Non-native and Invasive Plants in the Lower Coos Watershed

CLW DATA SOURCE

Summary:

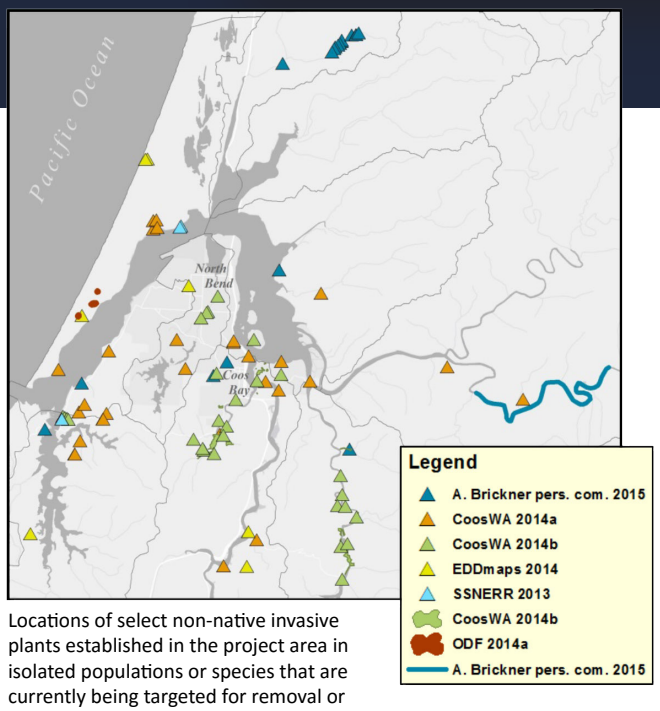
- *Seven invasive plant species already established in the project area pose imminent environmental or socio-economic threats; 10 species not yet present in the project area are expected to cause problems in the future.*
- *European beachgrass (*Ammophila arenaria*) and gorse (*Ulex europaeus*) are two non-native invasive plant species that have significantly changed the local landscape. Beachgrass is well established in the project area and gorse is common to the south.*

Meadow knapweed Photo: ODA

Gorse Photo: ODF 2014b

Evaluation

Many non-native plants threaten local socio-economic or environmental systems; they should be controlled and closely monitored.



Locations of select non-native invasive plants established in the project area in isolated populations or species that are currently being targeted for removal or control actions.

This data summary describes available data for non-native and invasive (see sidebar) vegetation species found locally and is divided, like other data summaries, into two sections: 1) What's happening?; and 2) Background.

The What's happening? section focuses on the presence, distribution, and threat levels associated with priority non-native and invasive plant species, and is divided into three subsections: 1) Predicted Threats; 2) Partially Contained Threats; and 3) Established Threats. The subsections are defined as follows:

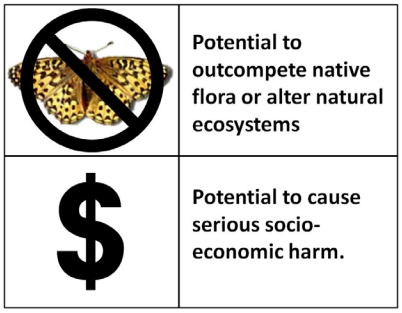
1) Predicted threats – invasive vegetation not yet found in the project area but will be in the future.
2) Partially contained threats – invasive vegetation currently found only in isolated populations within the project area.
3) Established threats – invasive vegetation found across much or all of the project area.

The Background section provides detailed descriptions of the specific threats posed by each of the 58 non-native and invasive plant species included in this data summary.

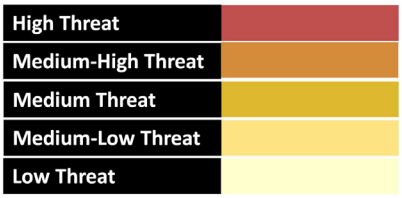
What's happening?

The threat status of the non-native and invasive vegetation species discussed in each section is indicated by icons and colors. A butterfly/slash icon indicates plant species with high potential to cause environmental harm; these species outcompete native flora and alter natural ecosystems. The dollar sign icon indicates plant species with high potential to cause serious socio-economic harm (see threat icon graphic). Threat levels are indicated by color codes- red being the greatest threat, pale yellow the lowest threat (see color code graphic).

Each section also includes a summary table listing the species discussed in the section along with general information about their introduction and impacts in Oregon. Species are color-coded using the same icon color codes described above- red being the greatest threat, pale yellow the lowest threat (see color code graphic).



Threat icon graphic.



Color code graphic.

Predicted Threats (Table 1)

These species have nearby established populations (adjoining counties or states) and are imminent threats to the project area. Several species have been introduced in the past but have since been eradicated.

Cordgrasses (*Spartina spp.*)

Three invasive cordgrass species are considered serious potential economic and environmental threats to the Coos estuary:

Smooth cordgrass (*Spartina alterniflora*), considered the most aggressive of the invasive cordgrass species, has been found once in the Coos estuary at the Oregon Department of Transportation's (ODOT) Barview Wayside wetland mitigation site near Barview (Figure 1). This population was accidentally transplanted during the wetland mitigation re-vegetation work. Because they never produced seed heads, the mysterious plants, growing into two large clones in the middle of the wetland, were very hard to positively identify (Figure 2). What was later identified using genetic techniques as smooth cordgrass was manually removed from the site over the course of seven years, both before and after the plant was positive identified. Helped immeasurably by the absence of seed production, smooth cordgrass is now considered completely eradicated at the Barview Wayside site. Aside from a site in the Siuslaw estuary (where the Barview Wayside infestation

Non-native species – *Plants or animals introduced either intentionally or accidentally to locations outside their native ranges.*

Invasive Plant – *Non-native plants or animals that aggressively outcompete native vegetation causing significant economic loss and/or environmental harm. Not all non-native species are invasive.*

Noxious Weeds – *Invasive plant species listed at the county, state or federal level as particularly harmful to public health, wildlife, agricultural activities, or public and private property.*

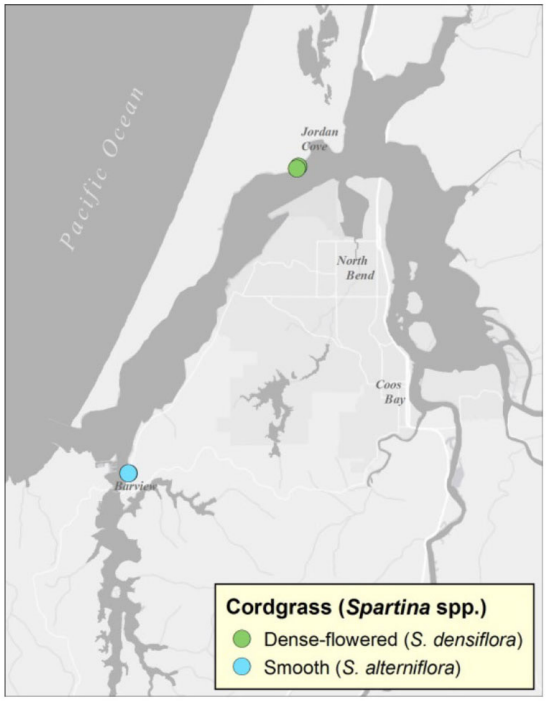


Figure 1: Locations of historic cordgrass infestations in the Coos estuary. All known plants have since been eradicated. Data: SSNERR 2013

Predicted Threats

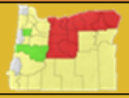
Common name	Species name	ODA listing*		$	Distribution in project area	Native location	Year Oregon introduction	Location Oregon introduction	Vector Oregon introduction	Oregon range**	References
Common cordgrass	*Spartina anglica*	A	x	x	Not known to be present	England	n/a	n/a	n/a	n/a	
Dense-flowered cordgrass	*Spartina densiflora*	T and A	x	x	Near Jordan Cove; eradicated 2013	Southern South America	2013	Coos estuary	Most likely ocean currents	n/a	
Saltmeadow cordgrass	*Spartina patens*	T and A	x	x	Not known to be present	Eastern North America	c1930	Siuslaw River	Most likely contaminated oyster spat	n/a	Howard et al. 2007
Smooth cordgrass	*Spartina alterniflora*	T and A	x	x	Barview (South Slough); eradicated 2005	Eastern U.S.	c1970	Siuslaw River	Intentional planting		Howard et al. 2007
Garlic mustard	*Alliaria petiolata*	T and B	x	x	Not known to be present	Europe	1959	Multnomah County	Most likely intentional		ODA 2014a
Portuguese Broom	*Cytisus striatus*	T and B	x	x	Not known to be present	Spain and Portugal	c1980	south of Florence	Intentional planting		ODA 2014a
Diffuse Knapweed	*Centaurea diffusa*	B		x	Not known to be present	Mediterranean	early 1900's		Contaminated alfalfa seeds		ODA 2014a
Giant hogweed	*Heracleum mantegazzianum*	T and A	x	x	Not known to be present	Caucasus Mt., Asia	2001	Eugene			Savonen 2003
Herb Robert	*Geranium robertianum*	B	x		Not known to be present	Eurasia, northern Africa					
Woolly Distaff Thistle	*Carthamus lanatus*	T and A		x	Limited	Mediterranean	1987	Douglas County	Imported California livestock		OSU 2006

Table 1. Predicted non-native and invasive vegetation species threats. * Listed species are considered noxious weeds by the state of Oregon (Oregon Department of Agriculture). A-listed species: Economically threatening weed which occurs in small enough infestations to make eradication or containment possible; or is not known to occur in the state, but its presence in neighboring states make future occurrence in Oregon imminent. B-listed species: Economically threatening weed which is regionally abundant, but may have limited distribution in some counties; T-listed species: Weeds annually selected from A or B listed species as the focus of prevention and control by Oregon's Noxious Weed Control Program. ** Weed distribution color key: Yellow: limited; Red: widespread; Green: historical; Gray: not known to be present. (ODA 2014a).

Figure 2. Top left: Smooth cordgrass (*Spartina alterniflora*) clones (black arrows) at Barview Wayside in 1995. Top right: close-up of a flowering smooth cordgrass seed head which never developed at Barview Wayside. Middle left: Dense-flowered cordgrass (*Spartina densiflora*) in Coos Bay near Jordan Cove (2013). Middle right: Close-up of dense-flowered cordgrass flowering head. Bottom left: Saltmeadow cordgrass (*Spartina patens*). Bottom right: Common cordgrass (*Spartina anglica*).

originated), and a site at the mouth of the Columbia River, the Barview Wayside infestation is the only documented case of smooth cordgrass becoming established in Oregon. According to Howard et al. (2007), regional invasions occur in San Francisco, CA, which has a large (~1,000 acres in 2006) smooth cordgrass population, and to the north, in Willapa Bay, WA where populations peaked in 2003 with 8,500 acres affected, costing Washington state over $3 million from 2005-07.

Dense-flowered cordgrass (*Spartina densiflora*) plants were found in the Coos estuary in 2013 near Jordan Cove, the first time this species has been found in Oregon (Figures 1 and 2). Five individual clones were found and subsequently removed. According to Howard et al. (2007), over 1,500 acres of marsh habitat in Northern California have been converted to dense flowered cordgrass-dominated systems. For example, dense-flowered cordgrass now occupies 94% of Humboldt Bay's remaining salt marsh habitat.

