Controlling Scotch (Scots) Broom
(*Cytisus scoparius*)
in the Pacific Northwest

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Scotch Broom Description

Photo 1. Mature plant

Scotch or Scots broom: *Cytisus scoparius*, also referred to as *Sarothamnus scoparius*, is a perennial shrub of the pea (Fabaceae/Leguminosae) family. Mature forms of this deciduous shrub range from 3 -10 feet (1-3 meters) in height (**photograph 1**). The green (when young) branches are strongly angled and appear nearly leaf-less (**photograph 2**). The short, almost linear leaflets are in sets of three near the stem bases and on young growth, becoming simple single leaves near the tops with short petioles (**photograph 3**). Scotch broom blooms between April and June in the Pacific Northwest. The yellow flowers (**photograph 4**) are found in the joints of the stem (axils). The brownish black seedpods, 3.5 to 5 cm long, have hairs only on the edges. These pods are compressed (flattened) with several to many seeds (**photograph 5**).

Photo 2. Close-up view of branch. Note strongly angled and "leaf-less" appearance.

To separate Scots from French, Portuguese or other weedy brooms please refer to botanic references or websites such as that maintained by The Nature Conservancy (**http://tncweeds.ucdavis.edu**) or the USDA plant database (**http://plants.usda.gov**).

Photo 3. Two leaf types

History and Threat

Scotch (Scots) broom (hereafter SB, broom or Scotch broom) is native to the British Isles as well as central and southern Europe. The common name "broom" may have been given to the plant because of its growth habit. Its narrow long stems were purportedly used as floor brooms. Scotch broom first became naturalized in North America on the East Coast (Mountjoy 1979) and is found from Nova Scotia to Georgia (Gill and Pogge 1974). It was sold as an ornamental in California in the 1860s (Butterfield 1964). By the turn of the century it had become naturalized on Vancouver Island (Bailey 1906) and now is widespread throughout the western portion of the Pacific Northwest from British Columbia to California. In the Pacific Northwest, broom has been widely used for landscaping, and has been planted along roads and waterways to help prevent erosion.

Photo 4. Bright orange-yellow flowers

Photo 5. Seed pod

According to the Oregon Department of Agriculture, SB costs the state of Oregon more than $40,000,000 per year, mostly in lost forest production due to delays in reestablishing trees in clear-cuts. Broom is also effective at displacing native vegetation in meadows, riparian areas and floodplains. The damage caused by SB is perhaps worst in meadows and other open areas where it not only displaces native species, reduces biodiversity and forage, but also alters the fundamental nature of the habitat by converting it from open systems to dense shrub lands (**photograph 6**).

Basic Ecology

Scotch broom tolerates a wide range of soil types and depths, but grows best in dry sandy soils in full sunlight. Mature broom commonly reaches heights of more than 3 meters. It grows well in soils with pH values ranging from 4.5 to 7.5 (Gill and Pogge 1974). Where it has been introduced, Scotch broom invades pastures and cultivated fields, dry scrubland and "wasteland", native grasslands,

roadsides, dry riverbeds, riparian areas (**photograph 7**), cobble bars and other waterways (Gilkey 1957, Johnson 1982, Williams 1981). It does not do well in heavily forested areas, but invades rapidly following logging, land clearing and burning (Mobley 1954, Williams 1981).

Photo 6. Meadow infested with dense broom cover

Scotch broom generally reproduces by seed, but has some capacity to reproduce vegetatively. It has been purposefully propagated from cuttings (Gill and Pogge 1974) and in some conditions it sprouts back after cutting (Mountjoy 1979).

Broom seeds have hard seed coats that can survive transport in river gravel (Williams 1981) and may remain viable for over 80 years if properly stored (Turner 1933). Individual shrubs can produce up to 60 seedpods per bush by their second year and hundreds when fully mature. Most plants produce seeds by their 4th year. Each pod usually contains 5-8 seeds (Waloff and Richards 1977). Broom pods often open explosively, and the seeds may be widely scattered (McClintock 1985). Rapid spread over long distances is possible along roads where the seed is distributed by passing vehicles and in gravel hauled from river bottoms or during flooding. Birds and other animals may transport seeds to isolated areas (Mobley 1954).

