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Weeds of South Puget Sound Prairies
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Abstract

While Scotch Broom may be the most apparent weed threat to the prairies of South Puget Sound, it is far from the only meance. Several non-native forbs and grasses have invaded the prairies, or threaten to do so, in numbers large enough to constitute an ecological threat. This paper looks at five common weeds well established in the prairies of South Puget Sound and at four weeds common elsewhere, but presently limited in distribution in the Puget prairies. Consideration is given to growth habits, tolerances, propagative methods, pests, and other characteristics which both makes these weeds plats of concern and which potentially limits their spread. The paper first discusses two common invasive grasses, colonial bentgrass (*Agrostis tenuis*), and velvet-grass (*Holcus lanatus*), and three common invasive forbs, St. Johnswort (*Hypericum perforatum*), hairy cat's ear (*Hypochaeris radicata*), and ox-eye daisy (*Chrysanthemum leucanthemum*). This is followed with discussion of four threatening wees, (gorse (*Ulex europaeus*), leafy spurge (*Euphorbia esula*), spotted knapweed (*Centurea maculosa*), and mouse-eared hawkweed (*Hieracium pilosella*), and some near relatives. The paper also looks at government noxious weed programs and how their work can affect prairie conservation, and concludes with a brief look at some issues prairie managers may face.

Introduction

This paper is an examination of a few pest plants of the Puget Prairie. It is undertaken with the belief that a better understanding of pest plants can assist in their control. This paper looks at both weed already common to the Puget Prairies, and at invasive plants common elsewhere which have the capacity to become pests on the Puget Prairies. While weeds often share common characteristics, and their control may share common solutions, each weed here is examined independently. Presenting consistent comments about each plant has proven difficult, and research gaps are present. While much of the material presented is based on research and interviews, some of the material is anecdotal in nature, based on my observations. Many of those observations were made during 1995 and 1996 while employed by The Nature Conservancy as a member of its prairie restoration team. Other observations are based upon many years experience as a professional gardener.

The prairies of Puget Sound are a relatively small ecosystem, facing double threats from invading human development and invasive plant species. It is generally agreed that the most blatant prairie invaders are Douglas-fir, (*Psuedotsuga menziesii*), a very large

native conifer historically excluded from Puget prairies by grass fires, and Scotch broom (*Cytisus scoparius*) and similar European relatives (*C. striatus, C. mospessulanus*). But Douglas-fir and Scotch broom are only the two most dramatically observable weeds of the prairie. This paper examines some of the other prairie weeds whose presence pose significant – possibly even greater – ecological threats to the Puget prairies.

First of all, what is a prairie weed? In native landscapes a weed is a non-native plant which is able to thrive in a foreign ecosystem. In this paper attention is given to those weeds which either overwhelm native plants and /or animals of the existing prairie landscape, or appear to have that potential. The weeds discussed in this paper are but a few of the many weeds which grow in the prairies. Most of the prairie weeds grow comfortably alongside their established native cousins in a tame and unobtrusive manner: they will not be discussed in this paper.

Five Well-Established Invading Weeds

The five plant species singled out in this section of this paper are among the most significant of the many weeds found on the Puget prairies. The two grasses, colonial bentgrass (Agrostis tenuis) and velvet grass (*Holcus lanatus*), are both very invasive but have distinctly different growth habits. Of the three forbs, hairy cat's ear (*Hypochaeris radicat*a) is already very wide-spread, and uncontrolled; St. Johnswort (*Hypericum perforatum*) is also very widespread, but is contained with biological controls; and ox-eye daisy (*Chrysanthemum leucanthemum*) is less widespread, but is uncontrolled and looks to be rapidly increasing.

Colonial Bentgrass- *Argostis tenuis* Sibth.

One of the most outstanding nuisances to the prairie is *Agrostis tenuis*, commonly known as Colonial bentgrass. The common and scientific names are both descriptive of this plant's nature. "Tenuis" shares the same root as "tenacious", a very apt description, and Colonial refers to the (large) colonies it forms as it grows. Pojar and MacKinnon (1994) contend that *A. capillaries* is the proper name for this weed, but that name is ignored by Hitchcock and Cronquist (1973) and rejected by Hortus III (1976). These disagreements greatly confuse the research. The thin leaves and relatively short size of bentgraass cloaks its aggressive nature. Bentgrass is a sod forming grass. In a bunch-grass prairie such as southern Puget Prairies, sod excludes many plants which depend on open soil for reproduction and survival, making bentgrass a very unwelcome pest.

