THE USE OF 2,4,5-TRICHLOROPHENOXY ACETIC ACID (2,4,5-T) IN FORESTRY IN THE SOUTH ISLAND, NEW ZEALAND

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Abstract

The forest growing industry in the South Island used 21.9 tonnes and 28.4 tonnes of 2,4,5-T (active ingredient) during 1978-9 and 1979-80, respectively. This accounted for 12.2 and 14.3% of the total volume of 2,4,5-T sales within the South Island. Assuming 0.02 ppm TCDD contamination, only 0.44 g and 0.57 g was released into the environment through the application of 2,4,5-T in forestry operations.

2,4,5-T is an essential land management tool to aid exotic forest development on land areas occupied by unwanted vegetation such as gorse, broom, Himalaya honeysuckle, wattle species, blackberry, sweet brier, hawthorn and indigenous scrub. All of these weeds must be controlled to ensure the development of a radiata pine crop at minimum cost. The aggressive development of any of these weeds often precludes silvicultural operations except at very high cost and at the same time causes uneven stocking and reduced crop growth and log quality.

Alternatives to deal with these weeds exist to only a very limited degree. In most cases 2,4,5-T must be used on scrubweed sites to ensure a viable exotic forest industry.

INTRODUCTION

Herbicides have become well established as one of the essential tools of forest managers (Chavasse, 1976) for manipulation of vegetation for forest establishment, for nursery weed control, and for chemical thinning of forest stands. Herbicides are generally considered to be indispensible tools for preparation of land for planting. Certain sectors of the public are now clamouring against their continued use, particularly that of 2,4,5-T. The history of this widespread concern is well documented elsewhere.

Forest managers are required to husband our major renewable resource. In particular, we cannot accept the occupancy of productive land (New Zealand's biggest resource) by unprofitable

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vegetation and we need to get unproductive land areas back into production without delay.

Mechanical and manual solutions to deal with the weed infestation, in particular scrubweeds, such as gorse (*Ulex europaeus*), broom (*Cytisus scoparius*), blackberry (*Rubus fruticosus*), Himalaya honeysuckle (*Leycesteria formosa*), wattle (*Acacia* spp.), hawthorn (*Crataegus laevigata*), and manuka (*Leptospermum scoparium*), have several disadvantages, including expense, topographic limitation, distance from a large labour supply, and most importantly their frequent failure to solve the problem. Herbicides often have considerable advantages over mechanical and manual methods.

Thus forest managers are confronted with a variety of problems of vegetation manipulation for which the best answers are often herbicides, or a combination of operations in which herbicides play a crucial part. Yet the "environmentally" conscious public could exercise considerable indirect restraint on the use of herbicides, particularly 2,4,5-T. This paper serves to summarise the answers to a questionnaire designed to determine our current usage of this herbicide within the forest industry in the South Island and whether or not this is justifiable in forest establishment programmes. The quantity of 2,4,5-T used and the amount of TCDD[1] this represents, purposes for which it is used, other methods that could be employed, and associated costs are all discussed.

1. *Quantity of 2,4,5-T used during 1978-9 and 1979-80 Seasons*

The total amount of active[2] 2,4,5-T sold in the South Island, but not necessarily used, during the 1977 and 1978 calendar years was in the order of 180 tonnes. This includes 2,4,5-T contained in proprietary mixtures. In 1979 and 1980 it was expected that sales volume would increase to 198 tonnes, an increase of 10% over the 1978 sales (these figures refer to sales from 1 January to 31 December).

Table 1 gives details of quantities of 2,4,5-T used by the forest industry in the South Island: a total of 21.92 tonnes in 1978-9 and 28.39 tonnes in 1979-80. Assuming that the quantity used equals the quantity sold in any year, then the forest growers' industry utilised 12.18 and 14.34% of the total quantity of 2,4,5-T distributed for sale within the South Island. This can be broken

[1] 2,3,7,8 — tetrachlorodibenzo-*p*-dioxin.