Photo 7. Flowering broom occupying Oregon river bank

Seed emergence is fastest when seeds are buried less than 3cm deep in a fine textured substrate (Williams 1981). Seedlings buried more than 10cm (4 inches) deep fail to emerge, but will germinate if brought to the surface. Fire or other scarification enhances seed germination.

Photo 8. Potato-like root nodules

First year broom plants can grow over a meter tall (Waloff and Richards 1977). Small nodules on the roots contain colonies of symbiotic bacteria that synthesize ammonium from atmo-

spheric nitrogen (N-fixing) allowing rapid growth even in nutrient deficient soils (**photograph 8**). Initial rapid growth during the first 4-5 years is succeeded by 2-3 years of relative stability (Waloff 1968). After 6-8 years the plant begins to degrade. Changes include an increase in the ratio of woody to green material, reduction in seed production and finally death. Bushes rarely die in one year, but rather a mosaic of dead, partly dead and living plants is formed. Individual bushes rarely live more than 10-15 years (Waloff 1968).

Control Summary

Scots broom can be effectively, albeit expensively hand-cleared, treated mechanically or killed with herbicides. Which method you choose will depend on the ecological, physical and geographic situation and the available human and financial resources. No viable biological control options currently exist. Generally speaking, soil disturbance should be kept to a minimum. Bare soil and mixing of the top 6 inches of soil encourages both broom seedling establishment and entry of other exotic species. Regardless of treatment method, because of its extremely long-lived seeds, areas infested with broom need long-term management to exhaust the seed bank and prevent rapid recolonization.

Manual

Manual methods use hand labor and hand operated tools to remove undesirable vegetation. These methods are highly selective and can permit weeds to be removed without damage to surrounding native vegetation.

Hand pulling is most easily done in moist soil (but see below for ideal timing of Scotch broom cutting). This facilitates removal of the rooting system, which may re-sprout if left in the ground, especially in moist soil or with young vigorous plants. Plants should be pulled as soon as they are large enough to grasp but before they produce seeds. Plants up to 3 feet (1 meter) in height are easily hand-pulled. Weed wrenches, root jacks, adz hoes, claw mattocks and pulaskis are useful tools for pulling large broom plants. Review **tncweeds.ucdavis.edu** or popular tool catalogues for descriptions of weed removal tools.

Manually operated tools such as brush cutters, chainsaws, axes, machetes, loppers and clippers can be used to cut Scotch broom. This is an important step before some other methods are tried, as it can provide access to the stem for uprooting, create shorter plants for future herbicide applications, or can be the main treatment. For thickly growing, multi-stemmed Scotch broom, access to the base of the shrub (for uprooting by weed wrenches for instance) may not only be difficult but dangerous where footing is uncertain.

About half of cut plants will re-sprout in typical conditions, but well-timed and executed cutting can nearly eliminate re-sprouting, especially on older stands. Young vigorous plants in moist soil re-sprout the most, up to 50% in moist soil if cutting is done incorrectly. Old plants in dry soil re-sprout the least, with re-growth rates near zero if cutting is done carefully. Bravo (1985) suggests cutting plants before the seeds are set, this prevents seed production and dispersal for that plant. However, if the stand is well established, one additional year of seed production is probably not significant.

For best results, cut plants below the basal node (i.e. near or below ground level), where the stem is more yellow than green) during the dry season (July - September in the Pacific Northwest). Cutting

large, mature plants at chest height during the dry season, and cutting off side branches will in most cases not result in re-sprouting.

The key to long-term control is prevention of seed set after the initial clearing takes place. If the site has an established broom seed bank, follow-up treatment over many years will be necessary. Allocate enough time to remove / treat all flowering individuals on two to four occasions in May and June with a follow-up visit in July to remove (and bag) any individuals that were missed and have produced seed.

Mechanical Control

Mechanical methods use mechanized equipment. These methods are generally non-selective in that all vegetation on a treated site is affected, and typically also affects desirable plant species. Mechanical methods are most effective on gentle topography with few site obstacles such as rocks, stumps or logs. Most mechanical equipment is not safe to operate on slopes over 30 percent. It is also of limited use where there is a matrix of desirable and weedy vegetation, where soils are highly susceptible to compaction or erosion or where soils are very wet. They reduce potential for biological control through plant competition and may open up new niches for other undesirable species. In addition, wildlife forage may be eliminated.