Saltmeadow cordgrass (*Spartina patens*) is only known to occur in Oregon on Cox Island in the Siuslaw River (Howard et al. 2007)(Figure 2). Present since the 1930's, eradication of this population began in 1996 and is still ongoing. As of 2006, San Francisco (California) had a small (< 1 acre) population of this species (Howard et al. 2007).

Common cordgrass (*Spartina anglica*) has never been found in Oregon, but has established populations in both the Puget Sound to the north and San Francisco to the south (Howard et al. 2007)(Figure 2).

Garlic mustard (*Alliaria petiolata*)

Although not known to occur in Coos County, the Coos County Weed Advisory Board has determined that garlic mustard can cause harm to the local forest ecosystems by dominating forest understory plant communities (Coos Weed Board 2011)(Figure 3). The Oregon Department of Agriculture (ODA) reports that the nearest county known to have garlic mustard is Josephine, just southeast of Coos County (ODA 2014).

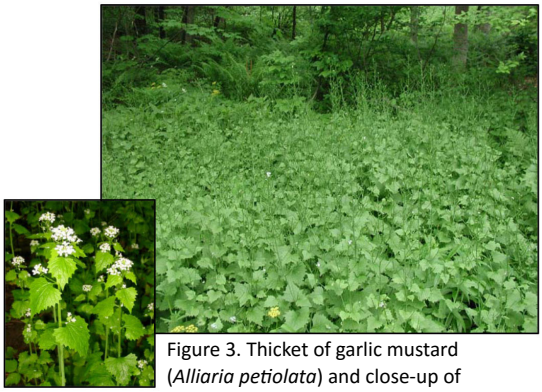


Figure 3. Thicket of garlic mustard (*Alliaria petiolata*) and close-up of flowers. Photos: ODA 2014a; EDDMapS 2014.

Portuguese Broom (*Cytisus striatus*)

Portuguese Broom infestations in Oregon are only known in Lane and Douglas Counties, with the closest documented location just south of Florence (ODA 2014a)(Figure 4). In North America, it only occurs in California and Oregon (Zouhar 2005a). The Coos County Weed Advisory Board has listed this species as a species of high concern due to its detrimental economic impacts and the likelihood of this species to infest Coos County (Coos Weed Board 2011). The California Invasive Plant Council lists Portuguese broom as one of the most invasive wildland pest plants in regional areas of the state (Zouhar 2005a).

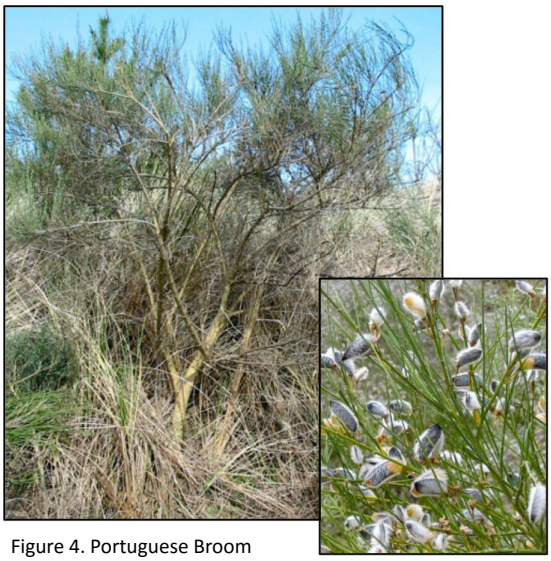


Figure 4. Portuguese Broom (*Cytisus striatus*) plant and close up of seed pods. Photos: ODA 2014a

Diffuse Knapweed (*Centaurea diffusa*)

Diffuse knapweed, which occurs in all surrounding counties but not yet in Coos County, is listed by the Coos County Weed Advisory Board as a species expected to be extremely damaging to the local economy if allowed to take hold (Coos Weed Board 2011)(Figure 5). This species cannot tolerate flooding or shading, therefore it is most likely to be found in drier pasture or cropland areas (Beck 2013). Duncan (2001 as cited in Zouhar 2001a) reports that Oregon had nearly one million acres of diffuse knapweed infesting it in 2000.

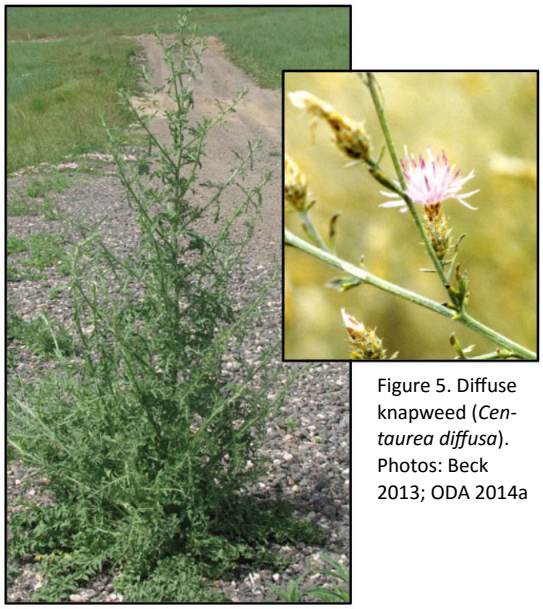


Figure 5. Diffuse knapweed (*Centaurea diffusa*). Photos: Beck 2013; ODA 2014a

Giant Hogweed (*Heracleum mantegazzianum*)

Giant hogweed has yet to be found in the project area, but has limited distribution along the northern Oregon coast (ODA 2014a). Moist wooded riparian areas of the project area would provide perfect habitat for this species and allow it to reach its full reproductive potential (Figure 6)(Forney 2013).

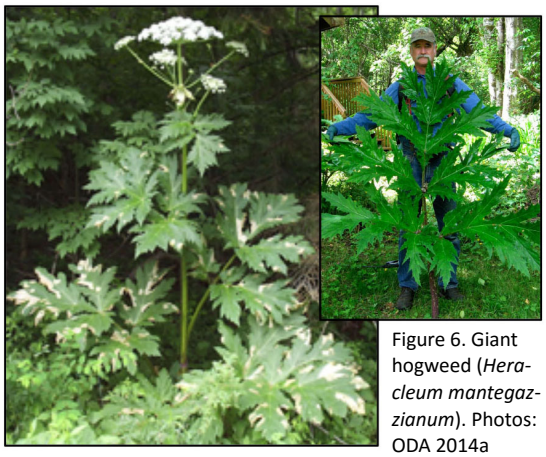


Figure 6. Giant hogweed (*Heracleum mantegazzianum*). Photos: ODA 2014a

Herb Robert (*Geranium robertianum*)

Herb Robert is not known to occur in the project area, but there has been positive identification of this species in Coos County by the United States Forest Service (USFS) in 2002 (Figure 7)(EDDMapS 2014). According to ODA (2014a), Herb Robert has the potential to become the most common woodland invader in Western Oregon.

Figure 7. Herb Robert (*Geranium robertianum*). Photo: ODA 2014a

Woolly Distaff Thistle (*Carthamus lanatus*)

Wooly distaff thistle is not known to occur in Coos County, but it can be found in all surrounding counties (ODA 2014a; OSU 2006). According to Burrill (1994), Wooly distaff thistle is a federally listed noxious weed considered one of the worst pasture weeds in North America and Australia.

Partially Contained Threats (Table 2)

Species described in this section have become established in the project area in isolated pockets, and whose populations are either being actively managed or were just recently discovered.

Old Man's Beard (*Clematis vitalba*)

So far, old man's beard has limited distribution in the project area. It is, however, fairly widespread along the South Fork Coos River (Figures 8 and 9)(ODA 2014a; A. Brickner, pers. comm. 2014). Old man's beard is much more common in northwestern Oregon and is expected to become widespread throughout most of the state due to this species' highly effective seed dispersal strategy (ODA 2014a).

False Brome (*Brachypodium sylvaticum*)

Identified in the South Slough watershed in 2006 by ODA, Oregon is considered the "epicenter for false brome" in the U.S. (Figures 8 and 9)(EDDMapS 2014, ODA 2014a). First discovered in North America (specifically, in Eugene) in 1939, this perennial grass has been naturalized (a self-sustaining population) in the Corvallis/Albany area since at least 1966 and has now taken over an estimated 10,000 acres in Oregon (Chambers 1966; Davi 2009; ODA 2014a).

Distribution of false brome is expected to become more widespread since the species has had time to genetically evolve and adapt (Holmes et al. 2010).

Policeman's Helmet (*Impatiens glandulifera*)

Until recently, infestations of policeman's helmet have been restricted to northwestern Oregon. However, in 2014 this species was found in the project area (Figures 8 and 9) (ODA 2014a; A. Brickner, pers. comm. 2015). Oregon invasions have come from expansion of established populations in western Washington and lower British Columbia (ODA 2014a).

Spanish Heath (*Erica lusitanica*)

Within the project area, Spanish heath occurs along Cape Arago Highway (Figures 8 and 9) (A. Brickner, pers. comm. 2015). First introduced at a rare plant nursery near Langlois OR, Spanish heath has become established in seven Oregon locations, mainly in Coos and Curry counties. It's well adapted to the moist acidic soils of coastal Oregon and is a prolific seed-bearer. Spanish heath is expected to spread exponentially in the coming years. High costs associated with controlling established populations make Spanish heath a high priority for early eradication (French 2009).

Partially Contained Threats

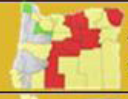
Common name	Species name	ODA listing*		$	Distribution in project area	Native location	Year Oregon introduction	Location Oregon introduction	Vector Oregon introduction	Oregon range**	References
Old man's beard	*Clematis vitalba*	B	x	x	Currently limited to Coos River	England	c1950		Intentional planting		A. Brickner pers. com. 2015
False brome	*Brachypodium sylvaticum*	B	x		South Slough	Eurasia, northern Africa	1939	Eugene			ODA 2014a
Policeman's helmet	*Impatiens glandulifera*	B	x		North Slough 2014	Himalayas					A. Brickner pers. com. 2015
Spanish heath	*Erica lusitanica*	B		x	Cape Arago Hwy	Western Europe	1970	Langlois			A. Brickner pers. com. 2015
Spurge species	*Euphorbia* spp.	A or B	x	x	Three known locations	Eurasia	1991	Salem			A. Brickner pers. com. 2015; ODA 2014a
Dalmatian toadflax	*Linaria dalmatica*	T and B		x	South Slough (Barview) in 2014	Mediterranean					A. Brickner pers. com. 2015
Yellow flag iris	*Iris pseudacorus*	B	x		Mingus park	Eurasia, northern Africa					A. Brickner pers. com. 2015

Table 2. Partially contained non-native and invasive vegetation species threats. * Listed species are considered noxious weeds by the state of Oregon (Oregon Department of Agriculture). A-listed species: Economically threatening weed which occurs in small enough infestations to make eradication or containment possible; or is not known to occur in the state, but its presence in neighboring states make future occurrence in Oregon imminent. B-listed species: Economically threatening weed which is regionally abundant, but may have limited distribution in some counties; T-listed species: Weeds annually selected from A or B listed species as the focus of prevention and control by Oregon's Noxious Weed Control Program. ** Weed distribution color key: Yellow: limited; Red: widespread; Green: historical; Gray: not known to be present. (ODA 2014a).

