne & Molofsky 2007; Spyreas *et al.* 2009) and otherwise degrading in-stream, riparian (Carrasco 2000; Seebacher & Reichard 2008; King County (WLR) 2013), and upland habitat (Jakubowski, Casler & Jackson 2010). "No other grass introduced to the Seattle area has made such an impact on wild acreage," writes Jacobson (2008).

Figure 53: *P. arundinacea* infestation. (Leslie J. Mehrhoff, University of Connecticut, Bugwood.org.)

Scientists disagree on whether *P. arundinacea* is native to Washington, introduced from European cultivars bred for high productivity, adaptability, and vigor (Tu 2004); or hybrids thereof (Pojar & MacKinnon 1994; Galatowitsch *et al.* 1999; Jacobson 2008)—an issue that has implications for management. Although native populations likely remain in Alaska (Jakubowski, Casler & Jackson 2013) and in the inland Northwest (Idaho, Montana, and Wyoming), most coastal Pacific Northwest populations are thought to descend from an 1885 introduction in Coos County, Oregon (Merigliano & Lesica 1998).

Distribution

In the Elwha, *P. arundinacea* is rapidly colonizing the river's edges between Glines Canyon Dam and the Aldwell River Delta (Chenoweth, Acker & McHenry 2011). Clallam County rates it as a Class C noxious weed (Clallam County 2008–2013). In Washington, it is a Class C noxious weed present in most counties (WSNWCB 1995; Knoke, Giblin & Legler 2005+; USDA 2013). Invading 42 states and much of Canada (USDA 2013), *P. arundinacea* is a high-impact weed according to NatureServe (2012).

Description

One of the first grasses to emerge in spring, *P. arundinacea* is a tall, long-lived, rhizomatous grass of moist to wet places. It bears compact, erect flower clusters on hollow stems. The plant turns purple in summer and a distinctive straw color in fall.

Figure 54: Ragged, papery ligule exposed. (Caleb Slemmons, University of Maine, Bugwood.org.)

Note: Although *P. arundinacea* is fairly distinctive, grasses are difficult to identify, and the terminology is specialized. See the glossary at the end of this book or get a good reference on grasses, such as *How to Identify Grasses & Grasslike Plants* (Harrington 1977), for line drawings and more-precise details.

Seedlings

Little information exists on identifying grass shoots. Seedlings begin to emerge from rhizomes or seed in early spring. Leaf blades are rolled (as opposed to folded) in the bud and are flat and hairless. I'm not sure that helps.

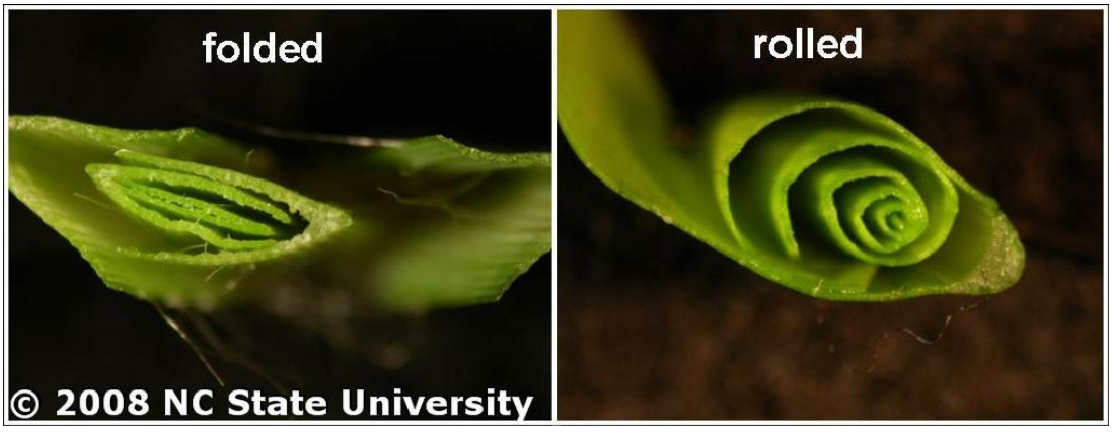

Figure 55: *P. arundinacea* blades are rolled in the bud, as on the right. (http://www.turfgrass.ncsu.edu/images/glossary/Web/vernation.jpg)

Figure 56: Seedling. (Ohio State Weed Lab Archive, The Ohio State University, Bugwood.org.)

Similar Species

The nonnative species *P. canariensis* (common canary grass) and *P. paradoxa* (Mediterranean canary grass) are invading Washington, but they are not yet in Clallam County (Marsh & Zika 2009; USDA 2013).

Quick ID

- Tall (to 6.5 ft.), hollow grass of moist to wet sites
- Leaves flat, firm, and hairless to 12 in. long and 0.7 in. wide
- Long, compact flower clusters to 12 in.
- Pale green turning purple in summer and straw-color in fall
- Papery ligules 0.16–0.39 in.
- Sheaths split to base
- Flattened spikelets

Roots

Seedlings grow scaly, elongated, pinkish rhizomes and send up erect shoots (tillers) in their first season. Roots form associations with arbuscular mycorrhizae (Harley & Harley 1987).

Leaves

Stem leaves grow to 12.0 in. (30.5 cm) long and 0.2-0.6 in. (5.0-15.0 mm) wide. They are flat, thick, and firm, with split sheaths (where the bottoms of the leaves encircle the stems) and prominent collars. Auricles are absent. Ligules are 0.16-0.39 in. (4.0-10.0 mm), white, tattered, and slightly reflexed.

Flowers

Flowering occurs May through June. The branching flower clusters (panicles) grow to 12.0 in. (30.5 cm). They are open during flowering, becoming narrow thereafter, and may be pale green to purple. Spikelets have 3 compressed flowers.

Fruits

Fruits are hard and have one seed.

Reproduction

Reproduction is primarily vegetative, although sexual reproduction also occurs. Mature plants spread rapidly from the rhizomes or rhizome fragments, which have numerous dormant buds (WIRCGMWG 2009). One rhizome can populate an entire drainage system (Stannard & Crowder 2002).

Figure 57: Spreading by rhizomes. (Ohio State Weed Lab Archive, The Ohio State University, Bugwood.org.)

P. arundinacea can mature in its first year, producing as many as 600 seeds per upright flowerhead in the Pacific Northwest (TNC 2008). Flowers are typically wind pollinated. Environmental conditions affect when seeds mature: They disperse over days, mid- to late summer (Stannard & Crowder 2002). Germination rates have been reported as low (Tu 2004) to high (97%) (Seebacher & Reichard 2008) and occurs 2 weeks after dispersing in suitable

conditions. *P. arundinacea* seeds can germinate in gaps in vegetation the year of dispersal if the temperature is suitable (Leck & Simpson 1993).

Figure 58: Reed canarygrass upright flowerheads. (Barry Rice, sarracenia.com, Bugwood.org.)

Both rhizome fragments and seeds float, so they disperse in water (Tu 2004; WIRCGMWG 2009) and rapidly colonize river banks. In experiments by Praeger (1913), all seeds of *P. arundinacea* sank within 6 days. Seeds underwater lose viability in 2 years (WIRCGMWG 2009). Seeds also have adhesive qualities enabling them to hitch long-distance rides stuck to animals (including humans), vehicles, clothing, and equipment (WIRCGMWG 2009). Wind is a minor disperser (Stannard & Crowder 2002).

Figure 59: Flowers turn purplish then straw-color by summer.(Jamie Nielsen, University of Alaska Fairbanks, Cooperative Extension Service, Bugwood.org.)

Successional Status

This species requires light and disturbance to germinate, establish, and compete (Seebacher & Reichard 2008; WIRCGMWG 2009). It can, however, establish in gaps in native vegetation (Leck and Simpson 1993).

Ecology

P. arundinacea is not adapted to coarse soils but can grow in moderately coarse to fine soils and acidic to basic soils (Granite Seed 2010). It prefers wet soils but can survive extended drought (TNC 2008).

Impacts

Adaptations such as early emergence, wide physiological tolerance, rapid spread, and ability to quickly adapt to changes in the environment enable *P. arundinacea* to outcompete native plants (Lavergne & Malofsky 2007) for water, light, and nutrients. It blocks other plant seeds from the soil with a mat of rhizomes (Nature Conservancy 2012) and dead stems up to 1.6 ft. (0.5 m) thick (Tu 2004). In doing so, it can alter or even halt succession (Seebacher & Reichard 2008).

P. arundinacea displaces native plants that provide shade, cool temperatures, and large woody debris needed for high-quality salmon habitat. It further harms in-stream habitat by reducing diversity and abundance of and arthropods) (Spyreas *et al.* 2010), increasing sedimentation, constricting waterways (Seebacher & Reichard 2008), and blocking salmon passage or even stranding them after flood waters recede (Carrasco 2000).

Management

In the Elwha, crews are treating *P. arundinacea* with foliar applications of Roundup Pro (glyphosate) at or after flowering. After removing *P. arundinacea*, planting lives stakes of *Salix* spp. cut from nearby shrubs may help restore habitat by shading out *P. arundinacea* and providing a nurse crop for native plants. Although *P. arundinacea* might better compete with *Salix* spp. in drier soils, other woody wetland species may serve a similar purpose (Ewing & Giblin 2006). Effective competitors will grow fast, leaf out in early spring (or be evergreen), and have a large leaf area to shade out the invader. Species to consider include *Lonicera involucrata* (twinberry), *Rubus spectabilis* (salmonberry), *Cornus sericea* (red-twig dogwood), *Rubus parviflorus* (red huckleberry), and *Scirpus microcarpus* (small fruited bulrush) (King County 2008).

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Family: Polygonaceae

Polygonum cuspidatum Sieb. & Zucc. (POLCUS)

Synonyms: *Fallopia japonica*, *Reynoutria japonica* Houtt.

Common name: Japanese knotweed

Polygonum sachalinense (POLSAC)

Synonyms: *Fallopia sachalinensis* (F. Schmidt) Ronse Decr., *Reynoutria sachalinensis* (F. Schmidt) Nakai

Common name: giant knotweed, Sakhalin knotweed

Polygonum x*bohemicum* (POLBOH)

Synonym: *Fallopia* x*bohemica* Chrtek & Chrtkova, *Reynoutria* x*bohemica* (Chrtek & Chrtkova) J.P. Bailey

Common names: hybrid Japanese knotweed, Bohemian knotweed

Polygonum cuspidatum, *P. sachalinense*, and their hybrid, *P.* x*bohemicum* are powerfully spreading, difficult-to-control herbaceous perennials that block succession and damage fish and wildlife habitat (Reichard, Urgenson & Halpern 2009; CCNWCB 2013). These escaped perennials are similar in form, biology, and ecological effects (Urgenson 2006). The IUCN named

P. cuspidatum one of the top 100 of the world's invasive alien species—and that list includes all life forms (GISD 2013).