Also present on the Puget prairies is *Agrostis diegoensis*, a native *Agrostis*. Similar in appearance to and easy to confuse with Colonial bentgrass, *A. diegoensis* is less competitive, and tends to grow in distinct and contained patches. On Puget prairies, with practice the two species can be readily distinguished in the field, even at a distance. A good field guide and a good hand lens will aid in differentiating the two.

Bentgrass's running root system is supplemented by its prodigious production of small, light-weight seed

which can be wind-blown considerable distances. The seed of bentgrass appears to have an extended ripening season which continues into late summer. Some seed germinates almost immediately with the fall rains, while other seed does not germinate until the following spring, or even later. My research did not turn up any information on long-term seed viability, although grass seed in general is short-lived.

An effective means of controlling Scotch broom may encourage the spread of bentgrass when bentgrass is producing seed. When chopping down Scotch broom with a tractor and heavy duty mowing deck, at Fort Lewis the first week of October 1996, I observed that a thick layer of grass chaff and seed had accumulated on the mower deck at the end of the day. In all likelihood seed tumbled onto and was broadcast from the mower deck all day. Roads through the prairies appear to have denser stands of bentgrass, presumably because of increased seed movement. In October 1995 at Thurston County's Glacial Heritage Park a wide swath of dense Scotch broom was mowed, including an old railway bed. The following spring the old rail bed showed up distinctly in the cleared prairie, a thriving straight line of bentgrass.

Some herbicides will damage bentgrass, as is recurrently mentioned in manuals on lawn management and confirmed by Richard Robohm (1996) in his recent studies on Idaho fescue. However, it is unclear as to how much herbicide would be needed to successfully and significantly reduce bentgrass over the long-term. Ho (1964, in Aarssen 1981) found *Hypochaeris radicata* (hairy cat's ear) to have alleopathic qualities which stunt bentgrass; conclusions on this dilemma are left to the reader.

Velvet Grass- *Holcus lanatus L.*

Holcus lanatus, (velvet grass, or in its native England, Yorkshire fog), is a large, coarse, easily recognized perennial grass, with bulky seeds, a loosely clumping habit, and a large fast growing fibrous root system. The seed is light enough to disperse on the wind and also spreads by adhering to fur and clothing. Velvet grass is generally a grass of poor and infertile soil, and tolerant of widely ranging environmental conditions. It has a remarkable ability to tolerate salts and heavy metals and to alter its root system in the presence or absence of water, nutrients, salts and metals (Thompson and Turkington 1988; Pilcher and Russo 1988). It is a vigorous competitor and its ability to absorb nutrients in essence robs other weaker plants. Furthermore, in lab studies Newman and Rovira (1975) found that velvet grass alleopathically inhibits competition. While velvet grass does spread by vegetative means, it mostly spreads by seed, which it produces prodigiously. Thompson and Turkington (1988) write that Watt (1976) found that plants grown from seed sown the previous spring produced as many as 240,000 seed for each plant.

While velvet grass is an inarguably important graminoid pest of Puget prairies, its roles as an invader in undisturbed prairie remains unclear. Based on two years of undocumented observations made while undertaking prairie restoration at Fort Lewis, velvet grass seems to grow most strongly in prairie soils altered by Scotch broom and Douglas-fir infestations. It does not

appear to spread as easily through undisturbed prairie as does bentgrass. Studies on Scotch broom and associated plants found that bentgrass was a common invader everywhere and velvet grass quite uncommon. In broom infested prairies the likelihood of finding velvet grass increased, but not significantly (Parker, unpub. data).

Regardless of the role velvet grass plays in disrupting pristine prairies, the disruptive role it plays in restoration merits equal or greater concern. It appears to outcompete prairie plants in severely disturbed prairie and to overwhelm native prairie plants being replanted. Based on both research and personal experience, it is clear that restoration must be conducted in ways which ensure that in infested areas, germination of the enormous seed bank does not defeat the restoration. Velvet grass seed does not exhibit much dormancy, does not typically sprout when buried, and once buried looses viability. The trick is to get the surface seed to sprout, destroy seedlings, and minimize future soil disturbance. Vigilance is still needed until the restoration is more established, as some seed displays delayed germination, and gophers and earth worms, if present, continually bring seed to the surface.

A number of herbicides effectively control velvet grass, although whether any are selective enough to use safely in the presence of desirable plants is unclear. Hand pulling plants is difficult and labor intensive, requiring considerable effort and causing significant soil disruption. It was found that 'lack of irrication (Morrison and Idle 1972; Watt and Haggar 1980), [and} burning (Grime and Lloyd 1973), " …reduce[ed] the relative abundance of *H. lanatus* in pastures" (Thompson and Turkington, 1988). In barren restoration sites potentially infested with velvet grass, it may be possible to manipulate condition and stimulate germination, and then treat the germinated area with herbicide or heat treatments such as flaming or steam. While these techniques may have been tried on velvet grass, I did not uncover any published research. Velvet grass has a number of biological pests and pathogens, but except for rabbits none appear to be significantly destructive.