Figure 8. Partially contained species. Clockwise from top: Policeman's helmet (*Impatiens glandulifera*)(inset: flower); Yellow flag iris (*Iris pseudacorus*); Old man's beard (*Clematis vitalba*)(inset: leaves and flower); Spanish heath (*Erica lusitanica*); Dalmatian toadflax (*Linaria dalmatica*). Middle: False brome grass (*Brachypodium sylvaticum*). Photos: ODA 2014a; Stone 2009; Lincoln county soil water conservation district; kingcounty.gov; wikipedia.

Spurge Species (*Euphorbia spp.*)

Approximately 12 spurge plants whose identification have not been finalized can be found at three locations in the project area. These spurge species are most likely leafy spurge (*E. esula*) or oblong spurge (*E. oblongata*)(Figure 9). The plants will be positively identified and pulled in the summer of 2015 (A. Brickner, pers. comm. 2015). Oblong spurge is only known to occur in three Oregon counties, Lane County being closest to the project area (ODA 2014a). Rare along coastal Pacific

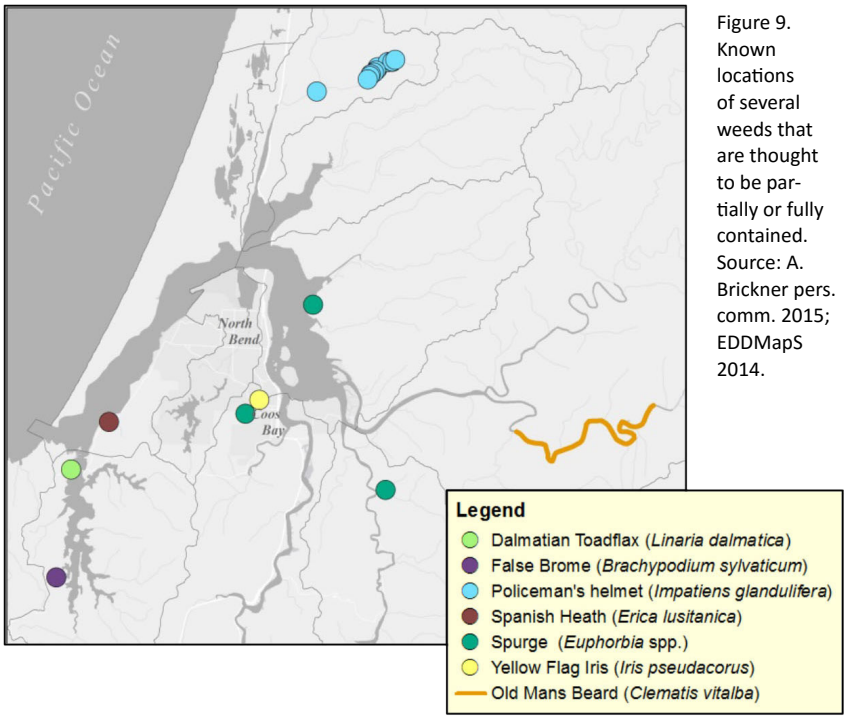


Figure 9. Known locations of several weeds that are thought to be partially or fully contained. Source: A. Brickner pers. comm. 2015; EDDMapS 2014.

Northwest in 1994, leafy spurge is more common in eastern Oregon counties, but occurs in Curry County to the south (Pojar and MacKinnon 1994; USDA 2015).

Dalmatian Toadflax (*Linaria dalmatica*)

Dalmatian toadflax was positively identified in Charleston in 2014 for the first time within the project area (Figures 8 and 9)(A. Brickner, pers. comm. 2015). Many Oregon counties east of the Cascades have widespread infestations of this species (ODA 2014a).

Yellow Flag Iris (*Iris pseudacorus*)

Yellow flag iris is an aquatic plant found sporadically within the project area and is more common further north (e.g., Umpqua River) (Figures 8 and 9)(A. Brickner, pers. comm. 2015; ODA 2014a).

Established Species (Table 3)

The following list of priority, already established non-native and invasive plant species (listed in Table 3 which spans two pages), are found throughout the project area, either in widespread or limited populations.

Figure 10. Top: Oblique sand dunes before beachgrass (*Ammophila spp.*) invasion. Middle: Inspection of intentional plantings of beachgrass in the Oregon Dunes Recreation Area c1930's. Dunes were planted to stabilize the highly mobile sand. Bottom: Bulldozer taking down a foredune north of Reedsport. The foredune was largely created by beachgrass (seen behind the bulldozer). Sources: University of Oregon Libraries; Siuslaw National Forest (bottom two photos); Coos Bay BLM (inset)

Beachgrass (*Ammophila spp.*)

Two related invasive beachgrass species occur in Oregon: 1) European beachgrass (*Ammophila arenaria*)(native to Europe); and 2) American beachgrass (*A. breviligulata*)(native to the east coast of North America)(Figure 10). European beachgrass was introduced to Oregon in 1910 near Coos Bay for dune stabilization and now dominates the dune system (Crook 1979). American beachgrass was intentionally planted near the mouth of the Columbia River in the 1930s and has since spread south. According to Hacker et al. (2012), American beachgrass was only found in isolated patches in Coos County, where the dunes are dominated by European beachgrass. Since their introduction in Oregon, beachgrasses have created a nearly continuous barrier from the foredunes inland to Highway 101, completely changing the formerly dynamic dune system (Crook 1979). Aerial photography of Oregon dunes from 1939 show 20% vegetative coverage; 50 years later over 80% of dunes in the same region were covered by vegetation (USFS n.d.).

Gorse (*Ulex europaeus*)

So far, gorse is found only in relatively small, isolated patches around the Coos estuary (Figures 11 and 12)(SHN 2013; A. Brickner,

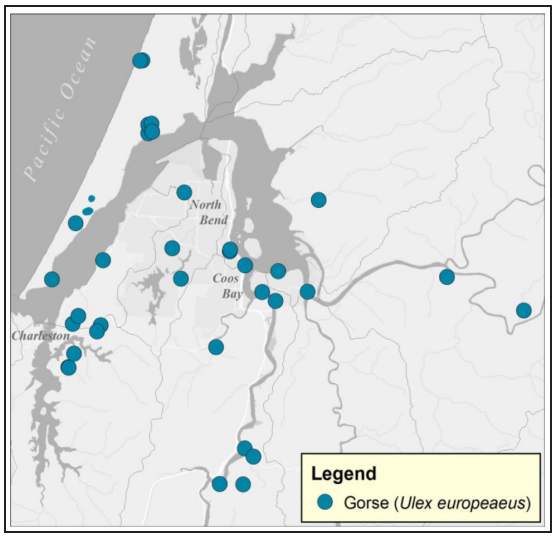


Figure 11. Known locations of gorse (*Ulex europeaeus*) infestations in the project area. Sources: ODF 2014a; EDDMapS 2015; CoosWA 2014a

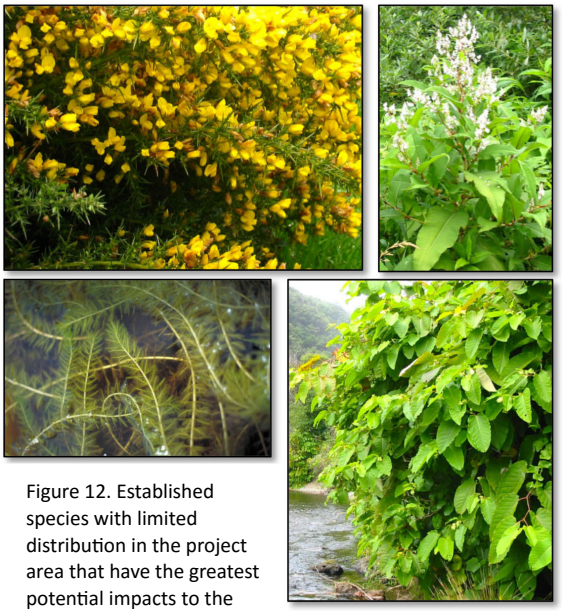


Figure 12. Established species with limited distribution in the project area that have the greatest potential impacts to the project area (clockwise from top left): gorse (*Ulex europaeus*); Himalayan knotweed (*Polygonum polystachyum*); giant knotweed (*Polygonum sachalinense*); and Eurasian watermilfoil (*Myriophyllum spicatum*). Photos: ODA 2014a

pers. comm. 2015; OR Dept. of Forestry [ODF] 2014a; CoosWA 2014a; EDDMapS 2014). Infestations at many of these locations are controlled by the Coos Watershed Association (CoosWA) and in some cases herbicide (Garlon 3A or triclopyr)(A. Brickner, pers. comm. 2015). Just south of the project area, gorse has completely overtaken native vegetation in many expansively infested landscapes. ODF conducted an aerial survey of 300,000 acres in coastal Coos and Curry counties in the spring of 2014; they recorded over 6,200 acres of gorse, nearly 4,400 acres of which were heavily infested (ODF 2014a).

French broom (*Genista monspessulana*)

Widespread on the southern Oregon coast, this plant prefers warm, moist, low elevation areas (ODA 2014a)(Figure 13). French broom is the most widespread broom in California (Zouhar 2005b).

Knotweeds (*Polygonum spp.*)

There are four knotweeds known in the project area: Himalayan (*P. polystachyum*), Japanese (*P. cuspidatum*), giant (*P. sachalinense*), and Bohemian (*P. bohemica*)(a hybrid between giant and Japanese knotweeds) (Figure 12). Himalayan knotweed is the least common of the three non-hybridized species

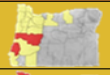
Established Threats											
Common name	Species name	ODA listing*		$	Distribution in project area	Native location	Year Oregon introduction	Location Oregon introduction	Vector Oregon introduction	Oregon range**	References
European beachgrass	*Ammophila arenaria*		x	x	Widespread	Europe; northern Africa	1910	near Coos Bay	Intentional planting		Russo et al. 1988
Gorse	*Ulex europaeus*	T and B	x	x	Limited	Europe	c1870	Bandon	Intentional planting		
Armenian blackberry	*Rubus armeniacus*	B	x	x	Widespread	Armenia; northern Iran	1922	Marion County	Intentional planting		ODA 2014a
Bohemian knotweed	*Polygonum bohemica*		x		Limited	hybrid between giant and Japanese					
Brazilian waterweed	*Egeria densa*	B	x	x	Widespread	South America					
English ivy	*Hedera helix*	B	x	x	Widespread	Eurasia					
Eurasian watermilfoil	*Myriophyllum spicatum*	B	x	x	Limited	Eurasia; northern Africa					
French broom	*Genista monspessulana*	B	x	x	Widespread	Mediterranean	1924	Curry County			
Giant knotweed	*Polygonum sachalinense*	B	x		limited (1st found in Coos County in 1937)	northeastern Asia and Japan	1937	Coos County			ODA 2014a
Himalayan knotweed	*Polygonum polystachyum*	B	x		Limited	Asia	1934	Polk County			
Japanese knotweed	*Polygonum cuspidatum*	B	x		Limited	eastern Asia	1965	Lane County			ODA 2014a
Jubata grass	*Cortaderia jubata*	B	x	x	Widespread	northern Andes					
Purple loosestrife	*Lythrum salicaria*	B	x		Widespread	Eurasia; northwest Africa					
Reed canary grass	*Phalaris arundinacea*		x		Widespread	Mediterranean; possibly North America					
Scotch broom	*Cytisus scoparius*	B	x	x	Widespread	Europe	1892	Benton County			
Butterfly bush	*Buddleja davidii (B. variabilis)*	B		x	Widespread	China; Japan			Intentional planting		ODA 2014a
Canada thistle	*Cirsium arvense*	B		x	Widespread	Eurasia					
Creeping buttercup	*Ranunculus repens*		x	x	Widespread	Eurasia; northern Africa					NPSO 2008
English holly	*Ilex aquifolium*		x		Widespread	Eurasia					Gray 2005; NPSO 2008
Field bindweed (morning glory)	*Convolvulus arvensis*	T and B		x	Widespread	Eurasia					
Meadow knapweed	*Centaurea pratensis*	B		x	Limited	Europe					

Table 3 (continued next page). Established non-native and invasive vegetation species threats.

