An adaptive experimental management program for English broom *Cytisus scoparius* (L.) Link in Victoria

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Summary An adaptive experimental management (AEM) program is being established by Parks Victoria in 2004 for English broom (*Cytisus scoparius* (L.) Link in the Alpine National Park. The effectiveness and efficiency of selected broom control strategies will be tested over five years. Herbicide selection and the timing and frequency of control programs will vary between plots. The program will evaluate changes in broom abundance, ground cover, species composition and seedling density at replicated sites. This paper outlines the design of the experiment and describes the methods used to establish the program.

Keywords Adaptive experimental management, monitoring, English broom, *Cytisus scoparius*, weed control.

INTRODUCTION

Parks Victoria invests considerable resources to control and prevent the spread of pest plants, with the aim of maintaining or improving native vegetation composition and structure. We are able to report annually at a state-wide level on the resources spent and area treated during pest plant control programs, but to date there has been no formal evaluation of the cost-effectiveness or environmental outcomes of various control strategies.

Furthermore, in many situations, a range of potential control techniques exists, but there may be uncertainty about the relative benefits of these. To deal with uncertainty in the effectiveness and efficiency of management programs, and to improve our understanding of current 'best-practice' management strategies, Parks Victoria is adopting an adaptive experimental management (AEM) approach to selected pest plant control programs. Initially, the focus of this program will be English broom (*Cytisus scoparius* (L.) Link), hereafter referred to as broom) in areas of northeast Victoria affected by the 2003 wildfires.

Broom was naturalised in Victoria by 1887, and declared a noxious weed in 1901 (Hosking *et al.* 1996). It is a highly invasive weed which forms dense thickets and can out-compete native species (DNRE 1998). The seed can remain viable if stored dry for up to 80 years, and seed density has been recorded beneath mature broom infestations in excess of 65,000 seeds m^{-2} (DNRE 1998). Any control program requires many years of follow-up control to deplete the soil seed bank.

Control programs have been in place in the Alpine National Park for approximately 15 years. The current strategy is to ensure that broom is contained within designated areas, and sustained control programs are in place in sites of high biodiversity value. Despite having clear management objectives for some sites, there is still a lot of uncertainty in the effectiveness and efficiency of the management program. The wildfires of January 2003 burnt many hectares of mature broom, and are likely to have killed broom seed in the top layer of soil. Dense regenerating broom has replaced mature stands, and plants will commence flowering in spring 2004 at lower elevation sites.

Currently, the only feasible option for large-scale management of dense broom infestations is the use of herbicides with high volume spraying. When used in combination with fire, this can result in effective control (DNRE 1998). Other methods such as cut and paint or hand pulling may be utilised in particular circumstances, and along with biological control will be an important component of the long-term management strategy (McArthur 2000).

Herbicide application usually occurs during late spring/early summer when broom is actively growing and flowering. Parks Victoria commonly uses two herbicides in the Alpine National Park to control broom: 300 g L^{-1} triclopyr with 100 g L^{-1} picloram, and 360 g L^{-1} glyphosate near waterways. However, label advice for herbicides containing the residual component, picloram, does not recommend use over tree roots or where run-off to areas containing desirable plants can occur. This program is examining whether an adequate broom kill rate and less off-target damage can be reached with 600 g L^{-1} triclopyr alone.

The key knowledge gaps of greatest concern to Parks Victoria relate to the relative effectiveness of different herbicides applied at different times of year and different frequency. Outcomes from the experiment will assist managers in deciding the optimal time of year for weed control to occur, how often and how many treatments are required to reach our objectives, and which of the herbicides tested maximises weed reduction and minimises off-target damage.

MATERIALS AND METHODS

Identifying key knowledge gaps A workshop was held with Parks Victoria staff and interested parties from the Department of Primary Industries (DPI) and Landcare groups during November 2003 to discuss ‘best-practice’ control methods for controlling broom after wildfires, and identify key knowledge gaps.

Experimental design This experiment will compare the effectiveness of treating broom with each of three preferred herbicides, at the two different times of year (late autumn and late spring), and compare ongoing annual treatment with irregular treatment triggered by flowering (Table 1).

Normally, spraying is undertaken in spring, however, the autumn treatment was included because logistic constraints meant initial post-fire spraying with herbicides 1 and 2 began in autumn 2004 and little is known about the effectiveness of treatment at this time. As Parks Victoria did not use herbicide 3 during autumn 2004, only a spring treatment will be tested for this herbicide. For the herbicide 1 autumn treatment, only an annual treatment will be tested, as managers and practitioners assume annual follow-up control would be required.

The experiment uses an incomplete block design. Three 9.6 ha blocks consisting of ten 120 × 80 m (0.96 ha) plots were established within the study area, with a treatment applied to each plot as outlined in Table 1. Plots were assigned to herbicide 1 treatment where that plot included a waterway. All other treatments were allocated at random.

Table 1. Experimental design showing treatments applied to each of three blocks. Each block contains one plot of each treatment.

Herbicide	Timing of initial treatment	Frequency of treatment
Herbicide 1 (glyphosate)	autumn	annual
	spring	irregular annual
Herbicide 2 (triclopyr with picloram)	autumn	irregular annual
	spring	irregular annual
Herbicide 3 (triclopyr)	spring	irregular annual
Control (no herbicide)		

Study area The study area is located in the Kellys Road area along the Mitta Mitta River corridor in the Alpine National Park in areas affected by the January 2003 wildfires. This area is close to the township of Omeo. The management aim for broom in this area is containment, and recent control efforts have resulted in buffers with low broom abundance and no seed set around existing roads, so that the risk of further spread by vehicles is kept to a minimum.