Scotch broom may be trimmed back by tractor-mounted mowers on even ground or by scythes on rough or stony ground. Cut this way, broom plants may require several cuttings before individual plants die. If only a single cutting can be made, the best time is when the plants begin to flower. At this stage, root reserves are at their lowest point and new seeds have not yet been produced. Follow-up treatment of some kind is generally necessary because broom may re-sprout following cutting, especially when cuts are made significantly above the ground surface (Amme 1983 and see Manual discussion above).

Thermal/Prescribed Burning

Both spot heat treatments and prescribed fire have been used on Scotch broom. A flame thrower or weed burner device can be used as a spot treatment to heat-girdle the lower stems of shrubs. This technique has the advantages of being suitable for use during wet weather and snow cover, and where herbicide use is not permitted.

Large infestations may be burned in order to remove the standing mature plants. This may be accomplished with a pre-spray of herbicides to kill and desiccate plants, or without such spraying if fine fuels are available to carry the fire between broom plants. Be aware that the volatile oils in broom can produce intense heat and large flames. Even if some re-sprouting occurs, burning facilitates effective herbicide treatments by reducing plant height and increasing the ratio of green to brown stems. Special considerations for the use of prescribed burning include the time and cost of coordinating a burn, administrative and legal issues related to burning and the soil disturbance resulting from firebreak construction and fire mop-up efforts.

Although burning effectively removes the shoot portions of broom plants, it also stimulates broom seed germination. Such germination is desirable if follow-up treatment will be done since it reduces the remaining seed bank. Improper use of broadcast burning however, especially without aggressive follow-up may contribute to a re-invasion of broom or other weeds by creating more bare soil and a flush of available nitrogen.

Burning should be followed by: **1)** herbicide treatment of re-sprouted plants, **2)** subsequent burning within 3 years to kill seedlings and exhaust soil seed bank, **3)** manual removal of seedlings as they mature, and **4)** re-vegetation with fast growing native species where appropriate.

Herbicide

Herbicides may be applied non-selectively (broadcast treatments) or selectively (spot treatments). Each approach has advantages and disadvantages.

As always, carefully read and follow directions on the manufacturer's label and materials safety and data sheet (MSDS). Whenever possible, a licensed herbicide applicator should plan and execute the herbicide application. If you are unsure whether your planned treatment is within the label guidelines, please contact your states Department of Agriculture or the local extension agent. The label is the law.

Mention of specific trademarked products in this document are for illustration purposes only and do not constitute support for the use of one product over another.

Note on herbicide use: Broadcast application of herbicides has become the mainstay of many weed control efforts. This may be because large areas can be treated quickly, creating the illusion of a "quick fix." Some herbicides (such as glyphosate) so applied are non-selective and will kill most, if not all, of the sprayed vegetation. However, species or individuals that survive the treatment may, after repeated sprayings, form an herbicide-resistant vegetation cover, thus creating a more difficult problem. Broadcast spraying may also kill off native plants, which have the ability to compete with exotic weeds. Broadcast herbicide application may be most effective where the weed infestation is very dense or needs to be desiccated prior to burning.

The most commonly mentioned herbicides for broom are 2,4-D, alone or mixed with other herbicides, triclopyr (Garlon) and imazapyr (Arsenal). Mixtures with 2,4-D may include triclopyr (Crossbow), diquat, picloram (Tordon), dicamba, and sodium chlorate (Watt and Tustin 1976, Balneaves 1981, Allo 1960, Elliott 1976). Broom proved to be very susceptible to picloram, regardless of the form - (Upritchard 1969; Moffat 1965). The 0.5 lb a.i./acre ester formulation gave control equal to the 0.751 lb a.i./acre amine formulation, both rates being clearly superior to the 0.5 lb a.i./acre amine formulation (a.i. = active ingredient). Broom has been eliminated using 8 lbs of sodium chlorate in 80 gallons of water per acre (Anonymous 1934). Triclopyr ester or amine is particularly effective in controlling broom, superior to glyphosate and fosamine ammonium (McCavish 1979, 1980; Gilchrist 1980). Glyphosate did not satisfactorily control broom (McCavish 1980). Paraquat and diquat result in only short term (3-6 weeks) control of stump sprouting and seedlings (Balneaves 1981). If herbicides are used be aware that if competing vegetation is eliminated, ideal conditions for re-infestation or invasion by other weeds will be created.