Klamath Weed- *Hypericum perforatum* L.

Few invasive prairie forbs have received more press than Klamath weed (*Hypericum perforatum).* Long valued in Europe as both a valuable medicine and an aid favoring good fortune and countering evil spirits, this plant continues to be regarded with great interest. In the old world it has been called St. Johnswort after John the Baptist, as well as Aaron's beard, Tipton weed, and goat weed. With its introduction to California came a new name – Klamath weed. Not only did Klamath weed spread rapidly and thickly in the New World, its potent pharmacological properties proved poisonous to grazing livestock.

Efforts to control Klamath weed have been written about in virtually every book on weed control published in the past 50 years. Unlike many efforts at weed control, biological control of Klamath weed was achieved when a species of Chrysolina beetle, *Chrysolina quadrigemina* Suffr., was successfully introduced in the 1940's into California.

Within a short span of time the beetle spread, defoliating vast acres of Klamath weed first in California, then Oregon, Washington and Idaho. While Klamath weed continues to be found in the Puget Prairie landscape, Chrysolina has reduced the plant population so greatly as to make the presence of the plant mostly just interesting (Holloway 1964; Crompton et al 1988).

Still one cannot expect Klamath weed to completely go away, for some factors favor it. Fluctuations in the predator and weed population are observable in the field. Briese (1996) writes of problems with biological controls in Australia, problems which seem to apply to conditions in Puget Sound. Klamath weed grows well in partial shade, which Chrysolina avoids. In Australia a great deal of infested land is shaded and control of Klamath weed is less effectively achieved by *Aphis chloris*, as shade-tolerant aphid. This suggests that the understory of the Puget prairies oaks remain at risk. Briese also found that after fire Klamath weed flourishes, increasing production of both seed and vegetative top growth. Fire also impacts predator populations, although Briese's study suggests that after an initial drop, the predator populations rebuild from the additional nutrients introduced by fire.

Klamath weed's potent medicinal properties also continue to attract attention. While its pharmacological value may seem to be of little importance in prairie management, the resulting demand seems to assure that full eradication, even if were possible, will not happen. For example, Pojar and MacKinnon (1994) note that "two compounds isoleated form this species strongly inhibit a variety of retroviruses, leading to speculation about its effect on HIV" and Ernst (1995) found it to be an herbal antidepressant possibly superior to synthetic ones.

Hairy cat's ear – *Hypochaeris radicata* L.

While sometimes mistaken for common dandelion, (*Taraxicum offinale*), hairy cat's ear, (*Hypochaeris radicata*) is distinctly different. Like dandelion, cat's ear's flower is a yellow composite which matures to a puffball of seeds. But the flower heads are born several to a stem, the stem frequently stands 18 inches high, and the leaves grow flat to the ground in a smothering rosette. Unlike dandelions, which relish fertile gardern soils, cat's ear thrives in neglected lawns and the poor dry soils characteristic of our Puget prairies. It is less distinctly different from another composite, autumn hawkbit (*Leontodon autumnalis*); in all likelihood the two are confused, including perhaps on our Puget prairies. See Hitchcock, et al (1955), Aarssen (1981), and Mulligan (1988) for distinctions.

While cat's ear thrives in poor soil it has been found growing in almost any soil – wet, dry, clay, sand, peat, - and probably on every continent of the world. With origins in Europe, Asia, and North Africa, it has traveled worldwide. It is recorded form the Aleutian Islands to Central America and the subject of scientific papers in places as distant as Tasmania, Croatia, Holland, New Zealand, and British Columbia. Cat's ear is not as common in the intermountain prairies of North America and is designated a "noxious" weed in Eastern Washington (Aarssen 1981; WAC16-750 1996).

Cat's ear's cosmopolitan nature is apparent by its many names. Not only does it have a multitude of common names, the scientific community cannot agree as to whether its name is properly spelled Hypochaeris or Hypochoeris (Turkington and Aarssen, 1983). Among its common names it is called false dandelion, hairy cat's ear, cat's ear, spotted cat's ear, gosmore, flatweed, coast dandelion, hairy dandelion, and in some of Europe, pigweed, (Ferkelkraut and Saukraut in German, Biggkruid in Dutch and Salade de Porc in French, which all translates as "pigweed") (Jacobson, 1987).

