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Ecology, Biology and Control of Exotic-Invasive Weeds in Forestry – Management of Gorse (*Ulex europaeus* L.) on Federal Lands in Victoria, British Columbia, Canada

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Abstract

Scotch broom (*Cytisus scoparius*), Gorse (*Ulex europaeus*) Daphne (*Daphne laureola*) and English ivy (*Hedera helix*), are four prominent, invasive plants that pose a serious threat to Garry oak and associated ecosystems in British Columbia. These plants colonize disturbed areas quickly, form monospecific stands, persist for a long time and defy easy eradication. They inhibit the growth of native plants and ultimately arrest forest succession. Several federal departments have expressed great concerns regarding their rapid incursion and adverse impacts. Research was conducted to examine the population dynamics, phenology and control methods of these invasive plants on federal lands near Victoria, B.C. Of the several methods of control tested, including manual cutting, application of a herbicide (triclopyr), a fungal bioherbicide (*Chondrostereum purpureum*), and a commercial plastic mulch, it was found that some treatments (mulch and herbicide) provided 100% efficacy on resprouting behaviour

Resumen

La retama negra (*Cytisus scoparius*), la aulaga o tojo o aliaga (*Ulex europaeus*), la laureola (*Daphne laureola*) y la hiedra (*Hedera helix*) son cuatro de las principales plantas invasivas que son una grave amenaza para el roble Garry y los ecosistemas conexos en la provincia de Colombia Británica. Estas plantas colonizan con rapidez las áreas afectadas, formando masas vegetales que perduran largo tiempo y resisten la erradicación simple. Inhiben el crecimiento de las plantas autóctonas y a la larga detienen la sucesión forestal. Varias entidades federales han expresado una gran preocupación por su rápida incursión y las consecuencias adversas. Se realizaron investigaciones para estudiar la dinámica de reproducción, fenología y métodos de control a las plantas invasivas en terrenos federales cercanos a la ciudad de Victoria, en Colombia Británica. De los diversos métodos de control ensayados, la tala manual, la aplicación de un herbicida (triclopyr), la aplicación de un herbicida biológico fungal (*Chondrostereum purpureum*) y la

of all four invasive species. While one bioherbicide (*Fusarium tumidum*) was very effective on Scotch broom under the greenhouse conditions, it was not tested under field conditions. *Chondrostereum purpureum* produced a variable response under the field conditions. Manual cutting was found to be the least effective. Also a novel prospective bioagent (*Phomopsis* sp.) was isolated from dying and dead samples of Daphne from the field and results from laboratory, greenhouse and field conditions suggest that it may hold great potential. Additional research is necessary to determine appropriate formulations of these bioagents as well as the effectiveness of the different and integrated treatments over a period of years. A new technology using superheated water (aquacide) to kill vegetative shoots of gorse did not offer long term control nor was it found to be cost effective. However, in this paper, only results on management of gorse are described and discussed.

colocación de una cubierta de plástico comercial; se encontró que ciertos métodos (cubierta plástica y herbicida) logran, con una eficiencia de 100%, modificar el comportamiento de regerminación de las cuatro especies invasivas. Aunque un herbicida (*Fusarium tumidum*) resultó muy eficaz contra la retama negra en condiciones de invernadero, no se hicieron pruebas aplicándolo sobre el terreno. El *Chondrostereum purpureum* obtuvo resultados variables cuando se le aplicó sobre el terreno. La tala manual fue el método menos eficaz. Asimismo, un prometedor agente biológico nuevo (*Phomopsis* sp.) se aisló de muestras moribundas y muertas de laureola recogidas del terreno; los resultados obtenidos en laboratorio, invernaderos y sobre el terreno sugieren un enorme potencial. Se necesita investigación adicional para determinar las fórmulas adecuadas de estos agentes biológicos, al igual que la efectividad de los variados tratamientos que son integrados durante cierto periodo de años. Una nueva tecnología que emplea agua súper calentada (*Aquacide*) para matar brotes vegetativos de aulaga no ofreció control a largo plazo ni demostró ser rentable. Solo los resultados del manejo de la augula son descritos y discutidos en este artículo.