Plant expert Arthur Lee Jacobson (2008) has no better opinion of *P. cuspidatum*: "It has proved as persistent as any plant, mightily resisting manual eradication or doses of poison. It can grow anywhere. And its hybrid is more successful still." If that doesn't have you checking under the bed at night, Jacobson tells of a poisoned clump of *P. sachalinense* that "resurrected after a few years and made some seeds, as if in revenge."

Except where necessary for clarification, the remainder of this description will refer to these three species simply as "knotweeds."

Distribution

In 2012 Clallam County joined forces with the National Park Service, the Lower Elwha Klallam tribe, and Washington Conservation Corps to battle knotweed infestations (Lucero & Moulton 2012). Much of the knotweed on the Olympic Peninsula is thought to be *P.* x*bohemicum*, although all three species grow there (CCNWCB 2013 a, b). In Clallam County, all three are classified as Class B, designated for special control to prevent further spread (CCNWCB 2013 a, b).

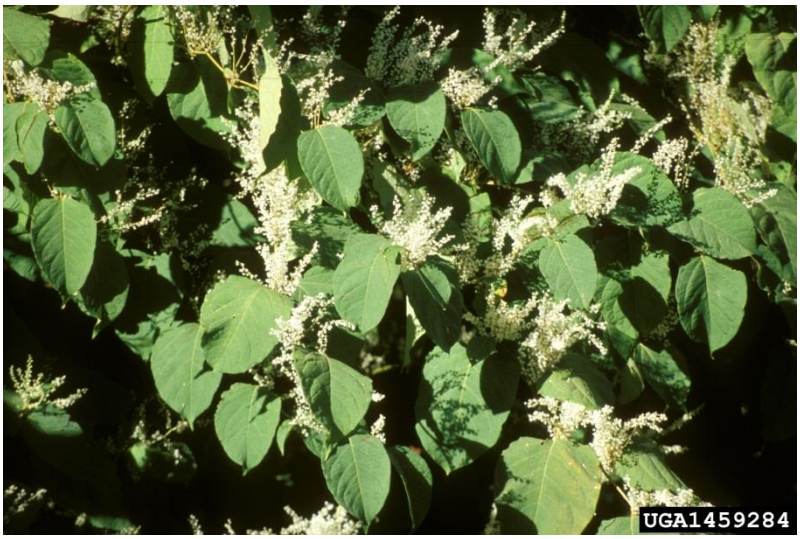

Figure 60: *P. cuspidatum* infestation. (Courtesy Steve Dewey, Utah State University, Bugwood.org.)

Washington also classifies them as Class B (WSNWCB 2013) and has put a plant and seed quarantine on them (USDA 210). Their NatureServe I-Rank is "high" (2012).

Description

Until recently, these rhizomatous *Polygonum* spp. were collectively called “Japanese knotweed” (Urgenson 2006). In general, they are tall, densely growing herbaceous perennials, with arching, hollow, bamboolike canes that may have reddish-purple markings. Stem joints are sheathed in a papery covering (*ocrea*). The oval leaves are alternately arranged; exact leaf shape depends on species. Flowers are clusters of small, greenish-white to white flowers. In winter, top growth dies back, leaving thickets of dead, often purplish canes that can remain standing 2-3 years.

Figure 62: Purplish blotches on bamboolike stems. (Joseph M. DiTomaso, University of California - Davis, Bugwood.org.)

Exact characteristics vary by species. In the Elwha, the most common of the 3 species is *P.* x*bohemicum* (Joshua Chenoweth, personal communication 9 Aug 2013), whose traits, though variable, are usually intermediate between those of the parents (Zika & Jacobson 2003). Note that leaf bases alone are not sufficient to distinguish among the species; look at the entire leaf shape, including tips and dimensions (Arthur Lee Jacobson, personal communication 3 September 2013.)

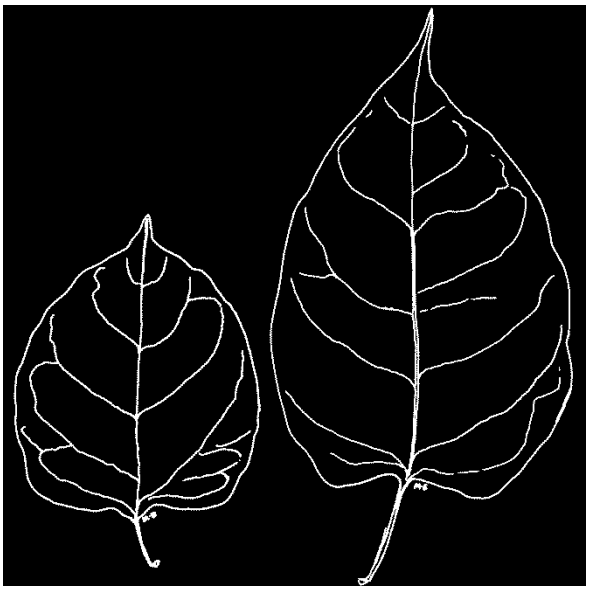

Figure 61: To-scale leaf outlines of *Polygonum cuspidatum* (left) and *Polygonum* x*bohemicum* (right). (Courtesy of Arthur Lee Jacobson ©2008.)

Table 6 compares superficial features (Hitchcock *et al.* 1955-; Zika & Jacobson 2003; Forest Health Service 2004; Knoke, Giblin & Legler 2005+; Forest Health Service 2006).

Table 6: Distinguishing features of *P. cuspidatum*, *P.* x*bohemicum*, and *P. sachalinense*.

	P. cuspidatum **(female parent)**	***P.* x*bohemicum***	***P. sachalinense*** **(male parent)**
Branching	Profuse	Intermediate	Limited
Height	3.3-6.6 ft. (1.0-2.0 m) (8.2 ft. (2.5 m))	Usually 8.2 ft. (2.5 m) but ranging from 6.6-9.9 ft. (2.0-3.0 m)	13.1-17.4 ft. (4.0-5.3 m)
Leaf traits (midstem)			
Thickness	Thin	Intermediate	Thick, tough
Shape, size	Broad oval, often <7.1 in. (18 cm) (sometimes wider than long)	Intermediate, usually >7.9 in. (20 cm)	Elongated oval, often >11.8 in. (30 cm)
Base shape	Square to tapered	Variable but usually shallowly heart-shape	Deeply heart-shape
Tip shape	Narrowing to extended point (cuspidate)	Generally long-pointy but not cuspidate (see previous)	Blunt or abruptly pointy
Underleaf[1, 2]	With tiny knobs or bumps	Scattered hairs	Fuzzy
Flower clusters	Longer than leaf beneath	Usually shorter than or the same length as leaf	Much shorter than leaf beneath

1 Hairiness easiest to see June through mid-September (Zika & Jacobson 2003).

2 Bend fresh leaf at base, and look at silhouette with a 15x-20x hand lens to see hairs (Zika & Jacobson 2003).

Figure 64: *P. cuspidatum*. (Courtesy James H. Miller, USDA Forest Service, Bugwood.org.)

Figure 63: *P.* x*bohemicum*.

Figure 65: Check for hairs on leaf bases; this leaf is from *P.* x*bohemicum* (Ben Legler ©2004.)

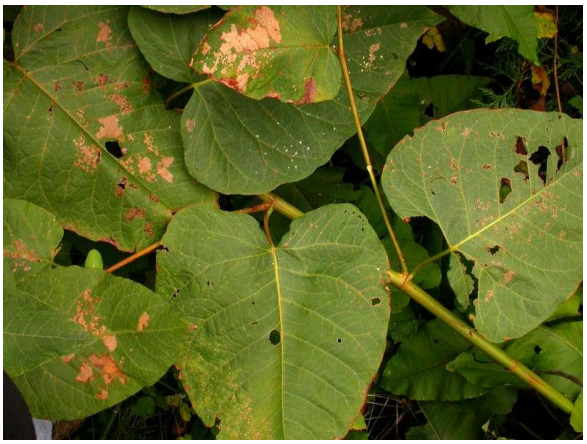

Figure 66: *P. sachalinense.* (Ben Legler, ©2004.)

Figure 67: *P. cuspidatum* flowerhead. (Courtesy Leslie J. Mehrhoff, University of Connecticut, Bugwood.org.)

Similar Plants

Figure 68: Narrow, tapering leaves of *Persicaria wallichii.* (Ben Legler ©2004.)

On the watch list for the Elwha watershed is *Persicaria wallichii* (preferred name for *Polygonum polystachyum*): Himalayan knotweed (Giblin *et al.* 2002+). Although it has been found at only 1 site in Clallam County, this Washington State Class B noxious weed (WSNWCB 2013) is in the early stages of invasion. It is already rampant in Oregon and will potentially be worse in Washington (Sarah Reichard personal communication 9 Aug 2013). *P. polystachyum* looks similar to *P. cuspidatum* except it has much narrower leaves that taper at the base (Knoke, Giblin & Legler 2005+).

Quick ID

- Hollow, arching stems, often reddish
- Papery sheaths at stem joints
- Large, deciduous, broadly oval to narrowly oval leaves alternating on stem
- White to greenish-white flower clusters

Seedlings

Seedlings do emerge from *Polygonum* spp. on occasion (Figure 69). Seedlings of *P. sachalinense*, though, are seldom seen (DiTomaso & Healy 2007), as knotweeds spread primarily vegetatively.

Figure 69: *P. cuspidatum* seedling. (Courtesy Philip Rusted, Thurlow Countryside Management (r&d), Bugwood.org.)

Plants resprout among dead canes from rhizomes as early as April, resembling giant asparagus (Soll 2004).

Roots

Roots are thick, knobby rhizomes that are dark brown outside and orange inside (Urgenson 2006). They form a formidable mat, penetrating hard surfaces and growing to 6.6 ft. (2.0 m) deep and 23 ft. (7.0 m) away from the parent (Urgenson 2006). Soll (2004) states that roots spread at least that far and possibly as much as 65 ft. (20 m).

Figure 70: Resprouting in early spring. (Courtesy Rob Routledge, Sault College, Bugwood.org.)

Leaves

Leaves vary, as described in Table 6, but they are broadly to narrowly oval, deciduous, green, and alternately arranged on the stems. Again, look at leaf shape, bases, tips, and size to distinguish the species (Jacobson personal communication 2013).

Flowers

Knotweeds can be dioecious or have flowers of both sexes on the same plant; their mating system is variable (Reichard, personal communication 2013). They bloom August and September in the United States (Urgenson 2006). Pollinated by bees and other insects (Urgenson 2006), flowers are clusters of small ~0.1 in. (2.0-3.0 mm), greenish-white to white flowers. The female reproductive organs (stigmas) of *P. cuspidatum* elongate during blooming to 0.3-0.4 in. (8.0-10.0 mm) (Knoke, Giblin & Legler 2005+).