* Listed species are considered noxious weeds by the state of Oregon (Oregon Department of Agriculture). A-listed species: Economically threatening weed which occurs in small enough infestations to make eradication or containment possible; or is not known to occur in the state, but its presence in neighboring states make future occurrence in Oregon imminent. B-listed species: Economically threatening weed which is regionally abundant, but may have limited distribution in some counties; T-listed species: Weeds annually selected from A or B listed species as the focus of prevention and control by Oregon's Noxious Weed Control Program.

** Weed distribution color key: Yellow: limited; Red: widespread; Green: historical; Gray: not known to be present. (ODA 2014a)

*** Non-native species not considered to be invasive.

Established Threats (continued)

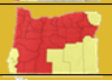
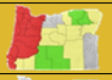
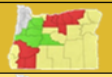
Common name	Species name	ODA listing*		$	Distribution in project area	Native location	Year Oregon introduction	Location Oregon introduction	Vector Oregon introduction	Oregon range**	References
Milk thistle	*Silybum marianum*	B		x	Widespread	Eurasia					
Parrot's feather	*Myriophyllum aquaticum*	B	x		Widespread	Amazon	c1940				ODA 2014a
Poison hemlock	*Conium maculatum*	B		x	Limited	Europe; Mediterranean	1919	Multnomah County			ODA 2014a
Slender flowered thistle	*Carduus tenuiflorus*	B		x	Widespread	Europe; northern Africa					
Spiny cocklebur	*Xanthium spinosum*	B		x	Limited	South America					
Spotted knapweed	*Centaurea stoebe (C. maculosa)*	T and B		x	Limited	central/eastern Europe					
Tansy ragwort	*Senecio jacobaea*	T and B		x	Widespread	northern Eurasia	1922				OSU 2008b
Velvetleaf	*Abutilon theophrasti*	B		x	Limited	southern Asia					
Yellow starthistle	*Centaurea solstitialis*	B		x	Limited	Mediterranean					
Biddy-biddy	*Acaena novae-zelandieae*	B	x		Limited	New Zealand	1951	Curry County	possibly imported sheep wool		ODA 2014a
Bull thistle	*Cirsium vulgare*	B		x	Widespread	Eurasia; northwest Africa	pre 1900				OSU 2006
Cherry laurel	*Prunus laurocerasus*				Widespread	eastern Europe; southwestern					
Cotoneaster	*Cotoneaster spp.*		x		Widespread	Eurasia; northern Africa					NPSO 2008
Japanese eelgrass	*Zostera japonica*		x			eastern Asia					
Pennyroyal	*Mentha pulegium*		x	x	Limited	Europe; northern Africa; Middle					
St. Johnswort	*Hypericum perforatum*	B		x	Widespread	Europe					
Sweet fennel	*Foeniculum vulgare*		x		Widespread	Mediterranean					
Yellow glandweed	*Parentucellia viscosa*				Limited	Europe					
Brass buttons***	*Cotula coronopifolia*					Southern Africa					Heutte and Bella 2003
Redtop grass***	*Agrostis gigantea*					Eurasia					Carey 1995

Table 3 (continued from previous page). Established non-native and invasive vegetation species threats.

* Listed species are considered noxious weeds by the state of Oregon (Oregon Department of Agriculture). A-listed species: Economically threatening weed which occurs in small enough infestations to make eradication or containment possible; or is not known to occur in the state, but its presence in neighboring states make future occurrence in Oregon imminent. B-listed species: Economically threatening weed which is regionally abundant, but may have limited distribution in some counties; T-listed species: Weeds annually selected from A or B listed species as the focus of prevention and control by Oregon's Noxious Weed Control Program.

** Weed distribution color key: Yellow: limited; Red: widespread; Green: historical; Gray: not known to be present. (ODA 2014a)

*** Non-native species not considered to be invasive.

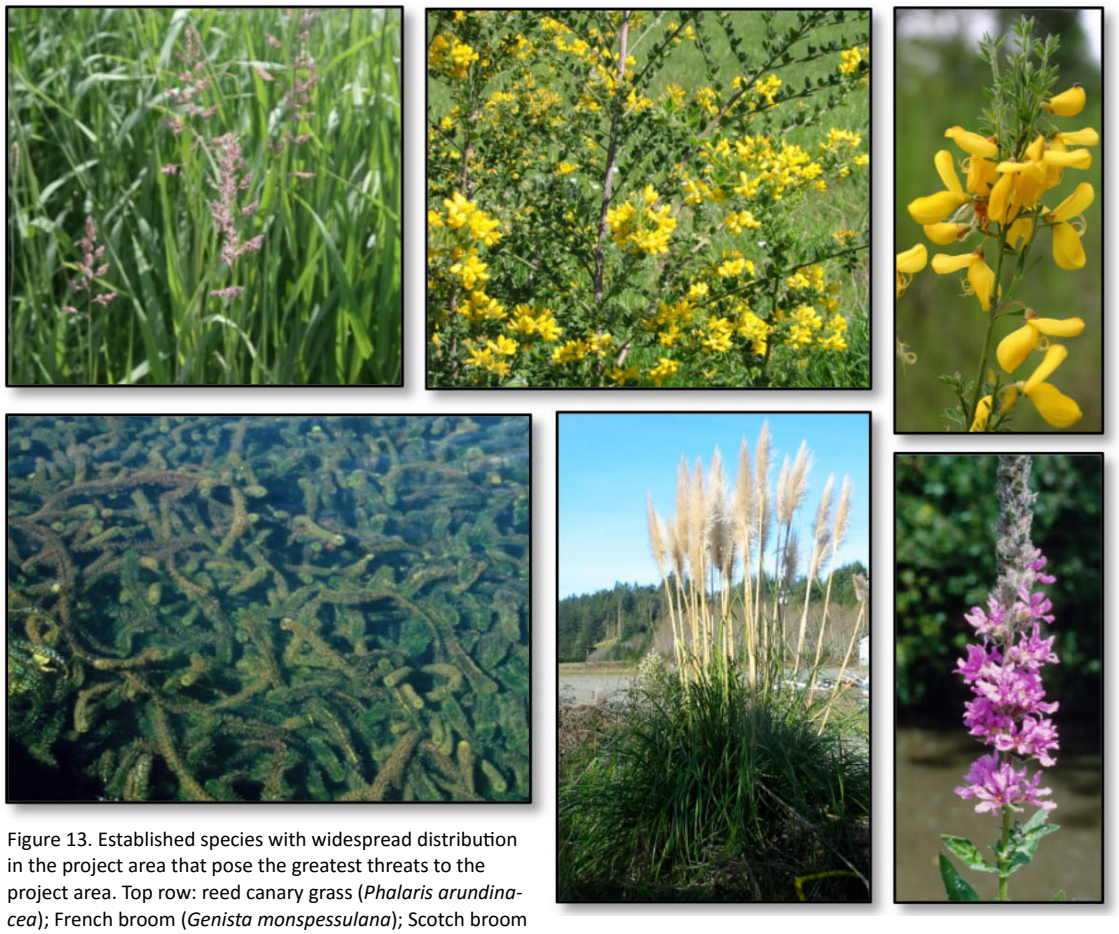


Figure 13. Established species with widespread distribution in the project area that pose the greatest threats to the project area. Top row: reed canary grass (*Phalaris arundinacea*); French broom (*Genista monspessulana*); Scotch broom (*Cytisus scoparius*); Middle row: Brazilian waterweed (*Egeria densa*); jubata grass (*Cortaderia jubata*); purple loosestrife (*Lythrum salicaria*). Photos: ODA 2014a; U of FL (Brazilian waterweed); and OSU (reed canary grass).

in the Pacific Northwest, while Japanese knotweed has the most widespread distribution, especially in western Oregon (ODA 2014a).

CoosWA provides free herbicide application to knotweed infestations for any landowner within the Coos watershed. Because of this effort, between 2008 and 2012, knotweed infestation in the Coos watershed was reduced from 12 acres to three (Cornu et al. 2012).

Purple loosestrife (*Lythrum salicaria*)

Found along moist sites in most subsystems of the project area, purple loosestrife populations are especially dense along Catching Slough and near the Libby area of Coalbank Slough (Figures 13 and 14)(CoosWA 2014b).

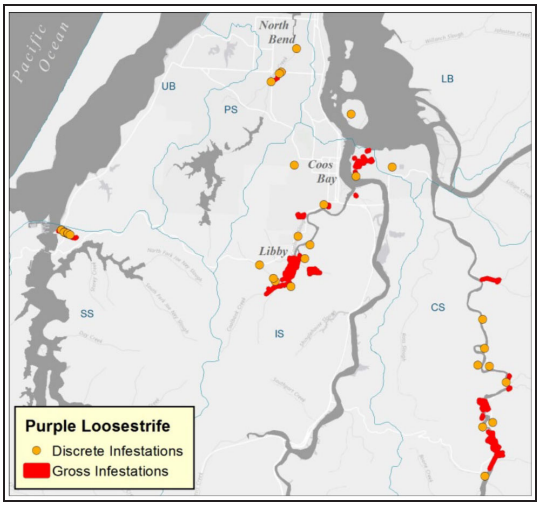


Figure 14. Discrete (small, isolated) and Gross (large, dense) infestations of purple loosestrife (*Lythrum salicaria*) in the project area as surveyed by Coos Watershed Association staff in 2014. Subsystems: SS = South Slough; LB = Lower Bay; UB = Upper Bay; PS = Pony Slough; IS = Isthmus Slough; CS = Catching Slough. Source: CoosWA 2014b

Reed canary grass (*Phalaris arundinacea*)

Reed canary grass (Figure 13) commonly occurs in freshwater wetlands and on agricultural lands in the project area. However, distribution of the species and the extent of invasion have not been documented locally. Magee et al. (1999) evaluated 96 freshwater wetland sites in the Portland (OR) area and found that the most frequently found invasive species was reed canary grass (93% of sites). In a related study by Magee and Kentula (2005), freshwater wetlands (43 study plots in seasonal, perennial, and open water wetlands within the Portland, OR urban growth boundary) where reed canary grass was present averaged 67% cover.