Introduction

Many species of plants were introduced into North America for beneficial purposes but some of these exotics (Prasad et al. *in press*) have escaped, invaded and expanded their ranges into the new environment beyond usefulness. Scotch broom (*Cytisus scoparius* (L.) Link) and gorse are such alien weeds that were introduced into Vancouver Island in the last 150 years. They are very aggressive, invasive and have come to dominate many landscapes; roughly 10% of the Vancouver Island is infested with these species and this area is increasing each year (Prasad 2003). Of particular concern is their threat to the unique and endangered Garry oak (*Quercus garryana* Dougl.) ecosystem on south eastern Gulf Islands of British Columbia (Peterson and Prasad 1998). They quickly form dense thickets that can easily shade out native vegetation and reduce biodiversity.

On forested lands, these weeds interfere with fibre and timber production by the economic conifer species (Prasad 2000). They are nuisance species occupying desirable land and limit

agriculture, grazing, recreation and other activities. Furthermore, gorse has high concentration volatile oils in branches and produces considerable biomass creating a Fire hazard (Clements et al. 2001). Therefore, a field experiment was carried to determine the effects of a bioherbicide containing *Chondrostereum purpureum* (Pers.) Pouzar (Cp), a chemical herbicide (triclopyr), a plastic mulch and a manual cutting method on resprouting behaviour in gorse.

Materials and Methods

Three sites were selected at the Rocky Point, Esquimalt, Victoria on Department of National Defense (DND) lands and only healthy gorse plants (3 m high, 5 cm diameter) were chosen for experiments. Gorse had been growing at the site for 10–20 years, had developed dense colonies, was 2–3 m tall with average stem diameter of 5 cm above the ground. At each site, six plots were established with a randomized block lay-out of all treatments, as follows: 1) cut and treated with sterile water, as control; 2) cut and treated with a blank formulation (without Cp); 3) cut and treated with Cp formulations; 4) cut and treated with triclopyr; 5) cut and covered with a plastic mulch; and, 6) uncut stems as check. Each plot was 3 (3 m containing 15 stems of cut or uncut gorse plants and was randomly selected to receive all treatments. Chosen stems were tagged and measured for their initial height and diameter; there were 45 variates of each treatment spread over 3 blocks. The formulation and application of Cp followed that of Prasad and Kushwaha (2001). Triclopyr herbicide was obtained from a local store and applied at 180 gm L^{-1}. All treatment solutions were delivered through a squeeze bottle at 3 ml per cut stem. For mulching, a commercial black plastic sheet (2 mm thick) was cut and fitted to each plot in such a way as to completely cover all cut stems. The plastic sheet was fastened to the ground with staples at each corner and in the middle of the plot. A few heavy stones were placed over the mulch to prevent its blowing away or disturbance by the wildlife. All stems were cut at 2.5 cm above the soil surface with a brush saw and all treatments were applied immediately on a rain-free day during July. The response was measured over 2 years. Data were analysed statistically by the LSD (least significant difference) method.

Results and Discussion

Figures 1 and 2 show the vigorous growth of gorse, note the dense thickets it forms and the growth up to 3–4 m. Figure 3 shows the distribution of gorse and scotch broom (yellow-brown colors) along the highway corridors and on the margins of Douglas fir plantations (green color) while Figure 4 shows the flowering habits of the gorse. As said earlier, one of the mechanisms of its invasiveness is in prolific flowering, seed set and production of seeds, about 18000 per plant per year, the seeds are contained in the pod which bursts to release the seeds (Figures 4 and 5). Other mechanisms of its invasiveness lie in: (a) reduced leaves (spines) to prevent rapid transpiration; (b) active photosynthesis in adverse conditions, and in winter months (5°C) by branches, and stems; (c) nitrogen fixation by roots; and, (d) absence of a natural parasite/ predator complex. Therefore, there are no checks on its rapid spread into newer locations. Gorse

Figure 1. Dense thickets of gorse on Rocky Point.

Figure 2. Fully grown gorse on federal land.

Figure 3. Distribution of gorse (brown) and Scotch broom (yellow) near highways and Douglas fir (green) plantation.

Figure 4. Prolific flowering and seed set in gorse.

can compete for space, light, nutrients and moisture with native vegetation such as grasses and Douglas fir and Garry oak trees in the ecosystems as shown in Figures 6, 7 and 8. One of the worst adverse impacts that gorse exerts is to produce large amounts of biomass which, when dried, becomes highly combustible as it contains volatile oils and becomes a source of fire hazard in the community (Figure 9).