Fruits

Fruits are dark, shiny, 3-angled seeds, about 0.1 in. (3.0 mm) long (Knoke, Giblin & Legler 2005+).

Reproduction

Although knotweeds produce a lot of seed, they primarily propagate vegetatively (Urgenson 2006). Knotweeds—including the hybrid (Soll 2004)—produce copious seed a few weeks after flowering (Urgenson 2006). With sexes occurring mostly on separate plants, most are infertile, however (Sieger 1991; Soll 2004; Forest Health Service 2004; Forest Health Service 2006), and it is unknown how sexual reproduction affects seed dispersal (Urgenson 2006), which is by wind.

Most knotweed spread is vegetative. Fragments of rhizome and stem spread quickly by water—for example, in floods. A tiny, 7-g. (0.2-oz.) piece of rhizome "about the size of a fingernail" can generate a new colony (Sieger 1991; Urgenson 2006).

Successional Status

Preferring full sun and moist habitats (Urgenson 2006), knotweeds in the Pacific Northwest can nonetheless grow in partial shade on forest edges and tolerate drought (Reichard, personal communication).

Ecology

Knotweeds grow well in most soils, occurring in coastal forests, wetlands, and riparian ecosystems (Urgenson 2006).

Impacts

Knotweeds are some of the "scariest" invaders in the Pacific Northwest (Reichard personal communication). They can cause long-term damage to riparian forests and to associated aquatic ecosystems (Urgenson, Reichard & Halpern 2009). Rapidly forming monocultures, knotweeds dramatically reduce biodiversity (Urgenson, Reichard & Halpern 2009), damage wildlife habitat, cause erosion (Sieger 1991), and block waterways (Forest Health Service 2006). Plants emerge from rhizomes as early as April at low elevations in the Pacific Northwest (Soll 2004), effectively

outcompeting emerging native plants (Sieger 1991), and can continue emerging until July (Soll 2004).

Knotweeds damage salmon habitat by preventing woody plants from establishing, reducing shade that cools the water; halting accumulation of large woody debris (Urgenson 2006); and increasing bank erosion (Soll 2004). Increases in water temperature and sediments threaten fish habitat. Effectively shading out native plants, knotweeds' masses of rhizomes and thick layer of leaf and stem litter additionally exclude native plant establishment (Urgenson 2006). In a 2009 study by Urgenson, Reichard, and Halpern, the quantity of litter was not greater in knotweed patches than in native plant patches, but native plant litter decreased 70%, and the nutrient input from knotweed litter was lower quality. The litter can also block small waterways and change nutrients on which aquatic life relies (Forest Health Service 2004; Forest Health Service 2006). *P. cuspidatum*, for example, can reduce aquatic invertebrate biodiversity by 50% or more, damaging ecosystem quality for all creatures that consume arthropods, such as amphibians, reptiles, fish, birds, and some mammals (GISD 2013).

Figure 71: Vegetative regeneration at bases of old canes. (Courtesy Philip Rusted, Thurlow Countryside Management (r&d), Bugwood.org).

Management

Herbicides are the best treatment option for knotweeds, as manual control is excessively difficult because of knotweeds' deep rhizomes. In the Elwha, control efforts began in 2002, but control coordinated between the Lower Elwha Tribe and the Olympic National Park Exotic Plant Management Team (EPNT) didn't start until 2007. Crews are using foliar applications of Roundup Pro (glyphosate) at or immediately after flowering and Habitat (imazapyr) when leaves are fully expanded (Chenoweth, Acker & McHenry 2011).

The Nature Conservancy has had variable results with foliar applications of glyphosate-based herbicides, triclopyr; 2, 4-D; imazapyr; and picloram (Soll 2004). TNC field experiments, however, showed good results with high-volume applications of triclopyr-based Garlon 3a and glyphosate-based Rodeo (Soll 2004). Garlon 3a killed 100% of target plants in 2 years; Rodeo took 3 years (Soll 2004).

The most-practical time to poison knotweeds is when they are approximately 3.3-6.6 ft. (1.0-2.0 m) tall, to avoid drift and maximize translocation of the chemicals to the deep roots. Applicators can bend taller plants in June or cut taller plants to 4.9 ft. (1.5 m) later in the year or. In TNC trials, applying herbicides in April and May was not as effective as applying them in June and July (Soll 2004).

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Family: Rosaceae

Potentilla recta L. (POTREC)

Common name: sulfur cinquefoil

Potentilla recta is an herbaceous perennial that seeds copiously, dominating seed banks, and spreading for acres, outcompeting native plants. Its resemblance to *Cannabis sativa* (marijuana) occasionally causes excitement among law enforcement officials, but it is easily distinguished upon closer inspection (DiTomaso & Healy 2007). *P. recta* is not, however, easy to distinguish from native *Potentilla* spp. in the Elwha. Early detection is critical to eradicating the plants, which resprout from roots and root fragments, making them extremely difficult to control (CCNWCB 2000).

Figure 72: *Potentilla recta*. (USDA Agricultural Research Service Archive, USDA Agricultural Research Service, Bugwood.org.)

Distribution

P. recta is widespread worldwide. In the United States, it goes from coast to coast, pointing to its wide ecological tolerance (Powell 1996). It occurs in the Lower Elwha watershed (Chenoweth, Acker & McHenry 2011). A 2001 survey of invasive species in the Elwha River Valley turned up 5 *P. recta* plants; however, it was absent in 2008 survey sites (Woodward *et al.* 2011). The Clallam County Noxious Weed Board knows of only 3 sites infested with *P. recta* in the county, but on 2 of those sites, the infestation covers several acres (CCNWCB 2000). Clallam County has declared

it a Class B-designate noxious weed (designated for control) (CCNWCB 2013). It is a Class B noxious weed on the Washington State list (WSNWCB 2013).

Description

P. recta is a hairy herb 11.8-31.5 in (30-70 cm) tall, with plentiful alternate, compound leaves on its stems. At flowering, it has few to no basal leaves. Its 5-7 (sometimes 9) leaflets attach at a single point (palmate) and have toothed edges. Flowers are a shallow cup shape with 5 pale- to sulfur-yellow petals. Although its few stems grow erect, they may fall over when laden with seeds (Jacobson 2001). Tops die back in the winter and resprout as rosettes in spring (DiTomaso & Healy 2006).

Figure 73: Hairs stick straight out from leaves and stems. (Joseph M. DiTomaso DiTomaso, University of California - Davis, Bugwood.org.)

Similar Plants

P. recta may be confused with several potentially co-occurring native species in the Elwha, with *Ranunculus* spp. (buttercups), and, from a distance, with *C. sativa*. The features that distinguish *P. recta* from native *Potentilla* spp. are (1) long hairs sticking straight out from the leafstalks and stem (Figure 73), (2) numerous stem leaves but few (if any) basal leaves during and after flowering, and (3) the netlike pattern on its dark seeds (Rice 1999).

Several *Ranunculus* spp. grow in Clallam County (PNW Herbaria 2013). They have brighter yellow flowers than *P. recta* (CCNWCB 2000), although they're easy to mistake for *P. recta* if you look at flowers alone. Look at the foliage, which is quite different between the genera (Arthur Lee Jacobson, personal communication, 2013).

Figure 74: *Ranunculus acris* foliage. (Ben Legler ©2004.)

Figure 75: *Cannabis sativa* flowers. (Manuel Martín Vicente, El Jardín Botánico de Gijón, Spain; Creative Commons License.)

You're unlikely to come across *C. sativa* growing wild in Clallam County or in the Elwha, although it has been introduced in other parts of Washington. Just in case: Its flowers are clearly unlike *P. recta*, its seeds are white to green mottled with purple, and it lacks hairs (Werner & Soule 1976; efloras.org [date unknown]).

Quick ID

- Hairy herb to 1.0-2.3 ft.
- 1-8 stems thick with leaves; few to no basal leaves when flowering
- Pale-yellow (not bright-yellow), cup-shape flowers with 5 heart-shape petals and 25-30 stamens
- 5-part leaves, with leaflets connected at one point (palmate)
- Leaflets coarsely hairy and green above and below; toothed less than halfway to midvein
- Dark brown seeds with a strong net-vein pattern

Roots

Seedlings first put down a taproot to access water deep in the soil and then send out branching lateral roots spread to soak up rainwater (Powell 1996; CCNWCB 2000). New stems sprout at the

edges as the center of the root rots, forming a circle with grasses or other species in the middle after several years (Werner & Soule 1976). Roots can sever, dividing the mass into separate plants.

Seedlings

Seed leaves (cotyledons) are oval, 0.1-0.2 in. (2.0-5.0 mm) long and 0.1-0.2 in. (1.5-4.5 mm) wide, with hairs on the lower leaf surface and stem.

Figure 76: *P. recta* seedling. (Joseph M. DiTomaso, University of California - Davis, Bugwood.org.)

The first true leaves, alternately arranged on a hairy stem, are 0.2-0.5 in. (6.0-13.0 mm) long and 0.2-0.6 in. (6.0-14.0 mm) wide, with 3 toothed, rounded leaflets. Once the plant matures, it forms a loose rosette before sending up 1 to several flower stems (DiTomaso & Healy 2007).

Leaves

Leaves grow densely on *P. recta* stems in an alternate arrangement, usually losing basal leaves before flowering. They are coarsely hairy, green above and below, and palmately compound, with 5-7 (sometimes 9) saw-toothed leaflets joined at a single point (Douglas, Meidinger & Pojar 1999). Leaflets are oblong, 1.2-5.5 in. (3.0-14.0 cm) long (Endress & Parks 2004).

Figure 77: Leaves palmate, green above and below. (Montana Statewide Noxious Weed Awareness and Education Program Archive, Montana State University, Bugwood.org.)

Flowers

Flowers appear late May through the end of summer (CCNWCB 2000). They grow in upright, branching, flat-topped clusters of 1-60 [Endress & Parks 2004]. The shallow, cuplike blossoms are pale (sulfur) yellow, with 5 egg-shape petals that are notched at the tip (Endress & Parks 2004), sometimes appearing heart shape. Each flower has 25 (to 30?) stamens (Hitchcock *et al.* 1955-).

Figure 78: Five-petal flowers with 25+ stamens. (Ohio State Weed Lab Archive, The Ohio State University, Bugwood.org)

Fruits

Fruits are dark brown, hard, and a lopsided egg shape, heavily veined in a lighter color.