For many years, the Mitta Mitta River corridor will be subject to ongoing input of broom seed from large areas of both public and private land upstream in Mitta Mitta/Big River catchments. Therefore sustained control or eradication will not be possible in this area in the near future. This allows us to leave some sites as experimental controls, to compare untreated sites with sites subjected to different management strategies.

Sampling methods Corners of each plot (120 × 80 m) were marked with a numbered steel post, and the location of each post was recorded using a global positioning system (GPS). Monitoring was conducted in the central 60 × 20 m of each plot. Within this area, seven parallel 20 m transects were located at 10 m intervals. One corner of the monitoring area in each plot was marked with a numbered steel post, and the start, centre and end of each 20 m transect were marked with wooden posts. Monitoring commenced in April 2004. Variables measured in each plot are described below.

Broom abundance, structure and growth stage were measured along the seven permanently marked 20 m transects. Mean percent cover of broom was estimated using the cover by line intercept method. Broom was recorded if it occurred directly above or below the transect tape. To ensure consistency in measurements between years, broom clumps were recorded if >5 cm wide, and gaps between plants or sections of plants were not counted if <5 cm. Methods for measuring broom abundance follow standard monitoring protocols (Ainsworth and Weiss 2002). Structure of English broom was measured by recording the top standing height (to nearest 5 cm) of all broom clumps included in each cover by line intercept transect. Plant growth stage was recorded for each broom clump as juvenile, flowering or seeding. After herbicide treatments, scorch on each broom clump will be recorded in five categories: none (0%), light (<25%), medium (25–75%), heavy (>75%), and dead (100%).

Ground cover was recorded using the cover by line intercept method in 5 cm intervals along each 20 m transect at ground level for broom, grasses/sedges, herbs, shrubs and trees, bare ground, logs, litter, rocks and moss.

Vegetation composition and structure were measured within three permanently marked 0.75 m^2 plots (circular plots 49 cm radius) evenly spaced along five central transects (n = 15 for each monitoring area). Species lists and counts of Eucalypt and broom seedlings were recorded in standard height categories. Visual estimates of ground cover categories and cover for each species were made within each circular plot using Braun-Blanquet cover scores.

Canopy tree composition, structure and condition were assessed within the central 60 × 20 m monitoring area by recording for each tree: species, plot coordinates, diameter at breast height (135 cm), tree height (estimated to nearest 5 m), presence of basal shoots or epicormic shoots, and whether the tree was dead or alive.

Site slope and aspect were recorded, and permanent photopoints were established 3 m from the start of each monitoring transect, and 5 m from the corners of the 60 × 20 m plot. Rainfall and temperature data for the months before and after herbicide treatments will be collected and assessed in relation to the effectiveness of various treatments.

Monitoring program Photopoints and broom cover will be reassessed in June 2004 to determine the effectiveness of initial spray treatments. Complete reassessment of each plot will be done during October 2004, directly before the late spring herbicide treatments take place. Monitoring will be repeated annually before late spring herbicide treatments, and the percentage kill of broom will be assessed 6–8 weeks after control each year if staff capacity allows.

Related research Long-term questions on the anticipated duration of control programs must be addressed by studying the soil seed bank. A research project will be designed during 2004 to assess the density and viability of broom seed at different depths in the soil profile.

DISCUSSION

Outcomes from this AEM program will assist managers with decisions on herbicide selection, timing of initial treatments, and frequency of broom control, particularly after wildfire events. The effectiveness of herbicide treatments on broom will be assessed within two months of each initial spray program, so the earliest results will be available in late spring 2004. The response of other species to the different treatments will take longer to assess.

Selection of herbicides used by field staff has been driven by recent program successes. Generally, Parks Victoria staff in the Alpine National Park use 300 g L^{-1} triclopyr with 100 g L^{-1} picloram at label rates as the kill rate is very good when used on broom during spring. This program is examining whether an adequate kill rate and less off-target damage can be reached with 600 g L^{-1} triclopyr (i.e. no residual picloram). Parks Victoria may select this as the preferred herbicide for broom.

Comparisons between herbicides that are selective for woody weeds and one which is non-selective may show interesting results. One possibility is that spraying with a non-selective herbicide removes all competing plants (particularly grasses), therefore allowing greater recruitment of broom from the soil seed bank.

Traditionally, broom control programs are planned for the spring-summer period, when the plants are actively growing and more likely to take up herbicide. This AEM program may show that spraying during late autumn successfully kills broom or postpones its flowering. If this is the case, there may be some advantage in extending the annual spray program to a longer time period, which may allow larger areas to be controlled within the financial year. If spraying during autumn proves to be effective in delaying flowering or killing broom plants, there may be opportunity to continue autumn control programs in 2005, particularly in high-elevation sites where flowering will not have commenced due to slower development with altitude.

Follow-up control is essential for any weed control program. Testing the frequency required to give effective control will assist in improving cost-efficiency. If follow-up herbicide treatment (before plants flower and set seed) is not needed for 2–3 years, there may be potential to control broom over larger areas on a rotational program, rather than treating the same sites every year. Whichever is the case, this program will assist in planning a feasible weed management program, with clear records kept for area treated, quantity of herbicide used, time taken, and average costs per hectare.

This program will continue for a minimum of five years. Field work will be carried out by Parks Victoria staff, and additional support will be provided by contract staff with botanical expertise. Staff within National Parks Division will analyse and report on the results annually, with peer review and statistical advice from external scientists.

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