It is clear that cat's ear impacts prairie flora significantly, if for no other reason than sheer numbers. When conducting vegetation surveys at Fort Lewis, the few times we did not find cat's ear in our study plots always elicited a remark of surprise. Beyond cat's ear ever-presence, its growth habit, with leaves hugging the ground to the exclusion of any other vegetation, places this plant high on the list of obnoxious invaders.

Salisbury (1942) found each cat's ear plant produces on average 970 seeds with an average germination rate of 60 to 70%. After flowering most flowering rosettes of cat's ear dies. After summer dormancy side (non-flowering) rosettes begin to regrow and most of the seed germinates; juvenile and side rosettes overwinter (H. de Kroon 1987). Newman & Rovira (1975) found cat's ear to be autotoxic, that is, to inhibits growth of other plants of its own species. In his article on cat's ear, Aarssen (1981) hypothesizes that "this may explain why plants of *Hypochaeris radicata* are normally found as isolated individuals, Or a few individuals in a group, but not as patches or pure stands." Aarssen also wrote that Ho (1964) found cat's ear to possess allopathic qualities, which significantly stunted bent grass. Sheldon and Burroughs (1973) studied seed dispersal in the lab and found that cat's ear seed on average does not disperse as far on the wind as one might expect. In a 16.4 kph (10+ mph) wind, seed disperse only an average of 2 meters; lesser winds result in a proportionately shorter spread.

Controls for cat's ear seem to be limited. Although susceptible to herbicides, in a prairie this plant is almost always growing in the presence of native forbs, which are also susceptible. Fall herbicide application would seem to be safer in limited situations, when most native forbs have died back. However, fall germination and growth is not exclusive to cat's ear. Even if a safe time for spraying can be determine, the frequency of spraying needed to control this invader may exceed the ecological benefit. Cat's ear also seems well adapted to fire regimes. In New Zealand Guthrie-Smith (1969, in Turkington and Aarssen 1983) reports it as one of the first invaders after pasture fires. Frequent fires may slow its spread (Wolfe and Horton 1959, in Turkington and Aarssen 1983), but other studies show that frequent fires slow the spread of native prairie plants as well, thus accomplishing little.

Biological controls – the introduction of some exclusive predator or disease – are highly expensive and highly unlikely prospect. While Torrington and Aarssen list a number of predators and some diseases, none seem to cause cat's ear

any noticeable harm. Besides, in most settings it is a minor pest. Cultivation virtually eliminates cat's ear from farms and gardens. Its susceptibility to herbicides quickly eliminates it from chemically maintained lawns, and just supplemental food and water and a greater mowing height will reduce the population. While it is listed as a "noxious" weed in Eastern Washington, and is regarded as poisonous to (some) livestock, herbicide is generally considered to be adequate control in pastures. Wile animals such as black bear eat cat's ear with relish (Poelker and Hartwell 1973) as do some domesticated animals (Turkington and Aarssen 1983).

Ox-eye Daisy – *Chrysanthemum leucanthemum* L.

Chrysanthemum leucanthemum L., (Syn. *Leucanthemum vulgare* Lam), commonly called ox-eye daisy, is a sentimental favorite in the bouquets of many and an invasive noxious weed. Its dual identity is displayed by the variety of common names given this weed. E.R. Spencer (1957), recounts some of them: "White week, Dog daisy, Bull daisy, Poorland daisy, Maudlin daisy, Butter daisy (meaning it spoiled the butter), Poverty weed, Dog blow, and Moon penny". Native through much of Eurasia, it is now well established in North America and New Zealand among other places. It is not as widespread in the prairies of Western Washington as is cat's ear, but it is present in large enough numbers to cause concern, and it appears to be spreading.

Ox-eye daisy flowers on weak stems, which can reach close to one meter in height. Salisbury (1942) found that each plant produces an average of over 2700 seed, with a 94% seed viability. Howarth and Williams (1968) report that ox-eye daisy's seed matures in late summer; the seed germinates mostly as soon as it is shed, and the seedlings then establish themselves the next spring. This is based on conditions in Great Britain, where summers can be wet; undoubtedly germination in the Puget Sound region waits until the fall rains come, While seed tends to germinate immediately, Toole and Brown's concluding report (1942) on "the Duvel experiment" found 82% of seed was still viable after 6 years (summarized by Howarth and Williams 1968). Several studies, including most recently O.M. Heide (1995) found it to be constant in its requirements for flowering: short days and cold temperatures followed by longer days are needed to ensure flowering.