Butterfly bush (*Buddleja davidii,* formerly *B. variabilis*)

Out of all Oregon counties, butterfly bush is most widespread in Coos and Lane counties (ODA 2014a). In the project area, it's been most frequently reported along Cape Arago Hwy, Isthmus Slough, and the mouth of the Coos River (EDDMapS 2015).

Buttercup (*Ranunculus spp.*)

There are numerous native and non-native buttercup species in Oregon. Introduced buttercups include: *R. arvensis, R. bulbosus, R. ficaria, R. sardous, R. muricatus, R. parviflorus,* and *R. repens*. The latter three occur in Coos County (USDA 2015). Of these three, creeping buttercup (*R. repens*) is considered the most problematic both environmentally and economically (Burrill 1996).

Knapweed or starthistle (*Centaurea spp.*)

There are three knapweed/starthistle species known to occur in the project area – spotted knapweed (*C. stoebe*, formerly *C. maculosa*), meadow knapweed (*C. pratensis*) and yellow starthistle (*C. solstitialis*). A fourth invasive

species, diffuse knapweed, (*C. diffusa*) has not been found locally and is described under Predicted Threats above.

Because yellow starthistle, already infesting nearly one million acres of Oregon rangeland (Duncan 2001 as cited in Zouhar 2002), prefers dry conditions with full sunlight, it's not likely to heavily infest the project area. Meadow knapweed, on the other hand, favoring moist conditions (e.g. riverbanks or irrigated pastures), can become established in a wide range of local environments (ODA 2014a; OSU 2006; Zouhar 2002). Spotted knapweed tolerates both wet and dry conditions, but prefers areas that receive summer rainfall (Beck 2013; PCA 2005). According to Zouhar (2001b), nearly 800,000 acres of Oregon lands were infested with spotted knapweed in 2000.

Tansy ragwort (*Senecio jacobaea*)

Already widespread in Coos County, tansy ragwort thrives in cool, wet, cloudy weather, like that seen along the Oregon coast (OSU 2008b).

Biddy-biddy (*Acaena novae-zelandiae*)

Biddy-biddy's distribution is limited in Coos County and in the project area. It's been reported in the lower Coos estuary near Empire and in the upper South Slough estuary (C. Cornu, pers. comm. 2015; EDDMapS 2014; ODA 2014a).

Cotoneaster (*Cotoneaster spp.*)

Multiple cotoneaster species have been introduced in Oregon including *C. simonsii* which is found in Coos County including the project area. Other species found elsewhere may pose threats in the future: *C. franchetii , C. lacteus* (Lane and Curry counties)*; C. horizontalis, C. divaricatus, C. nitens* (Lane County); *C. acuminatus* (Benton County); and *C. pannosus* (Jackson County)(USDA 2015).

Japanese eelgrass (*Zostera japonica*)

Japanese eelgrass coverage has not been quantified in the Coos estuary, but it commonly occupies previously unvegetated mudflat areas (Shafer et al. 2011). Japanese eelgrass was first observed in the Coos estuary in the mid-1970's in South Slough. By the mid-1980's it had spread throughout the South Slough and to middle portions of the Coos estuary (Posey 1988). This eelgrass invader has since increased its distribution and density in the Coos estuary (Rumrill 2006). Japanese eelgrass grows on the Coos estuary's mid-intertidal mudflats (0.6-1.2 m

[2.0-4.0 ft] above mean lower low water) and generally does not compete with the native eelgrass (*Z. marina*), which grows on lower intertidal mudflats and in subtidal channels (Posey 1988). In Yaquina Bay, Japanese eelgrass coverage has increased by 400% in just over nine years (Young et al. 2008).

Sweet Fennel (*Foeniculum vulgare*)

Fennel is considered only moderately invasive. Expansive populations can be found in coastal southern Oregon (NPSO 2008).

Background

Below are detailed descriptions of the specific threats posed by each of the non-native and invasive plant species included in this data summary (species listed alphabetically):

American Beachgrass (*Ammophila breviligulata*): See "Beachgrasses" below.

Armenian blackberry (*Rubus armeniacus*) (formerly Himalayan blackberry, *Rubus discolor*)
According to ODA (2014a), this invasive blackberry is the most economically damaging non-native species in western Oregon due to control costs on public and private rights-of-way, agricultural pasture and crop lands, and timberlands. The estimated economic impact of Armenian blackberry infestations and associated control costs in Oregon is over $40 million. When all susceptible acres of land are considered, this estimate could rise to $268 million (ODA 2014b). Armenian blackberry, which severely alters native ecosystems, can grow 20 feet per year and reproduces with prolific berry production, or vegetatively by rooting the tip of the cane when it touches the ground (ODA 2014a). Commonly found in open riparian areas, blackberry thickets provide little shade for streams and prevent native shade-producing trees and shrubs to colonize stream banks.

Beachgrasses (*Ammophila spp.*)
Non-native European and American Beachgrasses are well adapted to seasonal sand burial (up to 1 m per year according to Ranwell 1959 as cited in Russo et al. 1988), which allows them to outcompete the native dune grass, *Elymus mollis* (a.k.a. *Leymus mollis*). Invasive beachgrasses spread via rhizomes (i.e., rootstock), the fragments of which are dispersed along the shore by winter storms (Russo et al. 1988). Once established, these species are very difficult to control, much less eradicate.

Since the introduction of beachgrasses to the Oregon dunes, populations of native plant and animal species adapted to once dynamic Oregon dune habitats (including pink sand verbena, wolf's evening primrose, silvery phacelia, and the endangered western snowy plover), have declined precipitously (Figure 10)(Julian 2012, Kaye 2004, Kalt 2008, Russo et al. 1988).

Russo et al. (1988) attributed native dune species decline largely to changes in the orientation of the Oregon dune field's valleys (technically referred to as "slacks") and to the reduction in sand supply to interior dune habitats, both caused by the establishment of non-native beachgrasses. Historically, beaches associated with the Oregon dunes were characterized by the absence of foredune habitat running parallel to the ocean shore. Dunes and associated slacks were instead oriented obliquely to the shore, shifting with seasonal changes in prevailing winds. The Coos Bay dune field (stretching from Haceta Head in the north and Cape Arago in the south, the largest dune sheet in North America) contains the only "oblique-ridge dunes"' in the world, which are expected to disappear in the foreseeable future due to non-native beachgrass stabilization (Cooper 1958; Crook 1979).

According to a draft environmental impact statement by Siuslaw National Forest (1993 as cited in Wiedemann and Pickart 1996), the unique open dunes will completely disappear by 2040, a process which can only be reversed by removing the foredune, a cost-prohibitive solution.

Wiedemann and Pickart (1996) temper the threat by providing evidence for the long-term cyclical nature of Oregon dune stabilization and rejuvenation over the course of the past 3,000 years; a recurring process in which vegetation-induced dune stabilization creates a foredune, which is then eliminated during major natural disturbances (e.g., subduction zone earthquake, tsunami, sea level rise), releasing interior dunes once again to wind-driven sand movement. They suggest that non-native beachgrasses may only be hastening a natural cyclical process.

Biddy-biddy (*Acaena novae-zelandiae*)
Biddy-biddy is a low-growing perennial forb (non-grass herbaceous plant) that prefers disturbed open sites (e.g., stablilized dunes or open scrub communities) and competes poorly with established native vegetation (ODA 2014a). Its seed exteriors feature barbed burs that cling tenaciously to almost anything, allowing the seeds to spread far and wide by mobile species including mammals, birds and humans. Biddy-biddy can also spread vegetatively by the growth of above-ground "stolons" (horizontal stems)(ODA 2014a).

Brass Buttons (*Cotula coronopifilia*)
Brass buttons is a non-native, non-invasive species commonly found in disturbed wetlands and beaches in every Oregon coastal county. Brass buttons is easily outcompeted by native vegetation.

Brazilian waterweed (*Egeria densa*)
Exported from South America for use in aquariums, Brazilian waterweed has escaped to infest local lakes, ponds, and slow moving rivers where it forms dense mats on the water's surface. Once established, Brazilian waterweed slows or stops water flow, traps sediments, displaces native aquatic species, and interferes with recreational activities (e.g., swimming, boating)(Figure 13). Inter-

estingly, all Brazilian waterweed plants in the U.S. are male, but they still manage to spread vegetatively (WSDE n.d.).

Bull thistle (*Cirsium vulgare*)
Reaching 5 ft (1.5 m) tall and 3 ft (0.9 m) in diameter, bull thistle is made up of many spiny branches and can develop taproots that extend 28 inches (71 cm) into the soil (OSU 2008a; USFS 2005a). Seeds are wind dispersed and can remain viable for up to 10 years (OSU 2008a). This thistle is most commonly found in disturbed areas such as along roadsides and in pastures in poor conditions, though it can also be found in cleared forestland (OSU 2006; USFS 2005a). Bull thistle can reduce agricultural productivity by forming large, dense stands in pastures. Bull thistle also grows in native plant communities, out-competing these plants for water, nutrients and space.

Buttercup (*Ranunculus spp.*): Of all the non-native plant species found in Coos County, creeping buttercup (*R. repens*) is the most invasive, spreading by stolons and forming thick carpets in wet meadows (Burrill 1996). In buttercup-infested pasture lands this plant can poison and sometimes kill livestock (Burrill 1996). Creeping buttercup is also highly invasive in moist riparian terraces and wetlands, dominating streamside plant communities (NPSO 2008)

Butterfly bush (*Buddleja davidii* formerly *B. variabilis*)
Similar to Scotch broom (below), butterfly bush dominates open disturbed habitat, and is especially problematic to re-forested lands where it smothers tree seedlings (ODA 2014a). Butterfly bush can grow to 12 ft (3.6 m) in height and 15 ft (4.6 m) across and produces an abundance of wind-dispersed seeds (USFS 2005b).

Canada thistle (*Cirsium arvense*)
Canada thistle spreads aggressively through agricultural lands, riparian areas, wet meadows, and roadsides both vegetatively and from seed (up to 5,000 per plant)(USFS 2006a). Control of established populations can be difficult because even small root segments can form new plants (OSU 2006).

Cherry laurel (*Prunus laurocerasus*)
Also known as English laurel, cherry laurel can "escape" from cultivated hedges, spreading into nearby forest lands. Cherry laurel is a shade tolerant plant that can grow to 30 ft (9 m) tall and is toxic (especially the seeds) if ingested (USDA 2010).

Cordgrasses (*Spartina spp.*)
Except where otherwise noted, the following information is provided by Howard et al. (2007). Only one *Spartina* species (*S. foliosa*) is native to the U.S. West Coast. Four other *Spartina* species found in the region are non-native and considered particularly invasive: Common cordgrass (*S. anglica*), smooth cordgrass (*S. alterniflora*), dense-flowered cordgrass (*S. densiflora*), and saltmeadow cordgrass (S. patens). Common cordgrass is a hybrid between the European cordgrass (*S. maritima*, not found on the U.S. West Coast) and smooth cordgrass. Common and smooth

cordgrasses colonize West Coast estuaries, converting widespread unvegetated low intertidal mudflats to marsh habitat. These marshes are dominated entirely by *Spartina* since no native marsh plants are adapted to grow in the low intertidal zone. This dramatic habitat shift affects native plant and animal species that rely on intertidal mudflats (e.g., shore birds, native clams, eelgrass), and severely limits recreational and commercial uses of those same mudflats (e.g., commercial oyster cultivation, recreational clamming). Smooth cordgrass is the most aggressively spreading of the four species and is also able to occupy the broadest elevation range (mudflat to high marsh). Dense-flowered and saltmeadow cordgrasses are better adapted to local marsh habitats where they aggressively outcompete native salt marsh species.