The potential for herbicide damage to native plants must always be considered when deciding which herbicide to use. Pines are sensitive to triclopyr (but grasses are not affected). Douglas fir and Western hemlock growth may be stunted by fosamine ammonium. Herbicides cause less damage to conifers if applied in July and August, after first year needles have matured (McCavish 1980).

In general, when using broadcast application of herbicide, plants should be sprayed only in full leaf and prior to fall senescence. Results are poor if plants are sprayed when the leaves are developing

and when plants are in full flower before leaf development. The best results have been obtained when plants are in the seed head stage in late summer and early autumn (Matthews 1960).

Always follow directions on the product label, including application method and rate. If you are unsure if your plans meet legal requirements, please check with your site department of Agriculture or a local extension agent.

Spot chemical methods consist of various techniques for manually applying herbicides to individual plants or small clumps of plants (such as stump re-sprouts). These methods are selective as only specific plants are treated. They are most efficient when the area to be treated is relatively small and the local density of stems is high. Jones and Stokes Associates (1984) reviewed a variety of spot chemical techniques. The following is an excerpt from this report, listing techniques in order of increasing possibility of herbicide exposure to the environment or to humans in the vicinity of treated plants:

1) ***Stem injection***: Herbicides are injected into wounds or cuts in the stems or trunks of plants to be killed. The herbicide must penetrate to the cambial tissue (below stem surface) and be water-soluble to be effective. The chemical is then translocated throughout the plant and can provide good root-kill.

2) ***Cut stump treatment***: Herbicides are directly applied to the cambial area around the edges of freshly cut stumps. Best results occur if herbicides are applied within one minute of cutting. McHenry (1985) suggests late spring as the best season to do this. In early spring sap may flow to the surface of the cut and rinse the chemical off. At other times of the year translocation may be too poor to adequately distribute the chemical. Applications may be made with backpack sprayers, sprinkling cans, brush and pail, or squeeze bottles. Picloram should not be used for this technique as it is known to "flashback" through root grafts between treated and untreated plants and may damage the untreated individuals. Triclopyr is effective on many species in this type of treatment.

3) ***Basal/Stem sprays***: This technique involves the use of backpack sprayers in applying high concentrations of herbicides in oil or other penetrating carriers to the basal portion of stems to be killed. The oil carrier is necessary for the mixture to penetrate bark and enter the vascular system. This method gives good root kill, especially in the fall when vascular fluids are moving toward the roots. This method may be easier to use with small diameter stems than the two previous techniques.

4) ***Herbicide pellets***: Pelletized or granular herbicides are scattered at the bases of unwanted plants. Subsequent rainfall dissolves the pellets and leaches the herbicide down to the root system. Optimal time for treatment is towards the end of the rainy season to prevent leaching beyond the root zone. Pre-emergent type herbicides (i.e. Casaron) can effectively prevent germination of broom seeds without harming established vegetation, but they will also prevent native seeds from germinating.

Biological Control

The introduction of exotic natural enemies to control plants is a complex process and must be thoroughly researched before implementation to prevent biological disasters. Although there is at least one insect pest of broom (see below), no effective biological agents are currently available.

In 1960 and 1961, 6,750 twig-mining moths (*Leucoptera spartifoliella*) were brought in from France

and released. As of 1979 it had become well established along the Pacific Coast up to Washington. The small white moth is 1/4-1/2" long and can be seen flying around the broom at dusk in May and June when it lays its eggs on the new vegetative growth. The larvae mine directly from the eggs into the stems, tunnel throughout the stem and complete development in April or May the following year. Emerging from their tunnels, they spin white silken cocoons on the underside of twigs (Andres 1979). Moth-infested broom plants bear a number of dead and dying twigs. The overall effect is rather subtle, making it difficult to measure the full impact of the insect on the weed. The plants suffer damage, but the moth has clearly not solved the Scotch broom problem (Andres 1979).