Although the tall weak (floppy) stems help to strew the seed, animal and mechanical means play a large role in the spread of this plant. Well adapted to the dry Puget prairies, once establish ox-eye daisy forms dense colonies which spread by both seed and surface rhizomes and fully out competes its native neighbors. Other factors also contribute to how this plant spreads. For one, people like this flower. It is a tough job convincing people that this charming flower is a wicked weed. Restricted "Noxious Weed" laws in Washington State, (see next section); the flower seed remains a popular component of "wildflower mixes" in many parts of the U.S.

Some techniques might t help contain the spread of ox-eye daisy. In infested areas managers should be cautious about using a deck mower ('brush- hog") when

this weed is dropping seed. Manual containment and removal, while not a simple option, may be a necessary step to at least ensure that entire prairies are not completely overwhelmed by this plant. Ox-eye daisy is easier to manually remove than some weeds. First of all, the plant is very conspicuous and distinctive in flower, making filed observation and removal easier by people with limited training in plant i.d. And it grows in shallow-rooted mates, which are relatively easy to manually remove. In areas of Puget prairies where this plant is not yet thickly established these methods may be appropriate.

No biological control is listed for ox-eye daisy in the PNW weed control handbook, (1996). Howarth and Edwards (1968) list with little comment a number of presumably European insects, which feed upon ox-eye daisy. Guillet et al (1994) studied in a lab a moth, not mentioned by Howarth and Edwards, which eats ox-eye daisy. That moth tries to only feed and reproduce on plants growing in shade, because of ox-eye daisy's phototoxic qualities. Although some human cultures eat the distinctive semi-sweet leaves as a green, and some livestock will eat it, both cattle and pigs try to avoid it. Indeed one reason for ox-eye daisy's noxious weed status is due to the off-flavor it imparts to cow's milk. Herbicidal control of broadleafed weeds in a prairie mosaic is inherently difficult, for usually target plants are present in a mix with desirable vegetation; herbicidal control of ox-eye daisy is constrained further because this weed show resistance to most of the common broadleafed herbicides (Howarth and Edwards, 1968; PNW weed control handbook, 1996).

Noxious Weeds and Weeds Which Pose A Threat to Puget Prairies

Most state, and all four northwest states (Washington, Oregon, Idaho and Montana) have Noxious Weed Control Boards. Because the weed boards serve as a sort of guardian at the gate, I have turned to them to discover which weeds could be a source of future trouble in the Puget prairies. A digression here describing the weed board is appropriate.

The Washington State Noxious Weed Board was created by legislative act in 1969 in response to concerns of the agricultural community that certain weedy invaders were so noxious as to threaten livestock, crops, and even the livelihood of Washington State farmers. As defined by the Washington State law, a noxious weed is "any plant which when established is highly destructive, competitive, or difficult to control by cultural or chemical practices" (RCW 17.10). Presumably other states have similar laws and definitions.

The intent of Washington State's noxious weed control act is to prevent establishment of certain weeds. Weeds already well established in an area usually escape inclusion on the weed list, the primary purpose being to limit those weeds not already established (RCW 17.10). The state divides its noxious weeds list into three classes: "A", "B", and "C". Class A and B weeds are never native to the state. Noxious weeds not established in a region of the state are Class B; the state is divided into ten regions. Scotch broom, cat's ear, and ox-eye daisy are all Class B weeds in Eastern Washington regions. Class C is a catchall for any noxious weeds not in

Class A or Class B, and tends to include widespread weeds, which are agricultural pests. Klamath weed is a Class C weed.

The noxious weeds of concern in this section of the paper are mostly Class B weeds for the Puget prairie regions, established elsewhere in the state. Mouse-eared hawkweed, is a Class A weed, not established anywhere in the state. In 1996 23 weeds are listed as Class A, 47 weeds as Class B, and another 31 weeds as Class C, a total of 101 plants species defined as "Noxious" in Washington State (WAC 16-750 (1996)).

The state weed board and its director are responsible for designating plants as "Noxious" and to see to their control. Each county, however, is responsible for its own weed board, including board activation, funding, weed control, and requested listings. There is also a Federal Noxious weed program, and although the legal obligations are limited, the State and County weed boards are influenced by the Federal board. The federal weed board works closely with Customs to prevent the unintended (mis-intended) importation of noxious weeds.

County autonomy for the most part has worked very well. Each county sets its own priorities, arranges for its own funding, designates its target weeds. But a county board is inactive until the county governance; the citizenry, the neighboring counties, or the State weed board feels that it is necessary to activate the county board. Until a call arises to activate it, the county board rests in unobtrusive slumber. In on regard this failed miserably. King County activated its weed board only after vehicle radiator grills and horse digestive tracks shed millions of weed seed from Eastern Washington along the I-90 corridor through Snoqualmie Pass. AS will be discussed, Knapweeds, firmly establish in King County, now pose a big threat to the prairies of southern Puget Sound.