All four non-native *Spartina* species can reproduce both sexually (seeds), flowering late summer into early fall, and by vegetative means (i.e. rhizome fragments).

Cotoneaster (*Cotoneaster spp.*)
Cotoneaster species frequently escape garden plantings and are considered moderately invasive in coastal Oregon woodlands and prairies (NPSO 2008). On occasion, populations can become dense enough to crowd out native vegetation (DiTomaso et al. 2013).

Dalmatian Toadflax (*Linaria dalmatica*)
Dalmatian toadflax is a potentially serious weed that invades agricultural lands. It is resistant to many herbicides, hosts several viruses that can transfer to crops, outcompetes

Vectors of invasion

Not being aware of some plants' aggressive potential, people intentionally introduce what turn out to be invasive terrestrial vegetation to their local areas:

- *As garden ornamentals (e.g., butterfly bush, Scotch broom, gorse)*
- *For agriculture land enhancements (e.g., false brome, reed canary grass)*
- *For use in aquariums or water features (e.g. Eurasian watermilfoil, Brazilian waterweed)*
- *For use as bank or dune stabilization (e.g., European beach grass)*

Accidental invasive species introductions also occur, often the result of seeds or vegetative parts hitchiking on:

- *Internationally traded goods (e.g., biddy-biddy in sheep's wool)*
- *The boots or clothing of individuals traveling from infested regions*
- *Migrating animals*

Animals can also spread non-native and invasive plants by ingesting seeds and dropping seed-laden feces in areas with hospitable growing conditions (e.g., cotoneaster, English ivy).

desirable forage plants while having no forage value itself, and is difficult to eradicate once established (Figure 8). Control costs are currently estimated at over $250,000 per year. If all Oregon lands susceptible to infestation were covered by this species, annual control costs could reach over $20 million (ODA 2014b). Toadflax vegetative budding roots can extend up to six feet (1.8 m) deep and spread laterally up to 12 ft (3.6 m). Mature toadflax plants can produce as many as 500,000 seeds each year. This species commonly invades open disturbed areas such as roadsides and cultivated fields but rarely occurs in intact natural areas. Toadflax is not known to be used by local animals except as cover for small animals (Zouhar 2003).

Diffuse knapweed (*Centaurea diffusa*)
See 'Knapweeds and Starthistle' below.

English holly (*Ilex aquifolium*)
A common ornamental, English holly frequently escapes garden plantings and is considered moderately invasive in Oregon woodlands and prairies (NPSO 2008). English holly is a shade tolerant species that is frequently associated with increasing forest stand density. English holly populations in Oregon are expected to spread significantly in coming years (Gray 2005).

English ivy (*Hedera helix*)
English ivy is a perennial evergreen climbing vine that covers trees to canopy height, sometimes creating enough biomass that its weight topples trees. English ivy also spreads horizontally along the forest floor, displacing all native vegetation in its path (ODA 2014a). It is considered a threat to native plant communities in Oregon and has been placed on ODA's 2010 list of quarantine species (Waggy 2010). English ivy has a high tolerance to varying light conditions, thriving in both full shade and full sun. It can survive in early to late successional forests (Waggy 2010).

Eurasian watermilfoil (*Myriophyllum spicatum*)
See 'Watermilfoil' below.

European Beachgrass (*Ammophila arenaria*)
See "Beachgrasses" above.

False Brome (*Brachypodium sylvaticum*)
Brought to Oregon in the late 1930's by USDA as one of several grasses for range enhancement experiments, false brome has since escaped into Oregon's landscape (Figure 8). False brome is a perennial grass that thrives in both shady and sunny conditions, creating thick monoculture (single-species) mats that can outcompete native herbaceous vegetation and prevent native tree species' seeds from germinating. Further, false brome does not provide good forage, reducing pasture productivity (Davi 2009).

Field bindweed (morning glory)(*Convolvulus arvensis*)
Competing with crops for nutrients and water and extremely difficult to remove, field bindweed can reduce crop yields by as much as 50% (ODA 2014a). One plant can produce up to 500 seeds, which remain viable in the soil for up to 20 years (USFS 2006b). This

climbing vine has lateral roots that can sprout new plants from small root or vine fragments, greatly complicating eradication measures (USFS 2006b; Zouhar 2004a).

French Broom (*Genista monspessulana*)
An aggressive pioneer species that displaces native early colonizing plants in disturbed areas, French broom can drive up invasive species control costs in timber harvest areas and create a severe fire hazard during the dry season (Figure 13)(ODA 2014a). A medium sized French broom shrub can produce over 8,000 seeds per year, which are explosively ejected by the pod up to 13 ft (4 m) from the parent shrub (Bossard 2000, Zouhar 2005b). Over half the seeds from these dense woody shrubs are dormant upon dispersal. Germination takes place only under specific environmental conditions (e.g., scarification of the seed shell); seeds remain viable in the soil for up to 5 years (Adams et al. 1991, Bossard 2000b).

Garlic Mustard (*Alliaria petiolata*)
Extremely difficult to control once established, garlic mustard thrives in partial shade and forms dense thickets in forest understories, displacing native species (Figure 3). It can also infest riparian zones, roadsides, trails and agricultural lands and is almost totally reliant on seed production to spread (ODA 2014a). Garlic mustard can grow as tall as 3.5 feet (1 m)(USFS 2005c) and does not tolerate acidic soil, likely explaining its absence from conifer-dominated communities. This invader appears to negative affect native butterfly populations by fatally inhibiting larval development in butterfly eggs deposited on its leaves (Munger 2001).

Giant Hogweed (*Heracleum mantegazzianum*)
Unlike its native relative, cow parsnip (*H. maximum*), giant hogweed adversely affects both local economies and native plant communities (ODA 2014a). Most common in partial shade or full sun, giant hogweed readily invades riparian areas where it outcompetes native species, provides poor winter groundcover for animals, and leads to increased bank erosion during winter rains (Thiele and Otte 2006, DiTomaso and Healy 2007, Forney 2013). Forney (2013) describes giant hogweed as a human health hazard, since its sap contains a chemical that can cause severe burns on UV exposed skin, prompting the need for targeted control programs in public spaces. Although this plant is currently only found in very limited areas in Oregon, potential economic impact to the state (in lost agricultural production and control costs) if it was to infest all susceptible habitat would be over $1 million per year (ODA 2014b).

Giant hogweed is a large plant, growing approximately 15 ft (4.5 m) tall with flower heads and leaves that can be 3 ft (0.9 m) or more in diameter (ODA 2014a). It grows from a single hollow stem that can be 6 inches (15 cm) in diameter (Figure 5)(Page et al. 2006). Seeds can float in water for two days and remain viable, allowing this plant spread via waterways (Gucker 2009). Because of its size and prolific seeding ability (each flower head can produce 1,500 seeds), giant hogweed easily

outcompetes native species (USFS 2005d). According to Gucker (2009), giant hogweed seeds are capable of germinating within the first year of dispersal; the plants generally flower in three years and then die.

Gorse (*Ulex europaeus*)
Gorse is considered one of the most unmanageable weeds in the world, significantly affecting both native habitats and local economies (e.g., managed forestland) by forming impenetrable thickets that persist and thrive for many years (Figure 12)(ODA 2014a). A perennial, densely spiny shrub that can live for over 40 years, gorse colonization results in the development of large seed banks in underlying soils, which severely complicate eradication efforts. Gorse seeds, which can remain dormant but viable for up to 30 years, require scarification (damage to outer seed case) in order to germinate (Zouhar 2005c). Gorse currently infests less than 0.2% of possible area it could inhabit in Oregon but still costs the state an estimated $441,000 in lost economic activity and control measures. If it were to cover all susceptible lands, it would cost over $205 million to control.

Herb Robert (*Geranium robertianum*)
Herb Robert can affect native flora, with localized densities of 250 plants/m^2. Herb Robert's roots, however, are shallow, allowing for easy manual control. According to ODA (2014a), herb Robert can invade open forest or forest edge habitat, and can also thrive in shady conditions, allowing it to directly compete with native understory plant communities (Figure 7).

Japanese eelgrass (*Zostera japonica*)
The invasive status of Japanese eelgrass is debated. Evidence supports both its potential benefits and harmful effects. The following describes Japanese eelgrass's positive, negative and neutral effects on the local ecosystem.

Positive: Waterfowl (e.g., mallards) prefer grazing on Japanese eelgrass over native eelgrass, possibly due to the higher caloric value and easier foraging accessibility of the former (Baldwin and Lovvorn 1994).

According to Ferraro and Cole (2012), benthic macroinvertebrates species richness, abundance, and biomass are greater in Japanese eelgrass beds compared with native eelgrass beds.

Posey (1988) demonstrated that species diversity was higher in Japanese eelgrass beds than in adjacent unvegetated areas in the South Slough. Supporting Posey's results, Javier (1987), also studying Japanese

Figure 15. Continuous coverage of invasive Japanese eelgrass (*Z. japonica*) in Willipa Bay, WA at a site that was unvegetated mudflat 10 years prior. Source: Fisher et al. 2011

eelgrass habitats in the South Slough, found that the four most common spionids (worm species considered prey resources for various animals) were found in significantly higher densities in Japanese eelgrass beds compared to surrounding mudflats. This result supports the theory that Japanese eelgrass provides refuge for prey resources.

Negative: Able to spread through both seed production and vegetatively, Japanese eelgrass roots create a dense sodlike matrix, able to completely cover substrate surfaces (Fisher et al. 2011, Posey 1988).

In Willapa Bay, WA, Japanese eelgrass populations remained relatively confined for 50 years after introduction until 1998 when they began to greatly expand (likely surpassing some critical population/reproductive threshold), covering large swaths of formerly unvegetated estuarine mudflat (Figure 14). Japanese eelgrass then began to outcompete native eelgrass (in the transition zone where the two species overlap) and spread into existing low salt marsh habitat (Fisher et al. 2011). Coverage of unvegetated mudflats by Japanese eelgrass and its heavily matted root structures may also adversely affect burrowing benthic macroinvertebrates that colonize open mud habitats (Posey 1988).

Rumrill and Kerns (1991) found that juvenile Dungeness crabs (*Cancer magister*) accidentally settle in Japanese eelgrass beds, at higher intertidal elevations than they normally would, leaving the young crabs more susceptible to predators and desiccation.

Neutral: Known to overlap with native eelgrass (*Z. marina*) in other estuaries, Japanese eelgrass in the Coos estuary thus far colonizes discretely higher intertidal elevations (Dudoit 2006). Fisher et al. (2011) explain that native eelgrass can often suppress the density of Japanese eelgrass in beds where the species co-occur. However, a critical Japanese eelgrass population threshold may not yet have been reached in the Coos estuary (see Willipa Bay example in the Japanese eelgrass "Negative" section above).

