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HERBICIDES FOR CONTROLLING WEEDS IN DOUGLAS FIR  
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TOLERANCE**ABSTRACT\***

Results are outlined of North American and European experimental trials and operational herbicide applications over Douglas fir. (*Pseudotsuga menziesii* (Mirb.) Franco). The current and potential role of these herbicides and similar formulations for establishing Douglas fir in New Zealand is also discussed.

**Recommendations:**

Trials should be undertaken to determine the herbicides tolerated by Douglas fir in New Zealand. Currently only one herbicide in regular use (terbuthylazine) has a label recommendation for use with Douglas fir.

Chemical companies must be made aware of the importance of Douglas fir in plantation forestry. Liaison with forestry organisations and with FRI would help pinpoint specific urgent requirements.

Velpar, glyphosate, triclopyr, Versatill and primisulfuron are either being used, or have potential, and are prime targets for immediate research. The atrazine-based water dispersible granules (Atradex and Gesaprim) should be evaluated as "dry" granular treatments.

Escort, Tordon 50D and 2,4-D are likely to be limited to pre-plant site preparation only. Imazapyr (Arsenal) is not likely to be used.

Gallant, Targa, terbuthylazine and atrazine are safe "over the top" herbicides, but require some indication of possible loss of selectivity if applied to new foliage with additives (spray oils or surfactants).

A totally different range of herbicides is used in forest nurseries, and a separate study to determine appropriate pre and post-emergence chemicals is required.

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\* Note: This material is unpublished and must not be cited as a literature reference.

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**NOEL DAVENHILL**

**July 1994**

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## INTRODUCTION

In New Zealand there is a shortage of local information on the effects of currently available herbicides on Douglas fir. This is because there has only been very limited planting of the species during the past 30 years.

This paper reviews herbicides that may be suitable for controlling weeds in Douglas fir plantations. A survey of literature from North America and elsewhere provides some indication of herbicide efficacy. This is not always directly comparable in New Zealand, because our relatively small forestry market has motivated formulation differences aimed primarily at the farmer or crop grower. It is also not always possible to directly apply overseas results to New Zealand, because of differences in soils, climate, growth patterns etc.

This report lists herbicides and common herbicide mixtures which have been applied to Douglas fir overseas, and outlines their possible role in New Zealand. Where possible, each herbicide has been listed under its common name, but where a combination of two or more formulations are frequently used as a single treatment, it is appropriate to list these together.

Unless stated otherwise, application rates are shown in kg/a.i., and are applied with water only, as a carrier.

## THE HERBICIDES

### (1) Glyphosate

In the Inland Northwest region of the United States, glyphosate is an effective herbicide for establishing Douglas fir (Boyd et al, 1985). Whereas glyphosate usually performs well, inconsistent results sometimes occur, even under essentially identical conditions of application.

In addition to ground-applied sprays and spot treatments for site preparation, broadcast aerial release spraying with 2.24 kg glyphosate/ha is also undertaken, except during periods of new growth. To minimise the risk of foliar damage, needles



must have hardened off, with no late season growth. It is emphasised that glyphosate should be applied in the lowest possible water rates, as little as 50 litres/ha.

In a small plot trial in the UK, De'ath (1988) described Douglas fir as moderately tolerant to a broadcast application of 1.08 kg/ha glyphosate in July/August (midsummer).

Glyphosate, being non-residual, is widely used in New Zealand as a pre-plant treatment for controlling woody weeds such as blackberry, gorse, seedling broom, bracken, buddleia, Himalaya honeysuckle etc. It also kills grasses, pampas, and herbaceous broadleaved weeds. In recent years, several operational trials undertaken by forestry companies have increased the weed control spectrum by combining glyphosate with metsulfuron (Escort). In 1993 this resulted in the introduction of a new herbicide, Trounce (glyphosate formulated as an 85% water soluble granule). Trounce is manufactured specifically to be applied in combination with Escort to control gorse, blackberry, and bracken. The advantages of adding Escort may be negated on some sites, because metsulfuron residues require (for radiata pine), at least two months to elapse before planting. **There has to date, been little experience of metsulfuron application to Douglas fir planting sites, but it is likely that an even longer waiting period may be required to ensure tree safety.**