Gorse- *Ulex europaeus* L.

Some noxious weeds are obviously undesirable. Of those weeds with the potential of establishing themselves as a major prairie nuisance, top on the list of blatant undesirables is *Ulex europaeus*, commonly known as gorse, also called furze and whin, and humorously referred to as "Scotch broom, armed and dangerous". With thorns 3 cm in length, seedlings from a single plant can grown into impenetrable thickets more than 3 meters tall. While gorse is a more common pest in the coastal counties of Washington and Oregon, it is establish in both Thurston and Pierce counties, and in places uncomfortably near the prairies. One site in Thurston County is the Nisqually Wildlife Refugee. Another site extends from a Thurston County gravel pit a few hundred meters south of the Upper Weir prairie of Fort Lewis all along the county road almost to Upper Weir.

Apparently Thurston County is seriously concerned. At the instigation of the county weed board, Thurston County recently imposed construction conditions in one section of the county near the Nisqually Refuge, specifically to contain the further spread of gorse. Those conditions require all construction equipment to be thoroughly cleaned of all weed seed and subsequently inspected by a member of the weed

board staff before leaving a work site – conditions any prairie land managers might chose to voluntarily adopt in the presence of any invasive weed problems. And the county has stepped up its efforts at controlling gorse county-wide (Thurston Co Weed Board staff). None-the-less, a fully concerted effort to stop it from invading Fort Lewis seems urgently important, for military practices could lead to a rapid spread if it ever gets a start on Fort Lewis's prairies.
If there is good news, it is that gorse is slower to spread than Scotch broom. Thurston County Weed Board personnel estimate that gorse was planted (deliberately!) in the county at least 50 years ago, and the largest infestation is still confined to that general area, near the Refuge. It is most quickly spread through construction activities. The bad news is that once established it is devilishly difficult to control. Large Scotch broom plants when cut dependably dies; large gorse plants dependably resprouts. It yanked out by the roots; gorse roots left behind can sprout. Its highly flammable nature is credited for spreading the flames, which left the coastal Oregon town of Bandon in ashes in 1935, and yet after burning it tends to resprout from the base. Some herbicides are effective in controlling it, which is fortunate because cultural practices, as already state, seem ineffective. Some biological controls also have been found: a seed-feeding weevil introduced into California and Oregon in mind 1950 may be slowing it spread (J.K. Holloway 1964, Issacson, 1994), and Hoshovsky, (1988) and PNW Weed control handbook mention other predators as well.

Leafy Spurge – *Euphorbia esula* L.

Distinctly different from gorse, but obnoxious and tenacious in its own way, is leafy spurge, (Euphorbia esula). Individual plants up can grow to 3 feet tall and send taproots down more than 8 feet. The roots exude a chemical, which inhibits the growth of other neighboring plants, and its milky latex sap bears a very irritating alkaloid. Where established it can form dense stands which exclude all other plants. The very small yellow flowers are partially surrounded by larger yellow-green bracts, which from a distance appear to be the flowers. The seed of leafy spurge matures in capsules which when ripe pop explosively, propelling the seed up to 20 feet away (Callihan 1990).

A rhizomatious perennial, leafy spurge creeps in inconspicuously. Often it spreads unnoticed through seed and root fragments introduced by standard construction practices. It grows easily in gravelly conditions, so it is natural that one vector is gravel pits. Livestock are another vector; in grazing, the indigestible seed is eaten, excreted unharmed, and thus spread (Callihan et al, 1990). Because the remaining prairies of South Puget Sound usually exclude livestock and construction, it might seem unlikely that leafy spurge would represent a threat. But the habitat is ideal and once established this is a very difficult plant to control. Both cultivation and herbicide are limited in their effectiveness, requiring annual treatments for several years to achieve more than just suppression (Lym et al, 1993).

One of the sites where it is presently found in Western Washington is a prairie in the central portion of Fort Lewis. There are attempts to control leafy

spurge have been actively under way for several years. While it is contained to one site, as to eradication there is no immediate end in sight (Thurston Co. Weed Board, 1996).

Leafy spurge is not a significant weed in its native Europe, which suggests the presence of natural pests. In North America biological controls such as insects and pathogens have been introduced: in 1994, the Animal and Plant Health Inspection Service section of the U.S. Department of Agriculture "mass-produced" and then released eight biological pests of leafy spurge, in 127 counties in 16 States (Bridges, 1995). These controls are somewhat containing leafy spurge, but they are slow to establish and are not yet significantly reducing the plant population. For states such as Montana and North Dakota with hundreds of thousands of acres infested, this is unfortunate. Sheep may be the most effective means of reducing large stands in pastures, as sheep can eat leafy spurge without apparent harm (Lamp, 1995). With all the recently introduced biological controls, it is not surprising that leafy spurge continues to be heavily studied. An average of 5 scientific journal articles appear each year, with at least half a dozen insects and pathogens being researched. The results, and lack thereof, of this research seems to confirm that for now the most certain and effective controls in the Puget Prairies are awareness, avoidance, and immediate action.