Like the native eelgrass, Japanese eelgrass traps and stabilizes sediments and slows tidal currents to the benefit of smaller fish and crustaceans. Its senesced leaves contribute to the estuary's detrital food web, and it radically changes the character of formerly unvegetated mudflats. Long-term Japanese eelgrass colonization can result in significantly smaller mean sediment grain size, significantly higher levels of volatile organics (an indicator of detritus), and higher benthic macroinvertebrate density and species richness compared with adjacent unvegetated mudflats (Posey 1988).

Finally, in Oregon, Pacific herring use both Japanese eelgrass and the native eelgrass as spawning substrate (Matteson 2004).

Jubata grass (*Cortaderia jubata*)

Frequently confused with the related invasive pampas grass (*C. selloana*), the perennial jubata grass can grow to 7 m (23 ft) tall. A single plant can grow roots that spread 3.5 m (11 ft) deep and 4 m (13 ft) wide, easily

crowding out native vegetation (especially in native grasslands) and out-competing seedling trees in timber managed areas (Figure 13) (ODA 2014a; Marriott et al. 2013). Damaging even in small populations because of its rapid growth and formidable size, the large clumping grass once established can be very difficult to remove (Peterson and Russo 1988). Jubata grass is a prolific seeder (millions of seeds per plant) that does not require pollination. These giant grass plants can spread quickly because their numerous seeds are light and can travel easily on the wind (Peterson and Russo 1988).

Knapweed or starthistle (*Centaurea spp.*)
Diffuse knapweed (*C. diffusa*) is a highly prolific plant (18,000 seeds per plant) that forms dense thickets in a wide range of conditions, including gravel banks, sandy riparian areas, rock outcrops, and agricultural pasture lands. (Figure 5). Health hazards associated with this species include skin irritation due to plant juices and bites from associated mites (ODA 2014a, 2014b). It is an extremely difficult plant to manage once established. The expense associated with controlling and eradicating diffuse knapweed can often exceed the income potential of the pasture or forage lands it invades (Beck 2013, USFS 2014, Zouhar 2001a).

Meadow knapweed (*C. pratensis*) is a hybrid of brown knapweed (*C. jacea*) and black or common knapweed (*C. nigra*). According to ODA (2014a), this invader prefers moist open conditions such as wet pastures and riverbanks where it frequently outcompetes native and forage grasses, causing declines in pasture productivity. They add that once established, this plant is difficult to eradicate. Hand-pulling is a challenge due to the plant's woody root crown, and long-term herbicide regimens are only effective if maintained for many years.

Meadow knapweed's current annual economic impact to the State of Oregon is estimated at $146,000. However, at present it only covers 1% of possible habitats. If it were to infest all potential habitats, it could cost the state over $15 million per year (ODA 2014b).

Spotted knapweed (*C. stoebe* formerly *C. maculosa*), one of the most dominant weeds in the western US, spreads primarily by seed but can also spread vegetatively by sprouting lateral shoots (Beck 2013; Zouhar 2001b). This species releases a toxin into the soil that hinders growth of neighboring vegetation, reducing competition from native species (USFS 2006d). Considered a serious threat to Oregon rangelands, this perennial plant is able to live nine years (Zouhar 2001b). Spotted knapweed's estimated economic impact to Oregon thus far is limited ($33,000) but could grow. Luckily for Oregon's coastal communities, however, habitat suitability for spotted knapweed west of the coast range is scarce (ODA 2014b).

Yellow starthistle (*C. solstitialis*) is a prolific seed producer, thrives in full sunlight in areas of summer drought, and can grow 3-6 ft (0.9-1.8 m) tall (OSU 2008c). A single plant is able to produce 150,000 seeds (OSU 2006) which can remain viable in the soil for 10 years

(Callihan et al. 1993). According to Zouhar (2002), yellow starthistle taproots can grow deep enough (more than 3 ft) so that heavy infestations can lower the local soil water table below the root zone of most native plants, adversely affecting those plant communities.

Yellow starthistle can cause livestock injury (chewing disease) especially in horses. Currently this plant costs Oregon an estimated $775,000 per year to control. Costs could reach nearly $28 million if this species covered all possible lands in Oregon with suitable habitat (ODA 2014b).

Knotweeds (*Polygonum spp.*)
There are four knotweeds known in the project area: Himalayan (*P. polystachyum*), giant (*P. sachalinense*), Japanese (*P. cuspidatum*) and Bohemian (*P. bohemica*), which is a hybrid between giant and Japanese knotweeds (Figure 12). Knotweeds form dense thickets along water edges, outcompeting native riparian species (ODA 2014a). According to ODA (2014a), knotweeds can grow new plants vegetatively from any part of the plant, above or below ground, making proper disposal of cuttings imperative for preventing its spread. Once established, knotweeds are extremely costly and time consuming to control, much less eradicate. Giant, Japanese and Bohemian knotweeds all produce extensive rooted mats that hinder any kind of growth from other plant species (Steiger 1957, Weber 1987, Lema 2007).

Giant knotweed is the largest of the knotweeds, growing to 13 ft (4 m) tall, with 1 ft (0.3 m) long leaves, and able to spread via rhizomes (i.e., rootstock) up to 65 ft (20 m) laterally (ODA 2014a). Slightly smaller, Japanese knotweed grows up to 10 ft (3 m) tall with 6 inch (15 cm) long leaves and can tolerate adverse conditions such as high temperature, salinity, drought, or full shade (USFS 2004). Himalayan knotweed, the least shade tolerant species, is even smaller growing to 6 ft (1.8 m) tall and has narrow leaves 4-8 inches (10-20 cm) long (ODA 2014a).

Meadow knapweed (*Centaurea pratensis*)
See 'Knapweeds and Starthistle' above.

Milk thistle (*Silybum marianum*)
A large thistle, milk thistle can grow 10 ft (3 m) tall and 5 ft (1.5 m) in diameter (OSU 2006). Since it can grow so large and spread so rapidly, OSU (2006) notes that livestock can be entirely displaced in pastures that are heavily infested with milk thistle.

Old Man's Beard (*Clematis vitalba*)
Similar to English ivy, old man's beard is a woody climbing vine that can grow up to 100 ft (30 m) long, and can blanket entire trees or smother native ground cover (Figure 8). Individual plants can produce over 100,000 seeds per year, which are then easily transported by wind, water or animal. Further enhancing its ability to spread, small vine sections can regenerate into entirely new plants (ODA 2014a).

Parrot's feather (*Myriophyllum aquaticum*)
See 'Watermilfoil' below

Pennyroyal (*Mentha pulegium*)
Pennyroyal, member of the mint family, occurs in most coastal Oregon counties (Cal-IPC n.d.). Thought to be widespread and invasive in some Oregon freshwater wetlands, it is difficult to control once established (NPSO 2008). Found primarily in seasonally flooded, disturbed sites (e.g. pastures or riparian areas), pennyroyal's capacity to displace native plants is uncertain, but it is considered a problem species for ranchers since it can poison livestock (Cal-IPC n.d.).

Poison hemlock (*Conium maculatum*)
A member of the carrot family, poison hemlock is an extremely poisonous plant that inhabits pastures and irrigation ditches, growing 3-7 ft (0.9-2.1 m) tall (ODA 2014a).

Policeman's Helmet (*Impatiens glandulifera*)
Policeman's helmet can form dense stands in moist open areas (e.g., riparian zones)(Figure 8)(ODA 2014a). Individual plants can release up to 800 seeds per seed capsule, which explode when mature; in riparian areas, seeds are then easily transported downstream (ODA 2014a).

Portuguese Broom (*Cytisus striatus*)
Portugese broom outcompetes native scrub/shrub vegetation (particularly in commercial timberland) and provides no food for native wildlife. Individuals can reach sizes of 20 ft (6 m) in width, with trunk diameters of 14 inches (35.5 cm). Easy to confuse with the much more common Scotch broom, Portuguese broom seed pods are covered in thick white hair, similar to willow buds (ODA 2014a). See "Scotch Broom" below for more information on broom species.

Purple loosestrife (*Lythrum salicaria*)
Purple loosestrife is a perennial plant that spreads vegetatively by rhizomes (i.e., rootstock), or with seeds that disperse in water (Figure 13). This highly invasive freshwater wetland plant quickly colonizes disturbed areas and can create dense single-species thickets in wetlands and riparian edges, adversely affecting habitat availability for waterfowl and songbirds (Munger 2002, ODA 2014a).

A prolific seeder, Purple loosestrife seed capsules burst at maturity projecting two to three million seeds per year per plant that disperse by water or wind and can remain viable for up to three years (Munger 2002, USFS 2005e). Rhizome spread is about a foot per year and long-established plants can be shrubby, growing up to 10 ft (3 m) tall and 5 ft (1.5 m) wide (USFS 2005e, Munger 2002).

Purple loosestrife currently costs the state an estimated $12,000 to control. Luckily, this wetland invader is unlikely to reach its full biological potential in Oregon due to successful (achieves 50-95% reduction in established populations) and approved biological control measures (ODA 2014b).

Locally, CoosWA has since 1999 released over 41,000 biological control agents (two beetle species and two weevil species) at 23 of 70 purple loosestrife-infested sites in the project area. The release sites ranged in size from 0.5 to over 5 acres, large enough to

support viable beetle and weevil populations for effective purple loosestrife control. Each biological control release consists of 500-1000 beetle or weevil species which the USDA and ODA carefully selected over many years to ensure they only attack purple loosestrife (A. Brickner, pers. comm. 2015).

CoosWA partners with ODA and USDA Animal and Plant Health Inspection Service to obtain the beetles and weevils, which attack many parts of the plant including leaves, buds, roots, and seeds. The insects are released in the late summer and monitored by CoosWA staff each season for effectiveness. Several releases and many years may be required before results are evident but the beetles and weevils have proven to be effective for controlling and sometimes eradicating purple loosestrife locally and throughout the country. So far, these insects have helped CoosWA staff nearly eradicate purple loosestrife from a two-acre site. At Coos WA's other release sites, the insects have controlled purple loosestrife populations to varying degrees; the insects' effectiveness is oftentimes influenced by the presence of tidal flooding at the site (A. Brickner, pers. comm. 2015).

Redtop grass (*Agrostis gigantean*)
This non-native perennial grass has been widely introduced as pasture grass and thrives in meadows and grasslands, but also frequently occurs in open riparian areas (Carey 1995). Red top grass is common and can create single species patches but is not considered an invasive grass (Huang and del Moral 1988).

Reed canary grass (*Phalaris arundinacea*)
There is some confusion as to the native status of this perennial grass. It's likely native to parts of North America, but has been cultivated for livestock fodder with non-native strains and is now considered an invasive plant that is a major threat to natural freshwater wetlands (Figure 13)(Apfelbaum and Sams 1987, Lavergne and Molofsky 2007).

An aggressive invader, reed canary grass quickly spreads both vegetatively (by creeping rhizomes (i.e., rootstock)) and by seed (individual seed heads can produce up to 600 seeds). Reed canary grass seeds can germinate immediately after dropping with no dormancy requirements (Apfelbaum and Sams 1987, Tu 2004).