Reproduction

Although *P. recta* resprouts after top damage, and toppled stems root from growing nodes (CCNWCB 2000), it is well-suited to reproducing by seed: Individual plants in an Oregon study produced 6,000 seeds in a season (Dwire *et al.* 2006). This data was consistent with results in an unpublished, 3-year northwestern Montana study (Lesica 2002). In a Michigan study, a plot of *P. recta* produced an average of 1,560 seeds per plant (Werner & Soule 1976). Seeds primarily germinate in fall and spring, although exposing seeds to sunlight by disturbing the soil can

cause them to germinate anytime in the growing season (Baskin & Baskin 1990). Seeds are reportedly viable for 3-4 years in the soil, although a laboratory study found that those buried 3 in. deep were viable at 28 months (DiTomaso & Kyser 2013). In Michigan, the plant itself can live 20-30 years (Rice 1991). It was found to live 10 years in Oregon (Perkins 2004).

Figure 79: Plant portrait. (Montana Statewide Noxious Weed Awareness and Education Program Archive, Montana State University, Bugwood.org)

Seeds have no special dispersal adaptations, with half falling within 11.8 in. (30 cm) of the parent plant and 83% within 23.6 in. (60 cm) (Dwire *et al.* 2006). Because they are so abundant on the soil surface, however, seeds stuck in mud travel long distances via animals, shoes, or machinery. Seed-eating birds may also carry the seeds (Dwire *et al.* 2006). It is unknown whether water transports *P. recta* seeds. The seeds of some *Potentilla* spp. float for up to 12 hours, although others sink in less than 1 minute (Praeger 1913). Although seeds are not dispersed by wind, their landing site is influenced by wind direction (Dwire *et al.* 2006).

Successional Status

Often occurring in waste spaces and disturbed sites, *P. recta* is present at the earliest successional stages. It can persist, however, until numerous woody plants are present (Werner & Soule 1976). It does not tolerate deep shade but can invade seasonal wetlands, relatively dry *Pseudotsuga menziesii* (Douglas-fir) communities, and other intact ecosystems (Dwire *et al.* 2006).

Ecology

P. recta occurs in numerous soil types, at varying soil pH levels, and in different moisture regimes. It is found in sandy, rocky, gravelly, and clay soils, although it prefers coarse soils. In the Pacific Northwest, it is most invasive where there's an annual mean of 13-50 in. (33-127 cm) precipitation (Endress & Parks 2004).

Impacts

Unlike native *Potentilla* spp., a *P. recta* patch can form a dense cover of up to 32+ stems/yd^2 (39 stems/m^2), smothering acres of native plants, reducing biodiversity, disrupting succession, and potentially outcompeting native *Potentilla* spp. for insect pollinators (Soule & Werner 1976). Some scientists worry that *P. recta* might cross with native *Potentilla* spp. (Soule & Werner 1976), polluting the gene pool. The invader is also a poor substitute for native forage (Soule & Werner 1976), although elk have been observed browsing it in Oregon (Endress & Parks 2004).

Management

Because its roots and root fragments resprout, *P. recta* is difficult to control once it establishes; thus, it is imperative to identify and eradicate it as early as possible. Removing the plant manually is effective if most of the root is removed (CCNWCB 2000). In the Elwha, *P. recta* is being treated with foliar applications of Milestone (aminopyralid) anytime during the growing season (Chenoweth, Acker & McHenry 2011).

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Family: Rosaceae

Rubus armeniacus Vest. (RUBARM)

Synonyms: *R. discolor* Weihe & Nees misapplied, *R. procerus* auct., non P.J. Muell. ex Genev.

Common names: Himalaya blackberry, Himalayan blackberry

Rubus laciniatus Willd. (RUBLAC)

Common names: cutleaf blackberry, evergreen blackberry

Although *Rubus armeniacus* and *Rubus laciniatus* are not terribly abundant in the Elwha (Woodward *et al.* 2011), they are potentially destructive, forming massive thickets that outcompete natives, derail succession, and block animal movement. Both shrubs are viciously thorny and can grow up to 9.8 ft. (3.0 m) a year (Murphy 2006) and to a density of approximately 436 canes/y^2 (525 canes/m^2) (Hoshovsky 2000).

Birds and mammals, including humans, favor the fruit, which helps distribute the seeds long distances. Many people like to retain "just a small patch" for the tasty berries, increasing the supply of ready-to-invade seeds.

Figure 80: *R. armeniacus*. (©2013 Cynthia Lee Riskin.)

Distribution

In the Elwha, invasive nonnative *Rubus* spp. grow along roads, in reservoir deltas, and near the river, as do most other weeds. They also grow at the trailhead to Herrick Road. *R. armeniacus* is much more common than *R. laciniatus* (Woodward *et al.* 2011). Clallam County and Washington State have listed both as Class C noxious weeds (CCNWCB 2013; WSNWCB 2013). NatureServe ranks *R. armeniacus* as "G5," or globally secure, rather than classifying it as an invasive plant and lists *R. laciniatus* as "GUQ," or unrankable, possibly due to questionable taxonomy (2012). NatureServe did not have information for the United States alone.

Figure 81: Angled stems of *R. armeniacus* and *R. laciniatus*. (Joseph M. DiTomaso, University of California - Davis, Bugwood.org.)

Description

Individual blackberry patches may contain different genetic types with varying

physical characteristics (Murphy 2006). In general, invasive blackberries are fast-growing woody shrubs to 32.8 ft. (10.0 m) (Knoke, Giblin & Legler 2005+). They first grow upright and then trail, potentially rooting where they touch the ground.

R. armeniacus and *R. laciniatus* have angled stems with sturdy, somewhat curved thorns with thick bases. Both usually have 5-part compound (palmate) leaves and shiny, dark-purple compound berries. *R. armeniacus* is easily distinguished from *R. laciniatus* by its leaflets. *R. laciniatus* leaflets are deeply lobed to dissected and sharply toothed (Murphy 2006).

Figure 82: *R. laciniatus*. (Leslie J. Mehrhoff, University of Connecticut, Bugwood.org.)

Similar Plants

Another invasive *Rubus* spp., which is on the watch list for potential invasion into the Elwha, is quite similar to Himalayan blackberry: *R. vestitus* (European blackberry) is similar to *R. armeniacus* except that its thorns are straight, not curved, and its flowers bear stalked glands (Knoke, Giblin & Legler 2005+), visible with a microscope or a good hand lens.

Native berries *R. ursinus* (Pacific blackberry) and *R. leucoderm*is (black-cap raspberry) are valuable food sources. Their stems are round in cross section—as opposed to angular in the invasive blackberries (DiTomaso & Healy 2007). *R. ursinus* usually has 3 leaflets (is trifoliate) and slender, trailing stems with thin prickles (Knoke, Giblin & Legler 2005+).

Figure 83: Hollow raspberry versus pithy blackberry compound fruits.

Raspberries have hollow, cap-shape (semihemispherical), compound berries, which distinguish them from blackberries, which have a fleshy white receptacle in the center (DiTomaso & Healy 2007). *R. leucodermis* also usually has 3 leaflets, which are green above and woolly-gray below; round, whitish stems; strong, curved thorns; and typical raspberry fruits, which are hollow or cap-shape (semihemispherical) compound berries (DiTomaso & Healy 2007). *R. odoratus*—a raspberry with simple leaves (not multiple leaflets) to 8.7 in. (22.0 cm) across, no thorns, and purple flowers—is not likely to be confused with blackberries.

Roots

Although canes are biennial, the roots are perennial. They spread horizontally, mostly in the top 1.6 ft. (0.5 m) of soil, but they can grow as deep as 6.6 ft. (2 m). Plants can resprout from root segments and from root nodes, especially when above-ground portions are cut or burned (DiTomaso & Healy 2007).

Quick ID

R. armeniacus:

- Mounding, arching, and/or trailing shrub to 33 ft high
- 3- to 5-part compound leaves
- Leaflets oval shape (variable) and coarsely toothed, green on top and grayish-woolly below
- 5-petaled white to pinkish flowers in clusters
- Shiny, blackish compound berries to 0.8 in.
- Angled stems with flattened, thick, usually curved thorns

R. laciniatus:

Same as for *R. armeniacus* except that it is less vigorous (and therefore shorter stemmed), and its leaflets are deeply dissected or lobed, with sharp teeth.

Leaves

Figure 84: *R. armeniacus* flowers. (John M. Randall, The Nature Conservancy, Bugwood.org.)

Both species are mostly evergreen and usually have (3- to) 5-part, compound leaves. *R. armeniacus* leaflets are 2.4-4.7 in. (6.0-12.0 cm) long and coarsely toothed, coming to an abrupt point at the tip (acuminate). Green and smooth on top, they are grayish-green and woolly beneath. *R. laciniatus* leaflets are also green on top and grayish-hairy beneath, but they are deeply lobed to dissected, with sharp teeth.

Flowers

R. armeniacus blooms May through July; *R. laciniatus*, June through early August. Flowers have 5 white to pinkish petals in loose, branched clusters (panicles) and numerous stamens (male reproductive parts) (Knoke, Giblin & Legler 2005+). Pollination isn't needed for most *Rubus* spp. to produce fruit, although numerous insects—including nonnative honeybees (*Apis* spp.)—pollinate them.

Fruits

Both species have compound berries comprising numerous small, single-seeded, fleshy fruits (drupes). They are glossy and purplish-black when ripe—and, like all the other *Rubus* spp. mentioned in this document, are highly edible. *R. armeniacus* berries are round or oblong to 0.8 in (2.0 cm) long and sometimes have tiny hairs. *R. laciniatus* berries are more spherical, to 0.6 in. (1.5 cm) thick, and hairless (glabrous) (DiTomaso & Healy 2007). Fruits mature over a long period, from July through September (Hoshovsky 2000).

Figure 85: *R. laciniatus* berries. (Joseph M. DiTomaso, University of California - Davis, Bugwood.org.)

Reproduction

Invasive *Rubus* spp. spread aggressively by seeding copiously (Hoshovsky 2000; Murphy 2006) and produce viable seed in many asexual ways—for example, without pollination or without fertilization (Hoshovsky 2000). They also reproduce vegetatively.

Seeds disperse locally by gravity, but they are carried long distances by animals that ingest them, especially birds. Traveling through a bird's crop damages (scarifies) the hard seed surface, aiding in germination (Murphy 2006), which generally occurs in spring (DiTomaso &

Healy 2007). Although seeds can be carried in water on flotsam, and those that have lost their fleshy covering can float long distances (Ridley 1930), water does not seem to be an important disperser for invasive blackberries (Woodward *et al.* 2011). Seeds last several years in the soil (Murphy 2006).

Most *Rubus* spp. also spread by tiprooting; from nodes on the roots that occasionally sprout new plants (especially after the top is cut or some other disturbance); and by rooting where stem nodes touch the ground (DiTomaso & Healy 2007). Seedlings grow slowly. First year canes (primocanes) do not flower or fruit, although they can tiproot. Second year canes (floricanes) produce flowers and fruit after which they usually die (DiTomaso & Healy 2007). Some, however, live up to 3 years (Hoshovsky 2000).