Spotted Knapweed – *Centurea maculosa* Lam. – and Other Knapweeds

Of those noxious weeds gaining press and notoriety, the knapweed complex is doubtless one of the best known. Literature about knapweed is broadly available: both the State University Cooperative Extension Service and most county weed boards maintain sizable files of literature available for little or no cost. It is highly recommended that people concerned with weed control and identification in the Puget Prairie avail themselves of these resources, (a comment which extends to all the noxious weeds discussed here). While this paper singles out the two most worrisome knapweed species, several others are potential invaders and many seemingly specific comments are generally applicable. In addition, tow knapweed species – one perennial, (*C. montana*), another annual (*C. cyanus*), are grown as "Bachelor Buttons" in flower gardens and usually not considered a threat. (The State of Washington lists 6 *Centurea* species as "Class B" weeds, and 4 as "Class A".)

Several knapweeds are found in Western Washington, but in the opinion of Thurston County's Weed Board, spotted knapweed (*Centurea maculosa*), and meadow knapweed, (*C. nigra X jacea*), probably pose the most serious threat to the Puget Prairies. In Western Washington, spotted knapweed is the most common, and meadow knapweed is the most vigorous. Both of these knapweeds are "class B designate" weeds in the counties of southern Puget Sound, meaning that they are beyond control elsewhere in the state, (Eastern Washington), but designated for control in the Puget Prairies.

Most knapweeds differ markedly in ther juvenile and reproductive stages. The juvenile state of spotted knapweed forms basal clumps of foliage, which originates

from a strong taproot. Plant clumps nearly a foot across and 6" tall are possible, although half that size seem more common. At this stage the plant foliage can completely screen the ground. In its reproductive stage much of the lower growth withers as the main body of the plant grows to typically about 2 feet in height, sometimes twice that tall. At this stage, in the summer, plants flower profusely and then produce seed. While spotted knapweed at this stage do not typically shade out other plants, they never-the-less can grow so close together as to completely alter the physical (and visual) character of the landscape. Additionally, knapweed flowers seem to be so favored by bees that in large establish patches, native plants dependent upon bees for pollination may experience a drastic drop in fertile seed production.

Like all knapweeds, spotted knapweed spreads along travel corridors, the seed being easily caught on vehicles. With King County's utter failure to organize and enable a noxious weed board years ago, the I-90 corridor between Eastern and Western Washington became a perfect growth medium for an appalling infestation. Had it not been ignored for many years it would not be the invasive threat to Western Washington, which today it is. To be fair, highways are not the only vectors for this weed. An infestation of spotted knapweed is slowly creeping into an oak savanna adjacent to the McCord Air Force Base. Likely delivered by air, its success is a tribute to a different complex bureaucracy.

Animals are another vector for the spread of knapweed. A Montana State University study conducted on spotted knapweed indicates that knapweed seed eaten by sheep and deer can be excreted in viable condition for a week or more after ingestion (Wallander, 1995). Horses, in tandem with mobile and inattentive humans, regularly increase the spread of this weed through both droppings and trailer sweepings. At Fort Lewis spotted knapweed is found regularly along roads of those prairies used by recreational horse riders; other prairies with horse riding presumably have similar experiences.

Spotted knapweed spreads rhizomatiously as well as by seed. Because spotted knapweed is a short-lived perennial, which relies on seed reproduction (Lacey, 1986), repeated mowing might reduce this weeds long-term survival. But in general spotted knapweed seems well adapted to a mowed life, altering its shape to a more prostrate from of low-lying rhizomes and flower stems until it grows beyond the reach of a mower. A 3-year study on sheep grazing spotted knapweed at Montana State U. (Olson and Wallender, 1995) found that "shoot and toot biomass of spotted knapweed was not affected by repeated grazing, [but] Idaho fescue was negatively affected by repeated grazing.