Associated with a reduction in native plant species richness, reed canary grass often approaches 75-100% cover in the areas is invades (Houlahan and Findlay 2004, Mulhouse and Galatowitsch 2003). As an example, an Oregon study by Schooler et al. (2006) found that native species abundance declined exponentially with increasing cover of reed canary grass. Likewise, along the Willamette River in Oregon, Fierke and Kauffman (2006) found that reed canary grass abundance was negatively correlated with species richness and understory species diversity in established riparian forest stands.

Perkins and Wilson (2005), found a strong negative correlation between native plant community diversity in beaver-dammed

wetlands along the Oregon coast and reed canary grass infestations. They suggest that the cyclical nature of disturbance associated with beaver dam abandonment/beaver pond draining provides ideal opportunities for reed canary grass invasions, chronically suppressing natural wetland communities.

Animals are also adversely affected by reed canary grass. In a study by Spyreas et al. (2010), wetland plant diversity and abundance of *Homoptera* insects (true bugs such as shield bugs and leafhoppers) decreased as reed canary grass populations increased. Reed canary grass is extremely difficult to completely eradicate once established. Mechanically removed red canary grass stands quickly grow back from seed stocks and rhizomes remaining in the soil. Apfelbaum and Sims (1987) describe how reed canary grass continued to persist even as test plots were clipped to ground level and covered with black plastic for two growing seasons. However, since this species requires full sunlight, Kim et al. (2006) found that reed canary grass populations decreased 68% within two years by being shaded by willow plantings.

Scotch broom (*Cytisus scoparius*)

Scotch broom is a perennial shrub that can grow to 8 ft (2.5 m) tall in almost any soil type. It is considered the worst nuisance plant on Oregon forest lands, substantially increasing costs associated with timber land re-forestation (Figure 13). Once established, scotch broom is difficult to control, costing an estimated $47 million dollars annually in lost timber production and control costs (ODA 2014a). In Oregon and Washington, complete stand failure of Douglas-fir plantings has occurred due to Scotch broom infestations (Peterson and Prasad 1998). Scotch broom also displaces native colonizing species in multiple habitat types (e.g., forestlands or dunes), in both disturbed and undisturbed areas (ODA 2014a).

Scotch broom spreads by seed. Typically, a handful of seeds are projected from its seed pods, dispersing an average of 3 ft (0.9 m) from the parent plant (Zouhar 2003). Bossard (2000a) estimates seeds can remain viable in the soil for 30 years. They add that nearly 100% of seeds are viable but dormant when released from the pod, requiring scarification (damage to the seed coat) in order to allow water to penetrate and the seed to germinate. The environmental conditions required to release dormancy are not yet understood.

Along with seed production, brooms can sprout from root stumps following damage (e.g., from mowing or fire)(Zouhar 2005a).

Slender flowered thistle (*Carduus tenuiflorus*)

Slender flowered thistle can grow to 6 ft (1.8 m) tall, invade disturbed areas (e.g., vacant lots, old fields) and reduce forage productivity of less healthy pastures. However, it rarely overtakes healthy grasslands or native vegetation (DiTomaso and Healy 2007). Plants can produce as many as 20,000 seeds annually, which can remain dormant but viable in the soil for up to 10 years (Marriott et al. 2013).

Spanish Heath (*Erica lusitanica*)
Spanish heath is extremely prolific, able to produce nine million seeds per plant. It can create thick single-species stands in disturbed areas, potentially affecting Coos County timber and pasture lands (Figure 8). Since mowing has no lasting effect on controlling Spanish heath (plants do not die, just re-vegetate horizontally, creating dense mats), costly herbicide applications are expected to be the only method available for effectively controlling this invasive species (French 2009).

Spiny cocklebur (*Xanthium spinosum*)
Found in a variety of disturbed habitats, ingestion of Spiny cocklebur seedlings can be fatally toxic to livestock. Spiny burs can cling to animals and humans or float on water in order to disperse (DiTomaso et al. 2013).

Spotted Knapweed (*Centaurea stoebe* formerly *C. maculosa*)
See 'Knapweeds and Starthistle' above.

Spurge (*Euphorbia spp.*)
Both oblong and leafy spurges (*E. oblongata* and *E. esula*) are highly toxic to livestock and irritating to human skin and eyes. The spurges' milky sap contains the toxin ingenolis (St. John and Tilley 2014). Ingenolis is potent enough to cause blistering and hair loss around horses' hooves put in recently mowed pastures infested with leafy spurge (Gucker 2010).

Leafy spurge's massive root system can vegetatively reproduce (even when pieces are very small, partially dried and deeply buried), and can extent to nearly 15 ft (4.5 m) deep (Gucker 2010). This, along with its highly prolific seeding capability and its ability to establish itself in both disturbed and undisturbed sites in a variety of habitats, allows leafy spurge to successfully outcompete native vegetation (Gucker 2010, St. John and Tilley 2014).

Once established, leafy spurge is very difficult to eradicate. In fact, the Canadian Botanical Association ranked leafy spurge as 6th of 81 invasive species seriously affecting natural habitats in Canada (St. John and Tilley 2014, Catling and Mitrow 2005 as cited in Gucker 2010). Cattle will not graze in areas where leafy spurge is 10% cover or greater, degrading pasture carrying capacity by 50-75%. Leafy spurge currently costs the state an estimated $17,000 per year to control, but has only just gained a foothold (0.2% of likely habitats are currently infested). If it spread to its maximum potential, leafy spurge control measures could cost the state over $65 million per year (ODA 2014b).

Well adapted to a wide variety of habitats, in western Oregon, oblong spurge thrives in moist grassy bottomlands (including pastures) and sunny riparian areas, out-competing native vegetation. Oblong spurge is also a showy perennial herb cultivated commercially as an ornamental plant (ODA 2014a).

St. John's wort (*Hypericum perforatum*)
St. John's wort is commonly found growing on disturbed lands (e.g., roadsides, agricultural sites). Once established, St. John's wort will decrease forage productivity in pasture lands

and poison livestock with a photosynthesizing chemical (hypericin) that causes blisters, blindness or swelling of the animal's mouth, preventing them from grazing or drinking (Crompton et al. 1988, Zouhar 2004b). St. John's wort is a prolific seeder (up to 34,000 seeds per plant)(Crompton et al. 1988). However, seedlings are slow growing, especially during summer drought conditions, making them susceptible to competition from other plant species (Tisdale et al. 1959, Campbell 1985).

Perhaps this plant's most problematic effects are loss of grazing capacity in pastures where it takes over. Sampson and Parker (1930) reported that St. John's wort shades out desirable pasture vegetation and removes large quantities of moisture from the soil. Seedling survival of St John's wort for most years is extremely low, because the plant is unable to tolerate summer drought conditions. However, due to the sizable and persistent seed banks associated with St. John's wort infestations, this plant's populations can remain dormant for many years, only to expand rapidly through seed germination to cover large areas during wetter years.

Sweet Fennel (*Foeniculum vulgare*)
Sweet fennel is a perennial that invades open disturbed areas like roadsides and coastal scrub land, sometimes developing into dense stands that can displace native flora. It can grow to 10 ft (3 m) tall (DiTomaso et al. 2013).

Tansy Ragwort (*Senecio jacobaea*)
Tansy Ragwort is a poisonous member of the sunflower family. All parts of tansy ragwort are poisonous, causing lethal liver damage to most livestock if consumed. Normally biennial (lives 2 years), mowed or damaged plants will continue to regrow until seeds are produced. A prolific seed producer (200,000 seeds per plant), tansy ragwort seeds can last 15 years in the soil and still remain viable. Tansy ragwort is able to grow 6 ft (1.8 m) tall with a taproot that penetrates the soil up to 1 ft (0.3 m) deep, and requires open, disturbed habitat to become established (OSU 2008b). Prior to an extremely successful biological control program begun in the 1960's using the cinnabar moth, tansy ragwort flea beetle, and a seed head fly, Oregon lost over $5 million per year in control and lost productivity costs. Since then, cattle losses from tansy ragwort poisoning have become rare and lost productivity costs have decreased to an estimated $115,000 per year (ODA 2014b). It should be noted, however, that changing climate conditions may favor tansy ragwort growth while limiting productivity of the beneficial insects used to control the plant, thus helping tansy ragwort populations rise once again in western Oregon (OSU 2011).

Velvetleaf (*Abutilon theophrasti*)
Generally only invasive in very disturbed areas, velvetleaf has become a serious threat to orchard and croplands (USFS 2006e). Seeds from this species can lie dormant in soil for over 50 years (USFS 2006e).

Watermilfoil (*Myriophyllum spp.*)
Eurasian watermilfoil (*M. spicatum*) and Parrot's feather (*M. aquaticum*) are two freshwa-

ter aquatic plants that colonize slow moving water (e.g., lakes, ponds), forming dense mats on the water's surface (Figure 12). Both species can thrive in eutrophic (excessive nutrient) conditions.

Parrot's feather can grow up to a foot above the surface of the water, resembling small fir trees, while Eurasian watermilfoil forms long (up to 5 ft [1.5 m]) intertwining stems that grow near the water's surface. Infestation of either species reduces fish production and native plant diversity, helps increase mosquito populations, and is a general nuisance for recreational users (e.g., swimmers and boaters) (ODA 2014a).

Woolly Distaff Thistle (*Carthamus lanatus*)
An especially significant nuisance in pasture lands, woolly distaff thistle can grow to 4 ft (1.2 m) tall and remain rigid and upright even after it dies, creating a formidable barrier to grazing livestock (OSU 2006). French (2010) notes that dense infestations can also clog harvesting equipment. Woolly distaff thistle seeds remain viable for up to 10 years, creating the need for aggressive control measures in established populations and prevention strategies on susceptible lands to maintain productive grazing lands (French 2010).

In the 1980s, the ODA Weed Program successfully implemented a woolly distaff thistle prevention campaign, which has kept the wooly distaff thistle infestation to less than four acres in Oregon. This success translates to an estimated economic impact of less than $500 per year. In the absence of the sustained state-wide early-detection program, woolly distaff thistle control measures are estimated to cost over $164 million per year (ODA 2014b).

Yellow Flag Iris (*Iris pseudacorus*)
Yellow flag iris is an aquatic plant that can thrive in a wide range of environmental conditions (e.g., fresh to brackish waters, wetlands, rocky shores, stream banks or ditches) and can form dense impenetrable thickets that displace native vegetation and alter habitat for animals (Figure 8)(USFS 2006c). Its buoyant seeds allow widespread dispersal by water. Yellow flag iris can also propagate vegetatively by rhizome (i.e., rootstock), creating laterally spreading clones that displace native aquatic vegetation (Stone 2009; USFS 2006c).

Yellow Glandweed (*Parentucellia viscosa*)
This annual hemiparasite (obtains some nutrients from a host plant) invades coastal wetland prairies and pastures, thriving especially in dune wetlands (Pickart and Wear 2000). A 1996 study in Humboldt Bay dunes habitat by Pickart and Wear (2000) found that yellow glandweed is a prolific seeder (12,000 seeds per plant) allowing an extensive seed bank to build in underlying soils. However, native plant species did not appear to be affected by the presence of yellow glandweed, suggesting that this non-native plant is not particularly invasive.

Yellow Starthistle (*Centaurea solstitialis*)
See 'Knapweeds and Starthistle' above.

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