Successional Status

Blackberries need disturbed, open spaces to invade. They grow poorly or not at all in deep shade (Murphy 2006; DiTomaso & Healy 2007). Blackberry thickets themselves create shade, however, intercept tree seeds, and prevent natives from germinating. Thus, they interrupt succession (Murphy 2006).

Ecology

The invasive *Rubus* spp. can invade essentially any soil—tolerating different fertility levels, pH levels, and soil textures—as long as moisture is sufficient (Murphy 2006). In a greenhouse study by Michel *et al.* (2011), however, *R. armeniacus* (and *R. spectabilis*) seeds did not germinate in Elwha reservoir sediment. These results may not extrapolate to the field, however (Chenoweth, personal communication 2013).

Impacts

Forming massive thickets, especially along streams, invasive blackberries shade out native plants, alter succession, prevent wildlife movement (sometimes blocking them from water), and feed and harbor pests, such as nonnative European starlings (*Sturnus vulgaris*) and rats (*Rattus* spp.).

Figure 86: A tangle of *R. armeniacus* invaders. (©2013 Cynthia Lee Riskin.)

Management

Elwha staff is managing nonnative *Rubus* spp. infestations with foliar applications of Roundup Pro (glyphosate) after fruiting, cut-stump applications of Roundup Pro at any time, and foliar applications of Garlon 3A (triclopyramine) before flowering (Chenoweth, Acker & McHenry 2011). It is important to treat new sprouts after using herbicides because herbicides can stimulate lateral root growth (Murphy 2006). The most effective control method is to use systemic herbicides in late summer to early fall (DiTomaso & Healy 2007).

Repeatedly destroying the aboveground parts—manually, with herbicides, or with a combination of approaches—can eventually kill *Rubus* spp. These methods work best during flowering because roots are already depleted of energy stores. Manual control is effective, especially if most of the root is removed (Murphy 2006). Mowing or burning the shrub, however, can stimulate resprouting (DiTomaso & Healy 2007); this method is effective only if sprouts are killed when small or in combination with other control methods. After removing the weeds, replanting with fast-growing natives can shade out vulnerable *Rubus* spp. sprouts (Hoshovsky 2000). Mulching with approximately 8 in. (20 cm) of woodchips is also helpful (Murphy 2006).

A rust fungus, *Phragmidium violaceum*, discovered in Oregon in the spring of 2005 and since found in Washington and British Columbia, shows promise for controlling "evergreen" or European blackberries, including *R. armeniacus* and *R. laciniatus* (Callan *et al.* 2011; Murray 2013).

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Family: Asteraceae

Senecio jacobaea L. (SENJAC)

Synonym: *Jacobaea vulgaris* Gaertn.

Common names: tansy ragwort, mare fart, staggerwort, stinking Willie

Carpeting millions of acres west of the Cascade Range in Washington, Oregon, and Northern California (Coombs, McEvoy & Turner 1999), *Senecio jacobaea* is an erect herb with flat-topped clusters of daisylike flowerheads. It seeds prolifically, regenerates vegetatively from the roots, creates a long-lived seed bank (Macdonald *et al.* 2013), and is difficult to eradicate once established (Poole & Cairns 1940).

Figure 87: *Senecio jacobaea* infestation. (Eric Coombs, Oregon Department of Agriculture, Bugwood.org.)

Poisonous and ragged-looking with a nasty odor, this intractable plant is renowned for killing thousands of livestock—hence, its colorful common names, such as "staggerwort" (because of the behavior of poisoned animals), "stinking Willie," and "mare fart" (Coombs, McEvoy & Turner 1999; Jacobson 2008; GRIN 2009).

Distribution

Present in the Elwha in 2001 and 2008 surveys (Chenoweth, Acker & McHenry 2011), *S. jacobaea* is a Class B-select weed in Clallam County and a Class B weed in Washington State (CCNWCB 2008-2013; WSNWCB 2010). Infestations are heaviest west and north of the junctions of the Elwha River and Rte. 101, the Crescent Lake Area, and Fairholm Hill (CCNWCB 2013). NatureServe I-Rank for this species is "low" because its heaviest infestations and impacts are limited in range—west of the Cascades (2012).

Description

This weed starts as a rosette and matures into a leafy-stemmed herb to 7.9-40.4 in. (20-100 cm), with deeply divided, ragged-looking leaves and scads of composite, daisylike yellow flowers (Hitchcock *et al.* 1955-; Macdonald *et al.* 2013). It can be an annual, a biennial, or a short-lived perennial, although it usually acts as a biennial (Fuentes 2006).

Similar Plants

Several other *Senecio* spp. and lookalikes grow in Clallam County (Knoke, Giblin & Legler 2005+; PNW Herbaria 2013). *S. jacobaea* is the only nonnative tansy with a woody base (Macdonald *et al.* 2013) and an upright stem with large, twice-divided leaves, usually with 13 black-tipped green bracts below the flowers and 13 ray flowers (Figure 88) (Knoke, Giblin & Legler 2005+).

Figure 88: Thirteen ray flowers and 13 black-tipped bracts help identify *S. jacobaea*. (©2004 Ben Legler.)

S. jacobaea can be confused with 2 other weedy plants in the same genus: *S. sylvaticus* and *S. vulgaris.* As Arthur Lee Jacobson writes, however, "Tansy ragwort is an extremely beautiful

flowering plant; the other two Eurasian weeds are dingy" (Personal communication 28 Aug 2013). Further distinguishing details are in Table 7.

Table 7: Three weedy *Senecio* spp., compared.

S. jacobaea	***S. sylvaticus***	***S. vulgaris***
Perennial	Annual	Annual
3-6 ft.	1-3.75 ft.	1.5-2.5 ft.
~13 prominent ray florets	Inconspicuous flowerheads with short ray florets	Small flowers with no ray florets on long, drooping flowerheads that don't fully open
~13 black-tipped bracts under the flowerheads"	~13 involucre bracts	~21 black-tipped bracts
Upright stem covered with twice-dissected leaves—silvery white hairs	Upright stem with sharply toothed leaves	Leaves coarsely, irregularly toothed to deeply toothed (but not all the way to midvein)
Stinks	Stinks	Doesn't stink
 Figure 89: Long ray florets. (©2005 Ben Legler.)	 Figure 90: Short ray florets. (©2008 G.D. Carr.)	 Figure 91: No ray florets. (©2005 G.D. Carr.)

Two other *Senecio* spp. are native in the Elwha—*S. triangularis* and *S. neowebsterii*. Both are found at high elevation, in different habitats than the weedy *Senecio* spp. *Tanacetum vulgare* (common tansy), a class C noxious invasive weed in Clallam County, also is similar but has ferny leaves and button flowers—that is, all disk florets and no ray florets.

Figure 92: *Tanacetum vulgare*. (©2005 Stevens Co. Noxious Weed Control Board.)

Quick ID

- Ruffled-looking, upright herb to 3.5 ft.
- Twice-divided, bright green leaves
- 13 (10-15) yellow ray (edge) flowers, and ~13 black-tipped bracts
- Smells bad (as does *S. sylvaticus*)

Seedlings

The first seed leaves (cotyledons) are oval, 0.25-0.4 in. (0.6-1.0 cm) long (Poole & Cairns 1940), with squared-off or slightly indented tips and rounded-wedge-shape bases (Figure 93) (DiTomaso & Healy 2007).

Figure 93: *S. jacobaea* seedling. (Utah State University Archive, Utah State University, Bugwood.org.)

The first true leaves, which appear about a month after germination (Poole & Cairns 1940), are alternate, wavy-edged ovals 0.2-0.3 in. (6.0-8.0 mm) long, sometimes with a few hairs. They are either toothed or deeply lobed (DiTomaso & Healy 2007). Seedlings form a ruffled rosette to 12 in. (30.5 cm).

Roots

S. jacobaea lateral roots are fleshy, spreading to 5.9 in. (15 cm) wide from a crown or short taproot. Secondary roots are fibrous and grow more deeply (DiTomaso & Healy 2007), to 4.0 in. (10.2 cm) (Poole & Cairns 1940).

Leaves

Leaves are 1.6-7.9 in. (4.0-20.0 cm) long, doubly divided, and deeply lobed. They are arranged alternately on upright stalks. Basal leaves have long stalks (petioles); upper leaves attach directly to the stem. Rosette leaves die during flowering (Poole & Cairns 1940; Jacobs 2009).

Figure 94: "Ruffled" twice-dissected foliage. (Leslie J. Mehrhoff, University of Connecticut, Bugwood.org.)

Flowers

Flowering time is long, running from July to October (CCNWCB [date unknown]). Flowerheads bear up to 2,500 yellow flowers (Poole & Cairns 1940) in short, branching, flat- to round-topped clusters. As do most Asteraceae, *S. jacobaea* has two types of flowers—disk and ray flowers. The center flowers are called "disk" flowers, and the flowers that stick out from the edge—looking like petals—are actually individual ray flowers (or "ligules"). Each flowerhead measure approximately 0.6-1.0 in. (1.6-2.5 cm) across.

Figure 95: *S. jacobaea* have both disk flowers (middle) and ray flowers (edges). (Utah State University Archive, Utah State University, Bugwood.org.)

The flowerhead has 13 (12-15) yellow ray flowers 0.2-0.4 in. (4.0-10.0 mm), with 13 usually black-tipped green bract scales supporting the flowerhead from below. Insects pollinate them.

Fruits

S. jacobaea produces 2 types of seeds that disperse at different times and by different means (McEvoy & Cox 1987). Disk florets produce numerous light, hard, solid seeds (achenes) with woolly tufts of hair to carry them aloft shortly after they mature. They also have fine hairs that attach to animals and to bird feathers for long-distance dispersal. Disk floret achenes are more numerous and disperse before ray flower achenes. Ray flower achenes are heavy, hairless, and lacking in adaptations for dispersal. They can remain on the plant for months after maturing (McEvoy & Cox 1987).

Reproduction

Reproduction is primarily by seed, although *S. jacobaea* reproduces vegetatively with vigor (Poole & Cairns 1940; Jacobs 2009). One plant produces 5,000-200,000 seeds in a season. Seeds can remain dormant 4-5 years and viable up to 20 (BCMA 2002). About 80% of the seeds are viable (Jacobs 2009).

Figure 96: Seeds of disk florets remain on the plant until wind disperses them. (Leslie J. Mehrhoff, University of Connecticut, Bugwood.org.)

Seed needs light to germinate, although soil moisture and soil surface humidity also play a role (Macdonald *et al.* 2013). Germination occurs mainly in late summer or fall (Harper & Wood 1957; Jacobs 2009). In some conditions (in New Zealand, anyway), it can occur anytime, correlating with moist conditions (Poole & Cairns 1940). Seeds mature over 4-6 weeks (Poole & Cairns 1940).