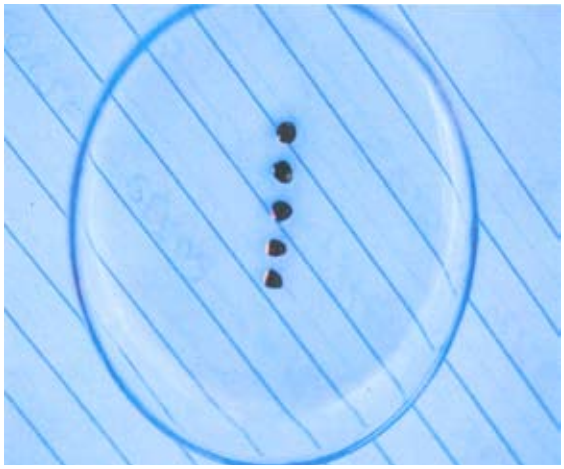

Figure 5. Seeds of gorse as sources of propagation.

Figure 6. Competition of gorse with conifers and Garry oak.

Figure 7. Extensive flowering, seed production and displacement of native grasses.

Figure 8. Showing adverse impacts of gorse on Garry oaks.

Figure 9. Dried biomass of gorse is a fire hazard.

Table 1. Influence of various treatments on resprouting of gorse stems after two years.

Treatment	Sprout height (cm)	Percentage
Cut stumps + sterile water	35.1	100
Cut stumps + blank	34.5	98.3
Cut stumps + bioherhicide (Cp)	18.2	51.9
Cut stumps + herbicide (triclopyr)	0	0
Cut stumps + mulching	0	0
Uncut stumps	15.2	43.3
LSD (0.05)	2.1	–

Results of the treatments for gorse are summarized in Table 1. As can be seen, only two treatments, namely mulching and the triclopyr treatment, provide the maximum advantage. Manual cutting is not effective as it induced vigorous resprouting, however, some reports (Prasad 2003) suggest that manual cutting carried out before flowering in early spring may reduce the rate of resprouting. Such labour intensive treatments are not cost- effective. Use of the bioherbicide provided only partial control (52%). Caution needs to be taken while employing these live agents as they are sensitive to environmental conditions (drought, ultra violet, sunlight and relative humidity). Therefore, efficacy of these bio-agents cannot be predicted or guaranteed and a proper formulation, timing and method of application and often re-treatments are required to ensure greater success (Prasad and Kushwaha 2001).

No one method can be relied upon for full cost-effective control of gorse, even though, the herbicide and mulching treatments prevented re-growth . Triclopyr has been found to be quite safe if applied on cut surfaces or as directed sprays (Prasad 2003), however, public concerns of use of chemical pesticides in urban or federal land close to aquatic and marine environment arouses scrutiny and controversy. The use of opaque plastic mulch was indeed effective after 6 months with initial re-sprouting, but eventually dying back. Whether mulching can be practical on a large operational scale remains to be seen. It seems an integrated approach, cutting before the flowering followed by herbicide or bioherbicide application at later stages to retard resprouting can be more successful. Mulching can be used to stimulate germination of seed banks (by increasing available moisture) and then causing the seedling growth to etiolate and die off under the mulch in absence of light. Further research is needed to delineate the best options for control of these exotic invasive weeds.

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Biography

Raj Prasad, who just retired from the Pacific Forestry Centre, Victoria, BC, is well known for his research on ecology, biology and control of weeds in forestry, and has published over 300 papers on pest management in forestry and is a co-editor of the standard Herbicide Handbook 6th Edition 1989 published by the Weed Science Society of America. He was honored by several Weed Science Societies (Weed Science Society of America, Asian-Pacific Weed Science Society, Indian Society of Weed Science) and Capital Regional District (Victoria, British Columbia) for his contributions to weed science and alien invasive weeds. Raj has supervised over 50 students and acted as Secretary- treasurer for the International Weed Science Society. He also holds a US Patent and a Canadian Patent jointly with others for his co-discovery and formulation development of bioherbicide (Chontrol) based on *Chondrosteum pupureum*. Raj was educated at University of Allahabad (B. Sc. Ag., M. Sc.), India, the University of Oxford (Ph. D.), UK, and the University of California at Davis (post-doctoral training in pest management).