Despite its effectiveness in North America, glyphosate has never been a candidate for aerial releasing in New Zealand. Severe tree injury would almost certainly occur if glyphosate was to be aerially applied over Douglas fir during spring, summer or autumn. Overseas experiences do however, indicate that there may be scope for trials in New Zealand, especially in colder districts, (eg Southland), after the completion of late season growth, when the Douglas fir are dormant, and well before any commencement of springtime bud swelling. A small trial undertaken near Murupara in 1984 by Monsanto, indicated considerable tolerance by 1-year old planted Douglas fir to an overall application of Roundup (M. Lane, *pers. comm*). Although not safe enough to be a commercial recommendation, results suggested that 1.8 kg/ha (3 litres) glyphosate could be applied as a grass release treatment during winter.

In New Zealand, glyphosate may with care, be applied around Douglas fir using a knapsack sprayer, to spot release from grasses, herbaceous weeds and seedling scrub weeds. A coarse nozzle should be fitted to prevent spray from contacting crop trees.

Glyphosate is best known in New Zealand as Roundup, but the same active ingredient is now available under a variety of trade names. A formulation marketed as Touchdown (48% glyphosate trimesium), has no label recommendations for controlling brushweeds, so should not be used as an alternative to the widely-used 36% ai products.

## **(2) Hexazinone**

Boyd (1984) reported tolerance to summer and autumn applications of hexazinone directly over Douglas fir in the Northern Rocky Mountains, at rates of up to 6.8 kg/ha.

Formulated as liquid Velpar, hexazinone is both foliar and soil active; in granular form it is of course, only soil active. Both formulations have also been applied in the Inland Northwest, (Boyd et al, 1985), where non-actively growing Douglas fir was generally tolerant to aerial applications of up to 2.24 kg Velpar L /ha. Conversely, Williamson and Lane (1989), warned that Douglas fir in the U.K. may be damaged by 1.68 kg/ha Velpar L - a rate tolerated by pines and spruce!

Velpar has also been effective in continental Europe (Allison 1980), In Germany, rates of up to 1.8 kg/ha hexazinone applied in April (to new growth), were non-damaging, whereas in Czechoslovakia and France, Douglas fir tolerated 3.6 kg/ha applied to foliage during summer. In France however, some yellowing occurred in actively growing needles.

Velpar controls a wide variety of weeds in New Zealand. Label recommendations include bracken, blackberry, seedling gorse and broom, Himalaya honeysuckle, buddleia, wattle, wineberry etc. Velpar is also effective against grasses and herbaceous plants.

Three formulations of Velpar are available in New Zealand, but there are no label recommendations for applying any of them over or around Douglas fir. In the North Island it is understood to be too risky to use, although Velpar 90 (soluble powder) at 1.2 kg/ha has been applied over actively-growing 2/0 Douglas fir seedlings at Rotorua, without causing damage. (Davenport and Priest, 1975).

Although there are several herbicides available for spot releasing newly-planted trees from grasses and pasture weeds, Velpar is one of only two herbicides registered in New Zealand for direct application as a granule. Velpar 20G may be dispensed with a Weed-a-Metre - an advantage in remote or steep country where carrying water can be a major problem.

With the current interest in the planting of Douglas fir, several South Island forest organisations have successfully undertaken spot releasing with Velpar. For example, Wenita Forestry (Mosgiel) have spot released 2000 ha of Douglas fir at Glendhu with 0.6 kg/ha (3 kg product) Velpar 90, prior to the onset of bud swelling. At City Forests, Dunedin, Douglas fir planted on the drier inland sites, cutover and tussock country have been spot released with 0.4 kg/ha (2 kg product) Velpar 20G. Trees in the wet coastal sites (mainly ex pasture) are initially spot treated with Gardoprim (terbuthylazine). A second release if required, is undertaken with 0.4 kg/ha Velpar 20G.

In New Zealand, there is clearly scope for further trial work for spot releasing. Christie (Dupont) makes the following observations from the Otago and Southland region.

- (i) Velpar must be applied at least 4 weeks after planting, but before the onset of bud swelling.
- (ii) Maximum application rate is 3.6 kg/ha
- (iii) Velpar should not be applied for releasing to light soils. Regular rainfall and good soil moisture appear to be important.
- (iv) Douglas fir show the highest tolerance to Velpar 20G, followed by Velpar 90 and Velpar L.