Biological controls for different knapweed species have been tried, achieving mixed results. Several pests and diseases are currently being researched and discussed. APHIS reports that as of September 1995, 12 insects ere cleared for release in the US by the USDA for control of some knapweed species. Like most biological pests, different ones attack seeds, stems, and roots (Bridges, 1995). Two gall flies, (*Urophora affnis* and *U.*

quadrifasciata); infest the seed heads of spotted knapweed, the larvae feeding on and around the seed head. The damage causes seed production to be reduced, but the fly does not seriously damage existing plants and only slightly reduces the plant's spread (Roche, Piper, and Talbot, 1986). An intriguing project with promise has been the development of a fungus discovered in the field. Maculosin is a host-specific phytotoxin, produced by the fungus *Alternaria alternata*, which can seriously damage spotted knapweed (Strobel, 1991). Finally, not to be overlooked is manual removal, which over several years is very effective, although initially labor intensive (Thurston Co. Weed Board).

Meadow knapweed, (*Centurea nigra X jacea*) is a naturally occurring hybrid between black knapweed (*C. nigra*) and brown knapweed (*C. jacea*). At this time its distribution in Western Washington is more limited, but it is found in all counties of the Puget Prairies. Some counties are experiencing rapid increases and in Pierce County it is considered the most commonly occurring knapweed. While I have not encountered it in the course of my prairie work, that Thurston County Weed Board staff believe that both its rapidity of increase and manner of growth pose a real threat to Puget Prairies. Meadow knapweed is a vigorous perennial with large coarse leaves growing in a broad basal clump. Apparently gaining the stronger characteristics of each of its parents. It was originally introduced into Oregon as winter forage, although it appears intolerant of heavy grazing (Roche et al 1986).

Mouse-eared Hawkweed – *Hieracium pilosella* L. – and Other Hawkweeds

Beyond the knapweeds, the other grouping of closely related invasives are the hawkweeds. This general are composites, mostly yellow flowered and in the Chichorieae tribe. Seeds have pappus (tuft), allowing the seed to disperse on the wind. Thurston County Weed Board agents are most concerned about mouse-eared hawkweed (*Hieracium pilosella*), which has been found in one site. At Rocky Prairie is south Thurston County efforts to eradicate it have been going on for nearly ten years. When first discovered the infestation was one patch of a few square meters. At this point the main infestation has been eliminated through judicious use of the herbicides Clopyralid and 2-4-D. Unfortunately, the plant when young is inconspicuous, the flowers are small and short lived, seed development is rapid and seed dispersal is airborne. When mouse-eared hawkweed was first discovered at the site, the plants had already gone to seed and dispersed throughout the site. While the ongoing control methods are fairly effective and the total population is shrinking, new plants continue to be found. An established infestation nest to the prairie preserve has recently been located; hopefully, its control will aid the preserve (Davenport, 1997).

Dalmatian Toadflax – *Lineria dalmatica* [L.] Mil.

One more noxious weed, added as a footnote, is *Lineria dalmatica*. Commonly called Dalmatian toadflax, this weed has an extensive horizontal and vertical root system, and grows 2 to 4 feet tall (Parker and Peabody, 1983). Thurston County Weed Board staff also considers this to be a threat to prairies. In the spring of 1997 I easily observed it

in flower along the I-5 freeway corridor in Pierce and King Counties, and it has reportedly been seen is some of our prairies. I have not researched it, however, and it will not be discussed in this paper beyond this note. Some materials are available from Cooperative Extension Service offices.

Conclusions

It is clear that there are many complex issues in the management of Puget Prairie weeds. In this paper I have explored different control measures: biological controls, controlled by fire, herbicides, manual removal. Typically the solutions are far from perfect. Control measures that curb one weed may benefit another. Or control measures may seem very effective, but arouse public ire – "air pollution", "groundwater pollution", and "misuse of public funds". And, each managing agency has different priorities and resources to bring controls into action. Some weeds are well researched, but control measures still have not been found. For other weeds, only limited research can be found in the literature, so we are faced with the problem of learning about the plant in order to control it.

While these issues may present a daunting task, we do have some resources at hand that may be useful. Noxious Weed Boards are already in place in Thurston. Lewis, and Pierce Counties, where the majority of the Puget Prairies are found. Their staff are already knowledgeable about the general issues around problem plants and indeed provided much material for some of this paper; of recent years they have become much more oriented to community education. As prairie managers and restoration biologist look to the future care of the Puget Prairies, a powerful ally in our work might be found in the County Noxious Weed Boards.

The Nature Conservancy, The Evergreen State College in Olympia, Washington, The Center for Urban Horticulture at the University of Washington, and other educational facilities including the State Universities will also make valuable contributions to research and conservation. There may be other allies to be found in business, government, or environmental groups. Certainly there is need for an umbrella organization, which regularly exchanges research and ideas, although the organization may already exist in another form. Together we can work together to define problem plants in prairies and support research into appropriate control plans. Working together, we can move forward into a deeper understanding of prairie ecology, so as to preserve our Puget Prairies for the generations to come.

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