Figure 97: Rosette stage. (Leslie J. Mehrhoff, University of Connecticut, Bugwood.org.)

The plant overwinters as a seed or as a rosette (Figure 97), usually spending its first year in the rosette stage (Macdonald *et al.* 2013); however, some plants have reportedly produced flowering stalks in their first year. In the second year, the plant typically grows a stalk and flowers (Poole and Cairn 1940; Macdonald *et al.* 2013). Technically a biennial, *S. jacobaea* usually dies after flowering. If it is damaged in its second year, however, it may live a third year (PNWC 1972) or become perennial (Poole & Cairns 1940). Root crowns, buds, and fragments can produce new plants. Damage to plant tops can cause resprouting up to 11.8-23.6 in. (30-60 cm) away from the parent (Harper & Wood 1957) and usually stimulates growth of multiple rosettes up to 18 in. (45.7 cm) across with several flowering stems (Poole & Cairns 1940). For an extensive discussion of roots and vegetative propagation, see Poole & Cairns (1940).

Wind, water, birds, and humans spread the seed (Harper & Wood 1957; BCMA 2002). The fuzzy attachment (pappus) on *S. jacobaea* seeds theoretically acts like a parachute, aiding in dispersal, which is primarily by wind (CCNWCB 2001; Macdonald *et al.* 2013). Rain and high humidity can limit wind dispersal, however (Poole & Cairns 1940), by dampening the pappi. A study of wind dispersal of *S. jacobaea* showed that wind is not an effective long-distance disperser of seeds: 31% fell within 3.3 ft. (1 m), 89% fell within 16.4 ft. (5 m), and none were collected more than 46 ft. (14 m) from the source. Dispersal distance depends on release height, surrounding foliage, wind direction, and air humidity (McEvoy & Cox 1987).

Seeds can float for 18 days (Praeger 1913) and germinate in water (Poole & Cairns 1940). The resulting seed leaves (cotyledons) can stay alive in water; in experiments, they were still green 2 months after germination (Poole & Cairns 1940). Birds and stock animals can also carry the

seeds, attached by small, hairs (trichomes) adhering to feathers and hair (Poole & Cairns 1940; PNWC 1972).

Successional Status

S. jacobaea most often behaves as an early successional species, invading and quickly dominating disturbed sites, although it can also invade intact pasture (Poole & Cairns 1940). It is often the first plant colonizing cutover forest lands in western Washington and Oregon. It cannot tolerate shade (PNWC 1972), and, at least in New Zealand, does not invade undisturbed tussock-grassland (Poole & Cairns 1940).

Ecology

S. jacobaea can grow almost anywhere (CCNWCB 2001), although it prefers moderate moisture—a minimum of 35 in. (89 cm) precipitation per year) (Poole & Cairns 1940)—a light sandy or medium loamy soil that's not overly acidic, and cool and cloudy conditions (Poole & Cairns 1940; Jacobs 2009). It does not tolerate a high water table or poor drainage (Jacobs 2009) and hence isn't found on heavy clay soils, which dry out during drought (Poole & Cairnes 1940).

Impacts

In its rosette stage, the low, dense foliage of *S. jacobaea* effectively smothers competitors. When it matures, the space opened up by basal leaves dying gives the innumerable seeds sufficient light to germinate (Jacobs 2009). Additionally, *S. jacobaea* is allelopathic—more so in the flowering stage—suppressing nearby plants through chemical warfare (Ahmed & Wardle 1994).

Figure 98: *S. jacobaea* infestation. (Eric Coombs, Oregon Department of Agriculture, Bugwood.org.)

Management

Modern herbicides are effective at controlling *S. jacobaea*. In the Elwha, crews are spraying foliage with Milestone (aminopyralid) from rosette to bolting (Chenoweth *et al.* 2001). Incomplete chemical kill and manual efforts to control *S. jacobaea* often stimulate resprouting from the roots (Poole & Cairns 1940; Harper & Wood 1957). Hand-pulling plants in their first year, before the roots become extensive, can be effective, especially when the soil is soft and moist. Cutting plants, however, stimulates resprouting (Poole & Cairns 1940; CCNWCB [date unknown]). Three insects have been introduced to reduce *S. jacobaea* abundance: *Tyria jacobaeae* (cinnabar moth larvae), *Longitarsus jacobaea*e (ragwort flea beetle), and *Pegohylemyia seneciella* (larvae of the ragwort seed fly). Biological control, however, cannot eradicate an infestation (Macdonald *et al.* 2013). For long-term control, it's necessary to halt seed production and attack the root system (CCNWCB 2001).

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Glossary

Botanical terminology can be exacting and exasperating. For example, botanists use more than 25 words for different kinds of hairiness or fuzziness, including *arachnoid*, *canescent*, *lanate*, *tomentose*, and *villous*—and then they start hyphenating them. This simple glossary is intended to suffice while you're in the field. For more complex uses, I recommend getting a copy of *Plant Identification Terminology: An Illustrated Glossary*, by Harris and Harris (1994 & 2001).

Note: Most of these illustrations are from Hilary Parkinson, Montana State University. Other sources are cited at the end of the glossary.

Terminology

alternate: an arrangement in which 1 leaf occurs at each stem node (compare "opposite")

anther: the pollen-bearing structure of the stamen

axil: the angle formed by the main stem and any structure coming from it, such as a branch or a leaf stalk

calyx: the nonreproductive outer whorl of a flower, often (but not always) green; made of individual sepals

cauline: on the stem, of the stem

compound leaf: a leaf made up 2 or more leaflets

corolla: all of the flower petals collectively

drupe: a fleshy fruit containing 1 stony seed

elaiosome: a small, oil-containing appendage on a seed intended to attract insect pollinators or dispersers, especially ants

filament: the stalk of the male reproductive organ, often supporting an anther

fruit: a seed-bearing structure formed from an ovary

inflorescence: a fancy word *flower cluster*

keel: a ridgelike structure like the keel of a boat; often 2 petals in a pea-family flower will fuse into this shape

legume: a member of the Leguminosae (pea) family; the pod of a legume, which is a flattened fruit with seams on the sides

lip: a liplike structure, as in an irregular flower (stupid definition, eh?)

node: the location on a stem from which leaves or branches grow

ocrea: a sheath around the stem, often at or above the nodes

opposite: an arrangement in which 2 leaves grow across from each other at each stem node

ovary: the base of the pistil, which contains ovules

palmate: having lobes or leaflets originating from one point, in the shape of a hand

panicle: a multiply branching flower, with flowers stuck on the ends of the branchlets; they can also flop over, as in some of the grasses we discuss in this text

pea flower: one type of flower in the Leguminosae (formerly Fabaceae) family, having a flower with a banner, 2 wing petals, and a keel; a **papilionaceous flower**

pedicel: the stalk of a single flower or grass spikelet

peduncle: the stalk of a flower, a flower structure, or a flower cluster (inflorescence)

petal: a member of the inner whorl of a flower, often colored or white

petiole: the leaf stem or stalk

pinnate: having leaflets arranged along a central axis, or *rachis*

pistil: the female reproductive orga**n papilionaceous: "like a butterfly"; used to describe one type of flower in the pea family (see "pea flower")**

prickle: a small, sharp structure growing out of a stem

pubescent: fuzzy, with soft, short hairs

raceme: an elongated, unbranched cluster of flowers, all on stalks radiating from a central axis

sepal: a structure in the outer whorl of a flower

simple: having one leaf attached to the stem

spike: an elongated, unbranching cluster of flowers like a raceme, only the flowers are stalkless, so they're right on the main axis; also, a vampire on *Buffy the Vampire Slayer*

spine: a thin, stiff, pointed plant structure (formed from a modified leaf)

stamen: the male reproductive organ of a flower

stellate: star-shape (often in the cross-section of hairs

stigma: the part of the pistil that receives the pollen

stipule: structure sometimes found at the bases of leaves or leaf stalks (petiole)

style: the stalk of the pistil

thorn: a stiff, woody, sharply pointed structure (formed from a modified stem)

trifoliate: having 3 leaves or leaflets

whorled: an arrangement in which 3 or more leaves occur at each stem node

wing: a thin, flattened edge on a plant structure, such as a stem; one of 2 side petals on the flower in the Leguminosae (formerly Fabaceae) family

Figure 99: Simple and compound leaf types. ((Hilary Parkinson, Montana State University, and other source.)

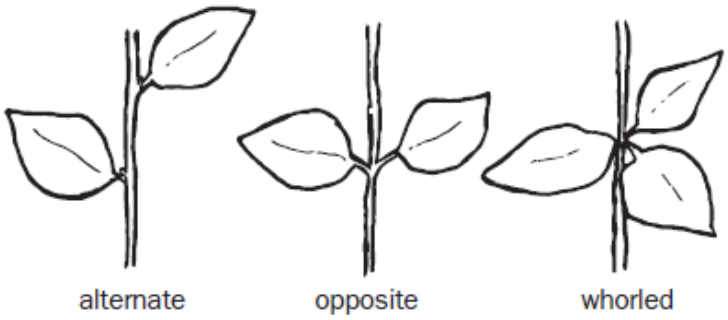


Figure 100: Leaf arrangements. (Hilary Parkinson, Montana State University.)

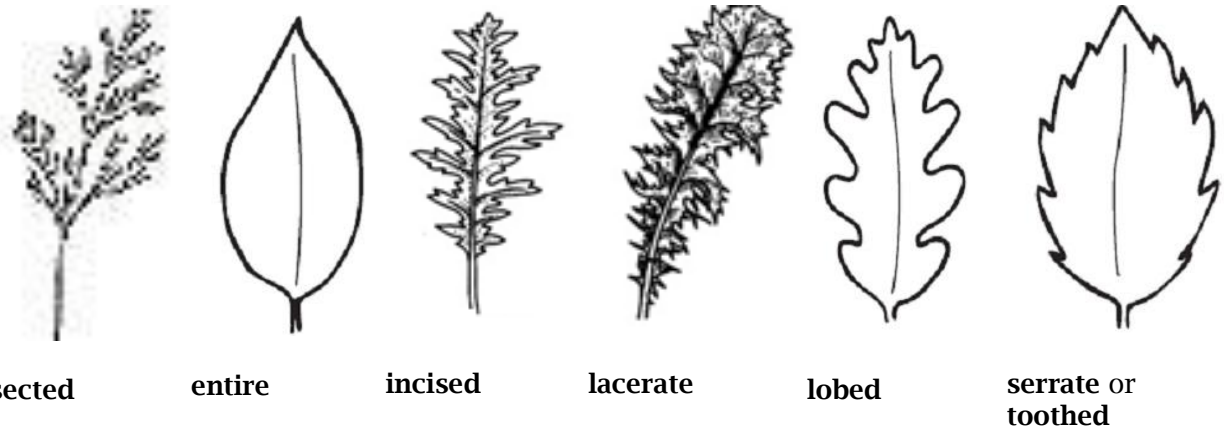


Figure 101: Selected leaf margins.

