REVIEW OF AND OBSERVATIONS ON CURRENT METHODS OF BRACKEN CONTROL IN FORESTRY

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Summary

Bracken (*Pteridium aquilinum* var. *esculentum*) is the most widespread weed affecting forestry in New Zealand. Fire, cultivation and selective and non-selective herbicides are the main weapons used in its control. Appropriate timing of site preparation burns in relation to bracken growth stage and supplementary cultivation or chemical treatments may make a significant contribution to long-term control. Many chemicals can provide adequate but unpredictable control. A better understanding of the influence of environmental and physiological factors on entry, uptake, translocation and activity is required if reliable control is to be achieved. The need is for greater skill in the employment of tools already available.

INTRODUCTION

The sporophyte of bracken fern (*Pteridium aquilinum* var. *esculentum*) is probably the most widespread weed affecting forest establishment in New Zealand. It occurs from the far north to Stewart Island, from sea level to altitudes of well over 1000 m. The European variety (var. *typicum*), likewise a pest of agriculture and forestry in the United Kingdom and Europe, is also probably in New Zealand now (New Zealand Ministry of Agriculture and Fisheries 1975).

It has been estimated by the New Zealand Ministry of Agriculture and Fisheries (1975) that there are over 1 000 000 ha of bracken-infested country in the South Island alone. Currently, approximately 5 000 ha are treated annually by one means or another to release trees from bracken competition.

In New Zealand, bracken is seldom a component of undisturbed virgin forest but soon makes its appearance once the forest is felled or burnt. The airborne spores germinate in moist, sheltered microsites to produce gametophytes which give rise to new sporophytes following fertilisation. A sparse but dominant bracken cover can develop within two years (Knowles 1970b).

The above ground parts consist of leaves or fronds which arise sporadically from a much-branched, starch-rich, perennial, underground rhizome system. After a long period of establishment, the interlacing rhizomes can form a massive mat continuous over wide areas, with individual rhizomes many metres long and up to 4 cm in diameter. The majority are usually within 20 cm of the soil surface.

New fronds are produced annually, typically in the spring-early summer (October-December), but a new crop can arise after cutting or burning any time soil moisture and temperature conditions are suitable. On sites subject to heavy frosts the fronds are killed off each year in the winter. In less severe climates the old fronds may persist for two or even three years until suppressed by a new crop of fronds. In warmer, moist areas (e.g., Northland) new frond emergence and development occur over a more extended period than elsewhere.

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Although bracken undoubtedly competes with young conifer transplants for soil moisture and nutrients, its main effects in most areas of New Zealand are to compete for light and, by its eventual collapse, to physically smother the young trees. The seriousness of the problem is largely related to the density and vigour of the fronds produced. These are dependent on soil and climatic factors and on the recent history of the site with respect to fire, grazing, soil disturbance and mechanical or chemical treatment. In harsher climatic areas, or on very poor soils, fronds are sparse, small, only 10-30 cm in height and offer little competition to the trees — they may, in fact, protect young trees from the effects of wind and frost. With deep rich soil, plentiful soil moisture and a warm climate, an abundance of large (1 to 3 m tall) fronds are produced in a matter of weeks. Newly planted tree seedlings are unable to compete with such growth and succumb over wide areas.

CONTROL MEASURES

Forest establishment does not require the eradication of bracken. Reduction of frond numbers and vigour to allow survival of the large majority of the trees is usually adequate.

Control measures may be short- or long-term. Short-term control deals with the current crop of fronds and is effective for only a few weeks or months. Long-term control aims at the debilitation or destruction of the rhizome system so that its ability to produce vigorous new fronds is impaired for one or more years. The necessity for short- or long-term control depends on the relative vigour of the bracken and the tree crop. Generally, in areas of vigorous bracken longer-term control will be required than in areas where bracken growth is short or sparse. Means of short- and long-term control include fire, hand cutting (or hand "releasing"), grazing, cultivation and chemicals.

Fire

Fire is the commonest means of achieving the initial clearance of bracken sites. It is usually considered to achieve only short-term control so that additional short- or long-term control measures, such as hand releasing, chemical treatment or cultivation, have to be employed.

There is evidence (despite Clarke 1960), that, with judicious timing (mid-summer to early autumn), fire can be used to provide a significant degree of long-term control. Forest Research Institute trial sites in the Rotorua area burnt off at this time have remained substantially bracken-free for two years, whereas earlier or later burns have resulted in heavy regrowth. It is theorized that the rhizomes largely exhaust their stored food reserves in producing a new crop of fronds. If these are removed when fully developed but before they have had time to replenish these reserves, the rhizome system is debilitated to the extent that weak regrowth only is possible for an extended period until the reserves are built up again. Sites burnt at this time of year often develop a heavy grass cover during the following autumn and winter which may also be a factor in limiting bracken regrowth.