There is no evidence to suggest that Velpar may be more damaging to containerised Douglas fir planting stock, but caution is advised.

### (3) Glyphosate plus hexazinone

In the North Western United States, glyphosate has been applied in combination with hexazinone without causing significant injury to Douglas fir. White and Newton 1984, reported on the effects of this mixture in a trial near Corvallis Oregon, where liquid and soluble powder formulations of hexazinone were applied over 3-year old Douglas fir seedlings by knapsack, at rates of 1.11, 1.68, and 2.23 kg/ha separately, and in combination with glyphosate at 0.62 kg/ha. All treatments enhanced Douglas fir growth for up to 4 years. In the glyphosate-alone treated plots however, the mean height of 4 year old trees was only 149.9 cm compared with 162.2 cm for hexazinone-only sprayed trees. Glyphosate-only treatments resulted in unacceptable injury.

It is difficult to see any advantages in using such a combination in New Zealand. Its only role would be for site preparation, where currently used treatments already provide effective weed control more economically.

### (4) 2,4-D:

2,4-D ester formulations at up to 3.36 kg/ha have been aerially applied over Douglas fir for releasing, with variable results in North America (Conard and Emmingham 1984). In Southwestern Oregon, the safest period was surprisingly just prior to, or at bud break. In Western Oregon and Washington, 2,4-D (2.24 kg/ha) caused injury when applied to new growth. In the Inland Northwest, 2,4-D ester at rates up to 4.5 kg/ha has been applied from early to late summer, with little injury to Douglas fir (Boyd et al 1985).

Although there are no records of 2,4-D having been tested for aerial releasing in New Zealand, it is probable that low rates of both 2,4-D ester and 2,4-D amine could be applied here during winter, with little risk of significant tree damage. However, the weeds these herbicides kill, with the possible exception of Spanish heath, inkweed and hawkweeds, may be equally well-controlled by safer to use alternative herbicides. It is concluded therefore, that 2,4-D is unlikely to feature in Douglas fir establishment in New Zealand.



## (5) Triclopyr

In the Inland Northwest, Boyd et al, (1985) report little injury to Douglas fir released with triclopyr ester (up to 2.24 kg/ha), when applied during late summer or autumn.

In central France, an application of up to 0.72 kg/ha triclopyr acid, to control broom, was tolerated by 1 year old Douglas fir (Michaud 1986). In a U.K. small plot trial, De'ath (1988), describes Douglas fir seedlings as moderately tolerant to an overall application of 1.44 kg/ha triclopyr in July/August.

An experiment to determine the tolerance of 1 and 2 year old Douglas fir to triclopyr was undertaken at Marquam, Oregon (Fischer and Carrithers 1992). Both ester and amine formulations were applied at different seasons, before bud break, during post bud set, and at bud set. Results showed that two year old seedlings were the more tolerant. All rates of the ester formulation, when applied in water, caused only minor needle injury to the 2 year old seedlings. No damage was apparent from the amine formulation. Terminal and lateral buds were damaged significantly when diesel was included as a carrier for triclopyr ester. A water/diesel emulsion increased selectivity over an ester/diesel mixture, but there was some lateral bud injury. Multiple applications of triclopyr amine and ester formulations made to the same trees did not cause significant injury, except when triclopyr ester was applied at 1.68 kg/ha. One and 2 year old Douglas fir were tolerant to 1.68 kg/ha triclopyr amine. Triclopyr ester was non-damaging at 1.12 kg/ha.

In New Zealand, the scrub-controlling herbicides, 2,4,5-T and 2,4,5-T/picloram were replaced in the mid 1980's by two new formulations, each containing triclopyr. These are Grazon (60% triclopyr ester), and Tordon Brushkiller (30% triclopyr ester plus 10% picloram amine).

For pre-plant Douglas fir site preparation in New Zealand, these formulations will control seedling woody scrub weeds including gorse, broom, Himalaya honeysuckle, wattles, lupin, sweet brier, tutu. However, the variety of alternative herbicides now available is likely to reduce the importance of these products during future Douglas fir establishment operations.