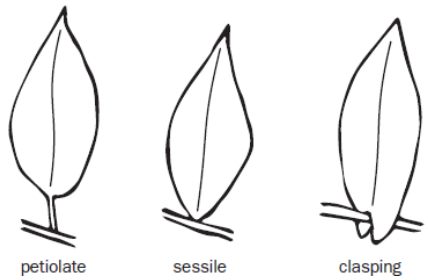


Figure 102: Leaf attachments. (Hilary Parkinson, Montana State University.)

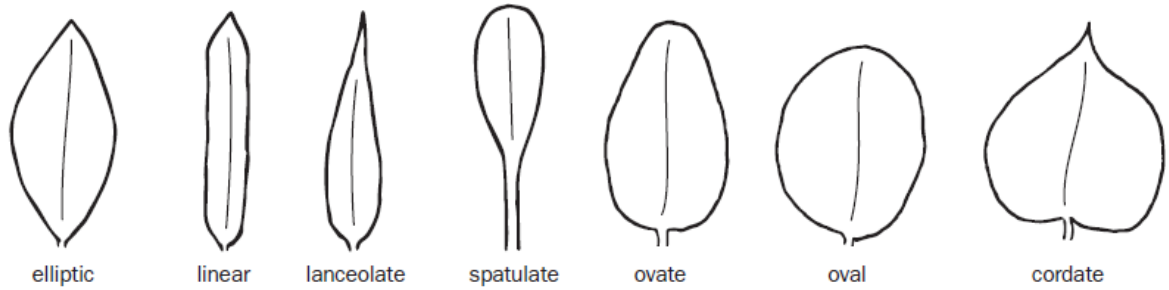


Figure 103: Leaf shapes. (Hilary Parkinson, Montana State University.)

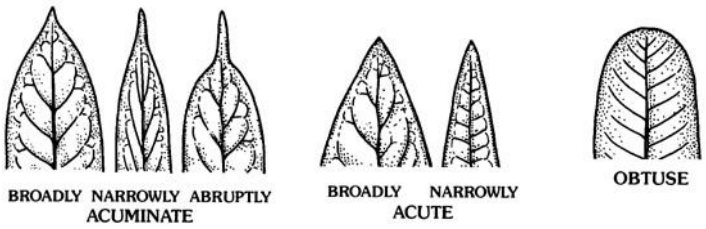


Figure 104: Selected leaf tips—especially important in *Polygonum* spp.

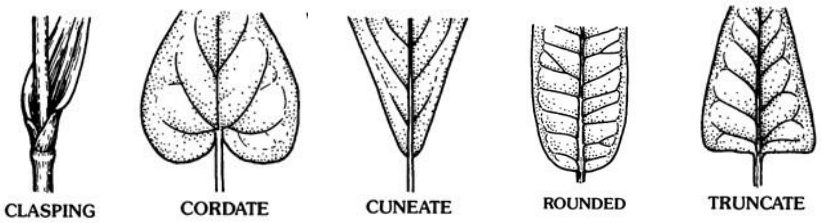


Figure 105: Leaf bases. Note synonyms: clasping (sheathing); cordate (heart-shape); cuneate (tapering), truncate (square).

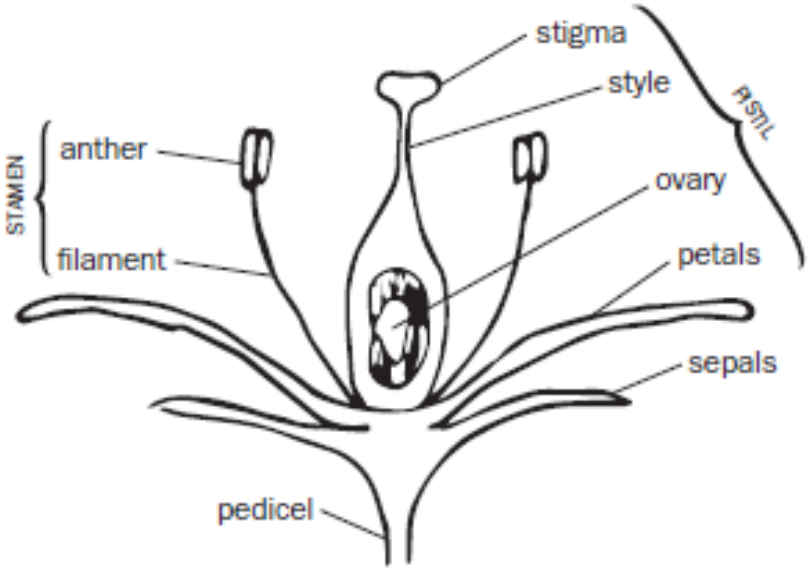


Figure 106: Flower organs. (Hilary Parkinson, Montana State University.)

Figure 107: Another view of sepals and petals.
(Hilary Parkinson, Montana State University.)

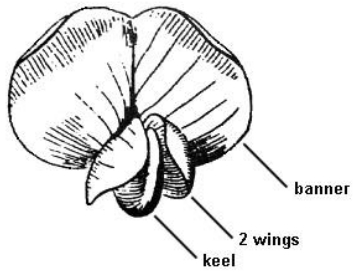


Figure 108: Papilionaceous flower illustrating banner, wings, and keel.
(Hilary Parkinson, Montana State University.)

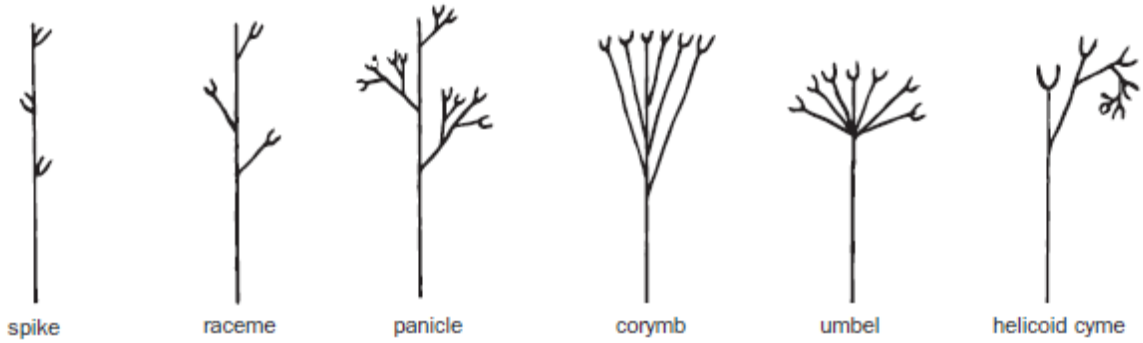
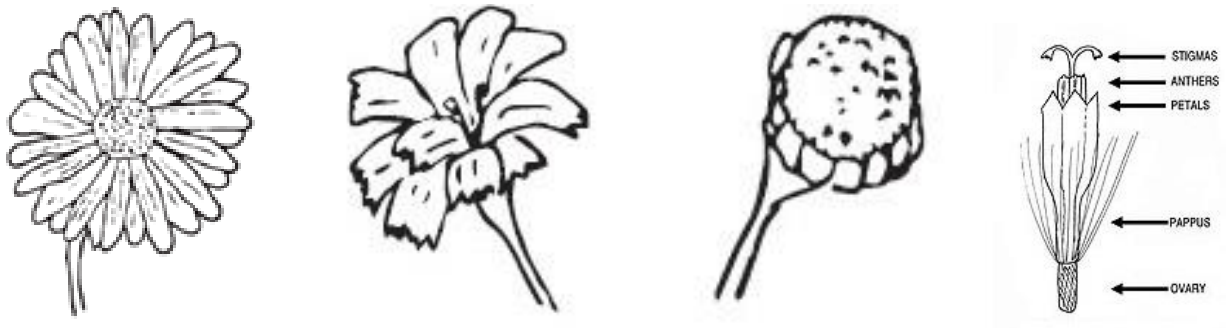


Figure 109: Inflorescence types. (Hilary Parkinson, Montana State University.)



ray and disc flowers | disc flowers only | disc flowers only | disc flower with feathery pappus

Figure 110: Secrets of the Asteraceae, often comprising many flowers of two types--disc and ray (ligulate) flowers but sometimes having all ray or all disc flowers. (First 3 by Hilary Parkinson, Montana State University.)

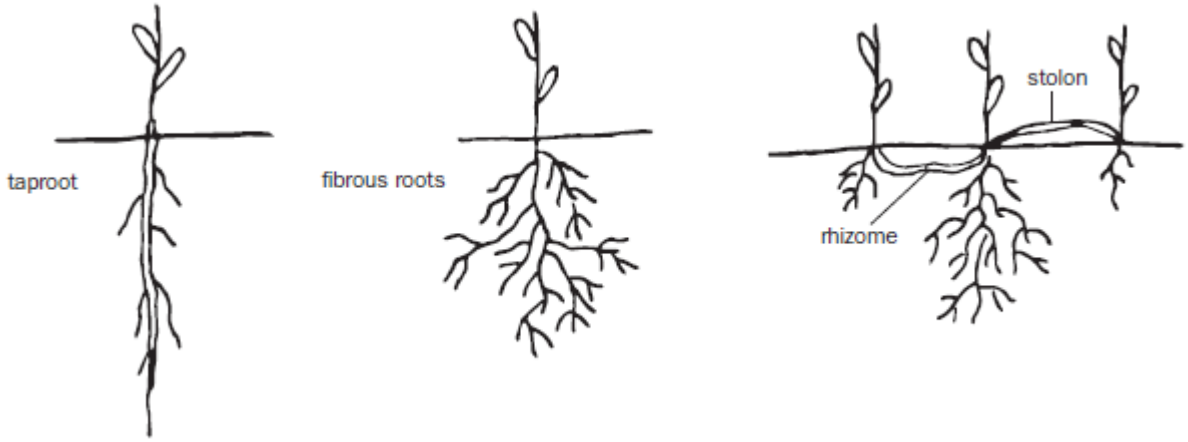
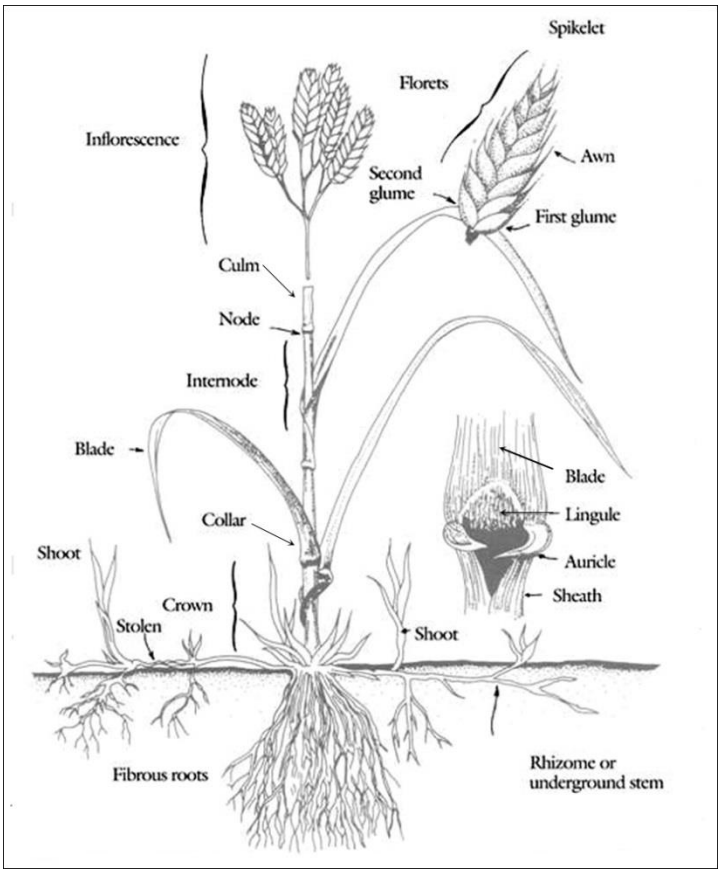