Hand Releasing

Cutting bracken with hand tools is costly and often unsatisfactory. Except in areas of low bracken vigour, it may have to be done every two to three months during the growing season to ensure stand establishment. Furthermore, it is often impossible to cover the large areas involved in the short time available before the trees are smothered. There is also considerable risk to trees from cutting (slasher "blight") during the hand release operation.

Cultivation

Where the contour permits, deep discing or ripping after a burn is the best means of providing long-term bracken control. Many rhizomes are brought to the surface and are killed by exposure; others are bruised or fragmented so that they are invaded by pathogens and die or, if they survive, have sufficient reserves to sustain only weak frond growth for several years. It is probable that the optimum results would be achieved if it were carried out in the autumn following a summer burn when the weak new frond growth had just matured. This would combine the effects of a near optimum burning time with the mechanical destruction of any late summer or autumn regrowth before it too has had opportunity to make a contribution to the rhizome starch reserves.

Grazing

In Australia and New Zealand cattle and sheep are used extensively to control bracken in agriculture (Braid 1959), the young fronds often being preferentially browsed, especially following topdressing (Clarke 1960). With the increasing interest in the grazing of forest land and the integration of farming and forestry, there may be increasing opportunities for using grazing to control bracken in forestry.

Following a summer burn, short-term mob-stocking at intervals during the autumn and early winter could be an extremely effective means of removing the short regrowth, lowering bracken vigour still further and making the site cleaner for planting operations. Post-planting control by animals would not generally be feasible, however, as lack of alternative fodder on typical bracken sites would render the trees liable to browsing damage.

Chemicals

Over the years a number of chemicals have shown varying degrees of promise for controlling bracken here and overseas. These include foliar sprays of 4-CPA, 2,2-DPA, amitrole, karbutilate, asulam, picloram, dicamba, glyphosate, DPX 3674 and granular formulations of sodium chlorate, chlorthiamid, dichlobenil and karbutilate. (See Knowles 1970a and Chavasse and Davenport 1973, for reviews of chemical trials up to 1970 and 1973, respectively).

A common characteristic of most chemical treatments to date has been the variability and unpredictability of results both here and overseas. This appears to be related to stage and evenness of frond development, physiological activity of the rhizomes, soil moisture and temperature conditions and overall vigour of the bracken.

Chemicals are employed in two main ways:

1. Pre-planting site preparation.
2. Post-planting release.

Only a few chemicals which could be used in site preparation are sufficiently selective towards the trees to be used in releasing. A single post-planting chemical release treatment applied to young expanding fronds can provide satisfactory release of radiata pine (*Pinus radiata*) in areas of low-to-moderate bracken vigour. In areas of more vigorous bracken, however, control for two years is usually required. A follow-up selective treatment or pre-planting long-term control treatments may thus be necessary.

1. *Pre-planting site preparation treatments.* These are aimed at sufficiently long-term control to get the crop away. All of the chemicals listed above could be considered potential candidates for site preparation treatments, although some (viz., glyphosate and DPX 3674) are not yet available commercially in this country.

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(a) Foliage-absorbed chemicals: Until recently it was considered that best results were obtained with applications to soft unfurling or expanding fronds with progressively poorer results as frond maturation proceeded. For chemicals such as asulam and glyphosate, however, the expectation is that, for maximum translocation and rhizome kill, mature actively-photosynthesising fronds should be treated, say in mid- to late summer (Volger 1969); Veerasekaran and Kirkwood 1972). It has been evident for some time that, while providing good short-term control, applications to soft unfurling foliage fail to reach the rhizomes in sufficient quantities to effect long-term control (Wasmuth 1973a). In the belief that the poor results from treating mature foliage were possibly due to the failure of the chemicals to penetrate the very heavy cuticle characteristic of mature var. *esculentum*, additives, comprising ammonium sulphamate, dimethyl sulphoxide, and diesel oil (20 litres/ha) plus emulsifier, were included in spray formulations of asulam and glyphosate in an FRI pilot trial near Rotorua (Preest 1975). Application was to the mature foliage of vigorous bracken in mid-January. Ammonium sulphamate and dimethyl sulfoxide did nothing towards improving long-term control but diesel oil caused a highly significant improvement in the performance of both herbicides. Seventeen months later regrowth on plots treated with the diesel oil additive was insignificant from the point of view of tree establishment.

A microscopic examination was made of the speed and completeness of mature frond wetting. A 10% diesel oil emulsion wet both upper and lower frond surfaces much faster and more completely than straight water or water plus 5% surfactant. There is, therefore, evidence that poor control associated with the treatment of mature fronds may be related to poor wetting, entry and uptake rather than any inherent deficiency in the chemical or physiological resistance in the bracken.