Another insect, the seed weevil (*Apion fuscirostre*), was introduced from Italy (Julien 1982) to the U.S. in 1964 and has become established in both coastal and Sierran broom infestations in California. Although there are high populations of the weevil in the coastal mountains, only small populations survive on Sierran plants. This is probably due to mortality of immatures in pods exposed to high temperatures (Julien 1982). Despite damage to as much as 60% of the seed at some sites, the weevil has only limited impact on controlling Scotch broom. Both the moth and the seed weevil are specific to *Cytisus scoparius*. Adequate control through biological means still remains promising as there are several broom-feeding insects from Europe which have not yet been introduced.

Grazing

Livestock grazing as a control measure may be effective, although Scotch broom is slightly toxic and unpalatable to most livestock (Mobley 1954, Long 1938). One attempt to control broom in New Zealand failed even though grazing commenced when broom plants were only a few inches high (Allo 1960).

In many areas of California the use of Angora and Spanish goats is showing promise as an effective control for Scotch broom (Daar 1983). Goats may be less costly to utilize than mechanical and chemical control methods. They can negotiate slopes too steep to manage with machines and do not pose the environmental dangers inherent with herbicides (Andres 1979), but are likely to also eat desirable vegetation.

Cultural Control

Research by Williams (1983) suggests that broom stands are early successional in nature and may be replaced by later seral stages (i.e. forest) if left undisturbed. Planting of tall growing shrubs or trees in or near broom stands may aid in reducing photosynthesis in broom plants and possibly lead to their demise. However, shade intolerant species such as Douglas fir probably will not survive the interim period of suppression by dense broom infestations. There are reports of salal and other plants in the Ericaceae family retarding broom regeneration, because these species may possibly have allelopathic properties.

Post-removal Planting

Replanting will probably be necessary for sites that have been dominated by SB for an extended period of time. While establishing a dense cover of native species in areas where broom has been removed may lessen the chances of survival of subsequent broom seedlings, it is not necessarily advantageous to do so immediately after the initial clearing of mature plants. Because of the long-lived seed, follow-up treatments may be necessary for many years. If herbicides are part of your control strategy, replanting should initially consist only of grasses, so as to allow continued use of herbicides that control broad-leaved plants. When the broom seed bank has been effectively ex-

hausted, native broadleaf plants can be planted within the established grass cover.

Cost of broom removal

BLM (in Oregon) contracts crews for broom control at $100-$110 per acre with chainsaws (10 person crew at $250/hr), and $160-$180 per acre for follow-up weed-eating that doesn't damage natives.

Metro Regional Parks and Greenspaces (a regional goverment department in Portland, Oregon) typically pays about $250-300 per acre to get control of all exotics on a site, but additional costs are associated with training the crews to recognize all the species.

Other contributors added the following comments on cost:
Chainsaw clearing: $100-$350 per acre
Mowing: $250-$500 per acre
Hand removal: many hours (up to 300) per acre. This equates to at least $2000 per acre
Chemical treatment: ~$300 per acre including chemical costs

Discussion of integrating approaches and long-term strategy

No single control method is best for all situations, and successful, affordable long-term control may best be achieved by combining approaches. Whether you pull, cut, burn or spray, persistence and perseverance will be required if Scotch broom has been present long enough to establish an abundant seed bank. Each year for 10 years or more and periodically for decades, diligent removal/control of blooming plants will be required to prevent new seed production and gradually deplete the seed bank.

It can not be over-emphasized: If you are not going to maintain the site, do not spend the effort and resources on the initial clearing. Without follow-up treatment of resprouting stems and newly germinating seeds, it will take less than 5 years for the site to descend back to Scotch broom dominance.

With soil disturbance (or fire) more seeds will tend to germinate, but that can be good news, if those new seedlings are controlled. Except directly along stream banks, plant material can be piled on site and left to decompose. Transporting seed-laden plants for off site disposal may result in expansion of the Scotch broom population.