The anticipated debut in New Zealand of a new selective herbicide for controlling woody weeds, compromises the continuing use of triclopyr for aerially releasing newly-planted radiata pine. There is also a reluctance to apply triclopyr over



Douglas fir, despite the conclusions of Balneaves and Davenport (1990) that release spraying is feasible at rates not exceeding 0.6 kg/ha if undertaken before bud swelling. This was the outcome of a trial at Rangiora, where triclopyr and triclopyr+picloram herbicides were applied with a hand-held boom to simulate aerial releasing at various rates over 2 year old, predominantly dormant Douglas fir in November 1988.

#### **(6) Triclopyr plus 2,4-D**

In North America, aerial foliar herbicide treatments using 2,4-D (available in several formulations), or triclopyr, separately or in combinations, are applied only during tree dormancy. Significant reductions in Douglas fir survival and growth occur if these herbicides are applied during periods of active growth. (Boyd et al, 1985). In a Washington study, (Figueroa et al 1990), Douglas fir were damaged by a mid May application of 2,4-D plus triclopyr ester at 1.34 +0.56 kg/ha. Thirty percent of the trees had less than 50% foliage compared with all unsprayed trees having more than 50% crown foliage. There was no mortality, but growth reductions were still evident after five years.

No commercial formulations of triclopyr + 2,4-D, are available in New Zealand, and there are no prospects of such a mixture serving a useful role here.

#### **(7) Picloram: Tordon.**

Actively-growing Douglas fir is sensitive to formulations containing picloram. Picloram is both foliar and root absorbed, causing needle yellowing and twisting, in addition to characteristic thickening of shoot tips and bud dieback. It is not readily metabolised, so trees may continue to show symptoms for several growing seasons. For these reasons it is considered to be unsuitable for aerially releasing Douglas fir in North America.

In New Zealand there are three commercial products containing picloram.

- (a) Tordon 2G (20g/kg picloram as a granule). The only "stand alone" picloram formulation available in New Zealand. The granules are used for the spot control of scattered brushweeds where spray treatments are impractical. They will severely damage or kill Douglas fir of any age, and are likely to cause residual problems if used, even several months before planting.

- (b) Tordon Brushkiller (10% picloram + 30% triclopyr). A similar mixture (Garlon 4 plus Tordon K) has been evaluated for aerial releasing Douglas fir in North West America. Tree injuries were moderately severe. (Conard and Emmingham 1983).

Although Tordon Brushkiller is registered in New Zealand for releasing radiata pine from seedling woody weeds, there are no label recommendations for releasing Douglas fir. Shielded or carefully placed spot spraying with a knapsack (6 ml/litre) is tentatively recommended for application around Douglas fir. A coarse nozzle should be fitted to minimise the risk of drift.

- (c) Tordon 50D (5% picloram + 20% 2,4-D). In North America, a similar product, Tordon 101, has invariably caused damage when applied aerially over Douglas fir.

Tordon 50D is not registered for aerial application in New Zealand, but may be applied with hand-held sprayers prior to planting. It is not recommended for application on, or around planted Douglas fir. Its most useful function appears to be for controlling difficult-to-kill broadleaved weeds and semi-woody weeds, but most of these can be adequately dealt with by herbicides such as Escort or glyphosate. Inkweed is however, one weed species on which Tordon 50D is particularly effective.

#### **(8) Atrazine**

Conard and Emmingham (1984), reported on the use of atrazine (up to 5.5 kg/ha), for aerial releasing Douglas fir from grass and herbaceous weeds, in several trials in Washington and Oregon. No significant tree damage was recorded, even when applied during active Spring flush.

In New Zealand forestry, atrazine (available under several brand names) has largely been replaced by Gardoprim. Atrazine may however be aerially or ground-applied directly over newly-planted Douglas fir, prior to flushing, at radiata pine label rates to control pasture grasses and herbaceous weeds. (Davenhill and Preest 1975).

Two brands of atrazine are marketed in New Zealand in the form of 900 g/kg water dispersible granules. Atradex 900 WG and Gesaprim 90 WG perform very satisfactorily when applied from a Weed-a-Metre as "dry" spot releasing treatments.

Although there has been no specific evaluation over Douglas fir, a high level of tolerance is anticipated.