There are two possible optimal times for treating mature foliage in relation to burning:

- (i) Following a summer burn. Application would be to the short, newly-matured regrowth in the autumn. The chances of getting a second burn are remote so that planting would have to be done through the short, standing, dead bracken.
- (ii) Preceding an autumn burn. In this case application would be to the vigorous, newly-matured, spring growth, with the burn delayed until the systemic activity of the chemical was complete.

These alternatives have yet to be compared. In theory the second should be the more effective. The foliage-applied herbicide should move with the photosynthate to the rhizomes and be stored there. A late summer burn would stimulate new frond buds into growth. These would constitute active metabolic sinks to which the herbicide, mobilised along with the starch, should then move, knocking them out.

(b) Soil-active, root-absorbed chemicals: These are aimed at long-term control and include sodium chlorate, karbutilate, chlorthiamid and dichlobenil granules and aqueous sprays of karbutilate and DPX 3674. Application to bare ground following a burn in the winter or early spring is often recommended for this type of treatment, presumably with the aim of holding the bracken in check into the following planting season and beyond. From the point of view of root and rhizome uptake, one would expect best results from application to warm, moist soils and young, maturing frond stands which are taking in large quantities of water and solutes in response to the demands of growth and transpiration. Preliminary results suggest that, at least as far as sodium chlorate is concerned, better control follows from applications to warmer soils following early summer burns, rather than to cooler soils following late winter or early spring burns. The same is not true of chlorthiamid and dichlobenil which, being readily volatilized, must be applied to cooler soils. Here again,

however, entry and uptake could be inhibited by frond removal prior to treatment. It is suggested that best results may be achieved if burning is delayed until after the treatment has had its effect, or at a time of the year and sufficiently prior to treatment to allow the emergence of a new crop of fronds.

A granular formulation of chlorthiamid has given poor-to-excellent control of bracken in small plot trials and has shown similar variability when used on a larger scale (unpublished Forest Research Institute and New Zealand Forest Service Conservancy results). Approximately 10 kg/ha are required. Deep litter has been found to improve the effectiveness of chlorthiamid on var. *typicum* in Britain (Aldhous 1964), due, presumably, to the cooler, moister conditions prevailing at the soil surface favouring the movement of this material into the soil. For the same reason, delaying burning until after treatment has had its effect, may be advantageous, although Lanz (1971) reported that an abundance of raw humus, due to its low wettability and moisture content, can reduce effectiveness.

2. *Post-planting treatments.* Three chemicals — asulam, DPX 3674 and chlorthiamid — show promise for selectively releasing radiata pine from bracken.

Asulam is now well proven and is being increasingly used very successfully to provide short-term (one season) control, (Wasmuth 1973b) especially on less vigorous bracken sites. It is applied at 5 kg/ha when the majority of the fronds are either unfurling or at the soft, early expansion stage — usually in the October-November period. On its own, it normally shows excellent selectivity towards radiata pine. It is conjectured that minor tree damage reported of late may be associated with the recent manufacture of asulam outside the United Kingdom.

Small quantities of 2,4,5-T emulsifiable ester or of a picloram sodium salt/2,4,5-T emulsifiable ester mixture, have been added to boost the activity against gorse growing in association with bracken. This has been generally successful but some asulam tree damage has been observed. This suggests that selectivity towards radiata pine is on the basis of differential absorption and uptake with which the presence of an oily emulsion interferes.

Experience with DPX 3674, a foliage- and root-absorbed triazine, is so far very limited. It appears to have a very wide spectrum of activity (which includes bracken), provides excellent residual control and has good selectivity towards radiata pine. Rates of 5 to 10 kg/ha are envisaged for selective control of bracken and many other forest weeds.

Chlorthiamid granules at 8 to 10 kg could be employed for selective release. Here again application needs to be early in the season while air and soil temperatures are still low. At these rates occasional tree mortality can be expected if the granules enter the planting slit and contact the lower stem or roots.

CONCLUSION

Fire, and cultivation or chemicals are undoubtedly the important means of controlling bracken in forestry. Significant gains in regrowth control appear to be attainable by appropriate timing of the site-preparation burn in relation to bracken growth stage and supplementary cultivation or chemical treatments.

An astonishingly large number of chemicals have given good-to-excellent results at one time or another, indicating that the forester now has adequate chemical weapons with which to attack bracken. The unpredictability and variability of results suggests, however, that the factor limiting reliable control is our lack of knowledge about what is happening once a chemical is applied; in particular, the way entry, uptake, transloca-

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tion and lethal action are influenced by environmental conditions outside the plant and physiological conditions inside.

It would appear that the tools are available for satisfactory bracken control; what is required now is more finesse in their employment.

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