The Bradley method is one sensible approach to manually controlling weeds (Fuller and Barbe 1985) in an area too large to clear all at once. This method consists of hand weeding selected small areas of infestation in a specific sequence, starting with the best stands of native vegetation (those with the least extent of weed infestation) and working towards those stands with the worst weed infestation. Initially, weeds that occur singly or in small groups should be eliminated from the extreme edges of the infestation. The next areas to work on are those with a mixture of at least two natives to every weed. As the native population stabilizes in each cleared area, work deeper into the center of the most dense weed patches. This method has great promise on nature reserves with low budgets and with sensitive plant populations.

There is combined mower-herbicide applicator called the Brown Tractor Mower. It can cut mature Scotch broom with stem diameters up to 3 inches and simultaneously stump-treat or spray with herbicides. Early reports on its use suggest it is a promising tool for circumstances in which the herbicide will not damage desirable vegetation or other resources.

Best Management Practices

As for most species, there is not one "best practice" for controlling Scotch broom. Your choice should be made based on your site, your program's capacity and your personal beliefs. The recommendations that follow are meant to be a combination of efficiency, effectiveness and environmental sensitivity. Several typical situations are described. If your site is different from the ones described here, mix and match following these guidelines, and of course your own creativity. As always, early intervention is best and minimizes the amount of replanting necessary to accomplish successful restoration. Finally, be sure to plan for the long-term.

Scattered large and small plants in native/desirable vegetation
1) Uproot large plants with root jacks or similar tools during wet season. Hand-pull small plants before they mature.
2) Cut and stump treat vigorous, large plants with triclopyr during dry season. Hand-pull small plants before they mature.
3) Cut less vigorous large plants during dry season, hand pull small plants

Whether choosing 1, 2, or 3, follow-up the following year(s) to treat resprouting individuals and hand remove any flowering plants.

Small patches and scattered plants in native/desirable vegetation
1) Uproot large plants with root jacks or similar tools during wet season; hand pull small plants.
2) Cut and stump treat large plants with triclopyr after leaves have formed; hand pull small plants.
3) Cut large plants during dry season; hand pull small plants

Consider prescribed fire as a first treatment and possibly as a follow-up in fire dependent/tolerant systems such as oak savanna. Expect and prepare for a large flush of seed germination following fire, with individuals maturing 1-4 years afterwards. A second fire within 3 years may be the most efficient follow-up treatment if the native plants will tolerate it and adequate fuel is available. Consider replanting native species in local areas of dense infestation.

Large patches / monocultures, little or no desirable tall vegetation
Clear initial infestation using a tractor or crews with power tools, follow up after leaves have fully developed on resprouted stems with herbicide treatment using triclopyr, picloram or imazapyr as directed on the label. Consider Brown Brush Mower where feasible.

Prescribed fire can be a viable first treatment for these situations as well. Repeated fires over a period of years combined with limited spot uprooting/spraying/mowing may be sufficient to control the broom and eliminate the seed bank.

Riparian areas
Focus on manual removal or integrated manual/herbicide stump treatment methods. If the broom is

dense or providing significant erosion control, aggressively replant with a mixture of native grasses, sedges, rushes and sprouting shrubs such as willow. Where suitable, planting cedars or hemlocks will offer long-term suppression of broom by creating shade.

If manual control is not an option, Garlon 3a is the probably the best herbicide choice because it now has an riparian/aquatic label and reasonably low toxicity to most fish and wildlife. Never the less, be sure to minimize the amount of spray that directly contacts water and avoid spraying when rain is expected within the following week.

Note: If you are receiving federal funding: Despite the EPA approval of the supplemental label for Garlon 3a in riparian/aquatic use, NOAA Fisheries has not approved the use of Garlon 3a in riparian situations near anadromous fish bearing streams out of concern for sub-lethal effects on fish.

Additional Resources

There is a wealth of information out there for Internet users. Here are three good sites to get you started:

http://tncweeds.ucdavis.edu/esadocs/cytiscop.html
The Nature Conservancy Element Stewardship Abstract. This includes detailed references. The website also includes information on other species and weed control technology.

http://eesc.orst.edu/agcomwebfile/edmat/pnw103.pdf
Oregon State University Extension Service. Information on brooms, includes photographs of several varieties.

http://www.invasivespecies.gov/profiles/scotchbrm.shtml
United States Biological Survey. Species profiles and good links to additional resources.

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