#### **(9) Amitrole:**

Registered for Douglas fir releasing in Oregon and Washington. (Conard and Emmingham, 1984). Only minor foliar damage occurred when applied at 1.12 kg/ha during early Spring.

In New Zealand, during the 1970's, up to 0.8kg/ha amitrole was commonly included with a triazine (either atrazine, Caragard or Eliminox, which is a mixture of atrazine and simazine), for aerially releasing radiata pine from grass and pasture weeds.

Personal experience from Kaingaroa and elsewhere showed that amitrole applied to Douglas fir during bud development, or after new growth had commenced, invariably resulted in severe needle damage and subsequent growth retardation. Amitrole's only relevance today appears to be as a component of one of the many SDA formulations, occasionally still used for pre-plant spot spraying.

#### **(10) Metsulfuron (Escort)**

Residues are damaging, so it is suggested that Escort be applied at least 9 months before planting Douglas fir. Cole et al (1988), reported minor injury to Douglas fir seedlings planted 7 to 8 months after applying very low rates of metsulfuron for site preparation in the Northwest USA.

Despite the potential risks, some New Zealand forestry organisations are applying Escort for site preparation prior to planting Douglas fir. The spectrum of control is increased by mixing it with glyphosate. This is also more economical, and has led to the introduction of Trounce, a water-soluble granular formulation of glyphosate especially designed for use with Escort on gorse, blackberry and bracken-dominated sites.

Escort is not appropriate for tree releasing, not even for shielded spot treatments.

### **(11) Imazapyr (Arsenal)**

From the U.K, Clay and Lawrie (1988), reported that overall application of 1 kg/ha imazapyr to potted Douglas fir in August, resulted in death or very severe damage.

Trials were established to evaluate the efficacy of imazapyr for site preparation in western Oregon (Cole et al 1988). Although effective for site preparation, imazapyr was found to cause severe injury when applied directly to Douglas fir.

The results of this work, and trials undertaken by CHH Forests (P. Carter, *pers. comm.*), clearly indicate that Arsenal is unlikely to have a role for site preparation in New Zealand.

### **(12) Primisulfuron (Beacon)**

There are no overseas references relating to Douglas fir. Beacon is a relatively new introduction to New Zealand forestry for releasing radiata pine from fully-expanded mature bracken fern. **Trials are urgently required to evaluate its effect on Douglas fir after the maturing of new season's needles.**

### **(13) Haloxyfop (Gallant)**

There are no overseas references relating to Douglas fir: In New Zealand, Gallant may be applied as an overall spray to release all tree species from grasses or pampas at label rates. Although we have no records of any specific application over Douglas fir, the species is unlikely to be adversely affected.

Trials are recommended before applying Gallant with a spraying oil additive to newly-flushed Douglas fir seedlings.

### **(14) Clopyralid (Versatill)**

Ahrens (1991) reported that 0.56 kg/ha Clopyralid caused Douglas fir in North East USA to develop curled needles on the youngest growth of some plants. The injury was tolerable, with subsequent growth and vigour not visibly affected.

In New Zealand, clopyralid may be applied as an overall spray to release Douglas fir from appropriate broadleaved weeds at label rates. Although significant tree damage is unlikely to occur, even when applied during active growth, trials to check out tolerance levels would be useful..

#### **(15) Quizalofop-P-ethyl (Targa)**

There are no overseas references relating to Douglas fir. In New Zealand this herbicide has replaced Zero. It may be used in the same way as Gallant and is unlikely to cause damage.

Trials are recommended before applying Targa with a spraying oil additive to newly-flushed Douglas fir seedlings.

#### **(16) Terbuthylazine (Gardoprim also available as Terbuthylazine 500)**

Terbuthylazine does not feature in North American literature pertaining to weed control in Douglas fir plantations.

From the U.K, Nelson et al. (1991) outlined the result of applying 7.5 kg/ha Gardoprim A (400g/litre terbuthylazine + 100g/litre atrazine) over actively growing Douglas fir. The herbicide was applied to newly-planted trees between March and June. By late summer, dead and damaged trees were observed. A hot, dry summer is thought to have placed the trees under stress, making them less tolerant to what was understood to be a selective treatment. However, further losses occurred in two more experiments to test this formulation in a different season. As a result of these trials, the authors recommend that Gardoprim A at 7.5 kg/ha is applied only to dormant Douglas fir.