Figure 111: Types of root. (Hilary Parkinson, Montana State University.)

Grass Structures



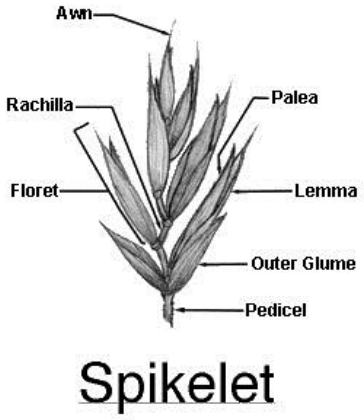


Figure 112: Parts of grass and sedge plant (left) (National Drought Mitigation Center, Lincoln, NE.) Close-in sketch of a spikelet and its components (right). (©2003 Jack Dekker, Weeds Biology Laboratory, Iowa State University.)

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Appendix: Nonnative Species Present as of 2011 in the Lower Elwha Watershed*

Scientific name	Common name	Life form
Acer platanoides	Norway maple	tree
Acer saccharinum	silver maple	tree
Agrostis capillaris	colonial bentgrass	graminoid
Agrostis gigantea	black bentgrass	graminoid
Agrostis stolonifera	creeping bentgrass	graminoid
Aira caryophyllea	silver hairgrass	graminoid
Aira praecox	early hairgrass	graminoid
***Amaranthus* sp.**	pigweed	forb
Anthemis cotula	dog fennel	forb
Anthoxanthum odoratum	sweet vernalgrass	graminoid
Arctium minus	common burdock	forb
Arrhenatherum elatius	false oat-grass	graminoid
Barbarea vulgaris	rocket cress	forb
Bellis perennis	English daisy	forb
Bidens tripartita	threelobe beggarticks	forb
Bromus commutatus	hairy brome	graminoid
Bromus hordeaceus* ssp. *hordeaceus	soft brome	graminoid
Bromus tectorum	cheatgrass	graminoid
***Buddleja* sp.**	butterfly bush	shrub
Calystegia sepium	wild morning-glory	forb
Capsella bursa-pastoris	shepherd's-purse	forb
Centaurea diffusa	diffuse knapweed	forb
Centaurea jacea	brown knapweed	forb
Centaurea montana	mountain cornflower	forb
Centaurea stoebe	spotted knapweed	forb

Centaurea xmoncktonii	meadow knapweed	forb
Cerastium fontanum* ssp. *vulgare	common chickweed	forb
Cerastium glomeratum	sticky chickweed	forb
Cerastium semidecandrum	little mouse-ear	forb
Chaenomeles speciosa	flowering quince	shrub
Chenopodium album	lamb's quarters	forb
Cirsium arvense	Canadian thistle	forb
Cirsium vulgare	bull thistle	forb
Clematis ligusticifolia	western clematis	shrub
Clematis vitalba	evergreen clematis	shrub
Convolvulus arvensis	field bindweed	forb
***Cotoneaster* sp.**	cotoneaster	dwarf shrub
Crataegus monogyna	oneseed hawthorn	small tree
Crepis capillaris	smooth hawksbeard	forb
Cynosurus cristatus	crested dog’s-tail	graminoid
Cytisus scoparius	Scot's broom	shrub
Dactylis glomerata	orchard grass	graminoid
Daphne laureola	spurge laurel	shrub
Daucus carota	Queen Anne's lace	forb
Digitalis purpurea	purple foxglove	forb
Draba verna	spring whitlow-grass	forb
Echinochloa crus-galli	barnyard grass	graminoid
Elymus repens	quackgrass	graminoid
Erechtites minima	toothed coastal burnweed	forb
Eschscholzia californica* ssp. *californica	California poppy	forb
Euphorbia cyparissias	cypress spurge	forb
Galeopsis tetrahit	common hempnettle	forb
Galium odoratum	sweet woodruff	forb
Geranium dissectum	cut-leaf geranium	forb
Geranium molle	dovefoot geranium	forb
Geranium robertianum	herb Robert	forb
Glechoma hederacea	ground ivy	forb
Hedera helix	English Ivy	shrub
Hedera hibernica	Atlantic ivy	shrub

Hesperis matronalis	dames rocket	forb
Holcus lanatus	common velvet grass	graminoid
Hypericum calycinum	Aaron's beard	dwarf shrub
Hypericum perforatum	common St. John's wort	forb
Hypochaeris glabra	smooth cat's-ear	forb
Hypochaeris radicata	hairy cat's-ear	forb
Ilex aquifolium	English holly	small tree
Kerria japonica	Japanese rose	shrub
Lactuca serriola	prickly lettuce	forb
Lapsana communis	common nipplewort	forb
Lathyrus latifolius	perennial pea	forb
Lathyrus sylvestris	small everlasting peavine	forb
Leucanthemum vulgare	oxeye daisy	forb
Linaria vulgaris	butter and eggs	forb
Lolium perenne	perennial ryegrass	graminoid
Lotus pedunculatus	pedunculate lotus	forb
Malus sylvestris	cultivated apple	tree
Matricaria discoidea	pineapple weed	forb
Medicago lupulina	black medick	forb
Mentha xpiperita	peppermint	forb
Mycelis muralis	wall-lettuce	forb
Myosotis arvensis	field forget-me-not	forb
Myosotis discolor	yellow -and-blue forget-me-not	forb
Myosotis latifolia	woodland forget-me-not	forb
Myosotis stricta	strict forget-me-not	forb
Narcissus pseudonarcissus	daffodil	forb
Papaver orientale	oriental poppy	forb
Phalaris arundinacea	reed canarygrass	graminoid
Phleum pratense	common timothy	graminoid
Plantago lanceolata	English plantain	forb
Plantago major	common plantain	forb
Poa annua	annual bluegrass	graminoid
Poa compressa	Canada bluegrass	graminoid
Poa palustris	fowl bluegrass	graminoid

Poa pratensis* ssp. *pratensis	Kentucky bluegrass	graminoid
Poa trivialis	rough-stemmed bluegrass	graminoid
Polygonum aviculare	common knotweed	forb
Polygonum xbohemicum	hybrid knotweed	shrub
Polygonum cuspidatum	Japanese knotweed	shrub
Polygonum sachalinense	giant knotweed	shrub
Potentilla recta	sulfur cinquefoil	forb
Prunella vulgaris* ssp. *vulgaris	common selfheal	forb
Prunus avium	sweet cherry	small tree
Prunus laurocerasus	Laurel cherry	small tree
Ranunculus repens	creeping buttercup	forb
Rubus armeniacus	Himalayan blackberry	shrub
Rubus laciniatus	evergreen blackberry	shrub
Rumex acetosella	common sheep sorrel	forb
Rumex crispus	curly dock	forb
Rumex obtusifolius	bitter dock	forb
Sagina apetala	common pearlwort	forb
Sagina procumbens	bird-eye pearlwort	forb
Saponaria officinalis	bouncing bet	forb
Schedonorus arundinaceus	tall fescue	graminoid
Schedonorus pratensis	meadow fescue	graminoid
Senecio jacobaea	tansy ragwort	forb
Senecio sylvaticus	wood groundsel	forb
Senecio vulgaris	common groundsel	forb
Sherardia arvensis	blue field madder	forb
Silene alba	white campion	forb
Silene coronaria	rosa campion	forb
Sonchus asper	prickly sow-thistle	forb
Sonchus oleraceus	common sow-thistle	forb
Sorbus aucuparia	European mountain ash	small tree
Spergularia rubra	red sandspurry	forb
Spergularia villosa	hairy sandspurry	forb
Stellaria media	chickweed	forb

Symphytum officinale	common comfrey	forb
***Syringa* sp.**	lilac	shrub
Taraxacum erythrospermum	red-seed dandelion	forb
Taraxacum officinale	dandelion	forb
Taxus baccata	English yew	small tree
Tragopogon dubius	yellow salsify	forb
Trifolium campestre	field clover	forb
Trifolium dubium	least hop clover	forb
Trifolium hybridum	alsike clover	forb
Trifolium pratense	red clover	forb
Trifolium repens	white clover	forb
***Ulmus* sp.**	elm	tree
Urtica dioica* ssp. *gracilis	stinging nettle	forb
Verbascum thapsus	common mullein	forb
Veronica arvensis	common speedwell	forb
Veronica officinalis	Paul's betony	forb
Veronica serpyllifolia	thyme-leaved speedwell	forb
Vicia hirsuta	hairy vetch	forb
Vicia sativa* ssp. *sativa	common vetch	forb
Vicia villosa* ssp. *varia	woolly vetch	forb
Vinca minor	bigleaf periwinkle	dwarf shrub
Vulpia bromoides	barren fescue	graminoid
Vulpia myuros	rat-tail fescue	graminoid
***Wisteria* sp.**	wisteria	shrub

*__Source:__ Chenoweth, J., Acker, S.A. & McHenry, M.L. (2011) Revegetation and restoration plan for Lake Mills and Lake Aldwell. Port Angeles, WA: Olympic National Park and the Lower Elwha Klallam Tribe. http://www.nps.gov/olym/naturescience/elwha-restoration-docs.htm. [Accessed 4 Sep 2013.]9