Terbuthylazine is the only herbicide in New Zealand to have a specific label recommendation for Douglas fir. Ciba Plant Protection claim that Gardoprim is selective to dormant Douglas fir at 15 litres/ha (1.5 ml/square metre). The Agpro NZ Ltd label states that Terbuthylazine 500 is safe over Douglas fir at 15 to 20 litres/ha, but does not refer to any growth stage of the tree. Caragard (25g/litre terbuthylazine + 25g/litre terbumeton) is also labelled as being selective to Douglas fir, but this product is now rarely used in forestry.



In New Zealand, there have been no indications of damage to Douglas fir from terbuthylazine. Spot treatments of 5ml/sq m Gardoprim, applied over Douglas fir in Otago and Southland, caused no damage when applied in October to already flushing Douglas fir (D.Lichfield, Ciba, *pers. comm.*). A mid-August aerial application of 12.5 kg/ha (25 litres product) Gardoprim plus 0.9 kg/ha (3 litres product) Versatill, effectively controlled broom seedlings at Dusky Forest, without damaging Douglas fir (D.Lichfield, Ciba, *pers. comm.*).

A. McCord (*pers. comm.*) reports operational use of Gardoprim at 10 kg/ha (20 litres product), directly over newly-planted Douglas fir to control young grass. Where gorse and/or broom seedlings are present, 0.48 kg/ha (1.6 litres product) Versatill plus 0.5% Boost penetrant is added to the Gardoprim.

In Southern Kaingaroa, Forestry Corporation aerially release Douglas fir with 7.5 kg/ha (15 litres product) Gardoprim plus 0.3 kg/ha (3 litres product) Gallant, in 200 litres water. In Kaingaroa North, Douglas fir are spot released in year one, and often again in year two, with Gardoprim (4.5ml) plus Gallant (2.4 ml).

## DISCUSSION AND CONCLUSIONS

Most of the herbicide formulations currently used during forest establishment in New Zealand have been covered in this review. Omissions include asulam, dalapon, simazine, paraquat and diquat, all of which now have very limited forestry application.

**Safe herbicides** (may be applied directly over Douglas fir) include: Gallant, Targa, terbuthylazine, and atrazine. However the addition of spraying oil or surfactant may reduce selectivity to new seasons growth.

**Partially safe herbicides** (may be applied with care around Douglas fir for spot releasing, with some evidence of tolerance to "over the top application") include: Velpar, Grazon, Tordon Brushkiller, and Versatill. Glyphosate should be restricted to shielded spot releasing and site preparation:

**Generally unsafe herbicides**, but probably acceptable for site preparation, include: 2,4-D, Tordon 50D, amitrole, Escort, Arsenal

The herbicide, Beacon, may be useful but there is no information.

In certain situations, it is apparent that tank mixes of two or more herbicides provide a much wider spectrum of weed control than the same herbicides applied individually.

Although herbicides such as atrazine, terbutylazine, Gallant, and Targa are selective when applied as single treatments, the application of combinations of any of these directly onto actively growing Douglas fir may result in severe injury, growth loss and even death. Unless proven to be safe, any such mixtures should be avoided until appropriate tolerance trials have been undertaken.

With the increase in Douglas fir planting in New Zealand, there is clearly a need for research to identify more herbicides which may be acceptable for releasing this species.

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## APPENDIX 1

## Weed species mentioned in text

blackberry	<i>Rubus fruticosus</i>
bracken	<i>Pteridium aquilinum var. esculentum</i>
broom	<i>Cytisus scoparius</i>
buddleia	<i>Buddleja davidii</i>
gorse	<i>Ulex europaeus</i>
hawkweeds	<i>Hieracium spp</i>
Himalaya honeysuckle	<i>Leycesteria formosa</i>
inkweed	<i>Phytolacca octandra</i>
tree lupin	<i>Lupinus arboreus</i>
pampas grass	<i>Cortaderia spp.</i>
Spanish heath	<i>Erica lusitanica</i>
sweet brier	<i>Rosa rubignosa</i>
tutu	<i>Coriaria spp</i>
wattle	<i>Acacia spp</i>
wineberry	<i>Aristotelia serrata</i>