[2] Throughout the text quantities are given in active ingredient.

down further: Forest Service 9.95 and 12.5%, and private forest industry 2.22 and 1.77% for the 1978-9 and 1979-80 seasons, respectively.

2. *Quantity of TCDD released into the Environment*

The current debate over 2,4,5-T is not so much directed at the phenoxy acetic acid itself but rather the manufacturing impurity, TCDD. This is one of the most toxic substances known (Cattabeni *et al.,* 1978) and for this reason the New Zealand Health Department set a permissible maximum level of 0.1 ppm in the manufacture of 2,4,5-T. The manufacturing company Ivon Watkins-Dow Ltd claims to manufacture 2,4,5-T with a TCDD level of 0.01 ppm and at times as high as 0.05 ppm (pers. comm.). A recent statement by the Health Department (Bates, 1980) indicates that at present there is actually only about 0.02 ppm of TCDD in New Zealand manufacured 2,4,5-T.

In Table 1 the range of TCDD levels is shown corresponding to each of several allowable levels of contamination. It is apparent that the amount of dioxin released into the environment, from forestry operations within the South Island at least, is very small.

3. *Purposes for which 2,4,5-T is used in Forestry*

Tabe 2 summarises the uses to which 2,4,5-T is put (as at 31 March 1980), first by Forest Service conservancies and then by major private and public corporations.

TABLE 1: 2,4,5-T USED AND TCDD RELEASED IN THE SOUTH ISLAND FOR VARIOUS PPM LEVELS OF CONTAMINATION

	Total in Forest Industry	*Total for South Island*
1978-9 SEASON		
2,4,5-T used (kg)	21 920	180 000
TCDD (g):		
0.1 ppm	2.19	18.0
0.05 ppm	1.10	9.0
0.02 ppm	0.44	3.60
0.01 ppm	0.22	1.80
1979-80 SEASON		
2,4,5-T used (kg)	28 387	198 000
TCDD (g)		
0.1 ppm	2.84	19.8
0.05 ppm	1.42	9.9
0.02 ppm	0.57	3.96
0.01 ppm	0.28	1.98

TABLE 2: PURPOSES FOR WHICH 2,4,5-T IS USED

Purpose	*Conservancy/Other Organization*
1. Desiccation in preparation for burning:	
gorse	Southland, Nelson, Canterbury, Westland, Dunedin City Corp, Baigents, Marlborough Forestry Corp
broom	Southland, Nelson, Canterbury, Dunedin City Corp, Marlborough Forestry Corp
Himalaya honeysuckle	Southland
indigenous scrubweeds	Southland, Nelson, Canterbury, Westland, Baigents
2. Post-burn/pre-kill spray	
gorse	Southland, Canterbury, Selwyn Plantation Bd
broom	Southland, Selwyn Plantation Bd
wattle	Selwyn Plantation Bd
blackberry	Selwyn Plantation Bd
3. Release spray trees from competition	
gorse	Southland, Nelson, Canterbury, Westland, Dunedin City Corp, Baigents, Marlborough Forestry Corp, Selwyn Plantation Bd
broom	Southland, Nelson, Canterbury, Dunedin City Corp, Marlborough, Forestry Corp, Selwyn Plantation Bd
Himalaya honeysuckle	Southland
indigenous scrubweeds	Southland, Westland
wattle	Selwyn Plantation Bd
blackberry	Selwyn Plantation Bd
4. General control of all scrub-weeds including all species mentioned above on road sides, forest boundaries, or encroachment into otherwise scrub free areas. Additional weeds include sweet brier and hawthorn	Southland, Nelson, Canterbury, Westland, Dunedin City Corp, Baigents, Marlborough Forestry Corp, Selwyn Plantation Bd

4. *Application Methods*

There are three methods of application generally employed within the forest industry. Ninety-one percent of the 2,4,5-T used in forests is applied by air, using both helicopters and fixed-wing aircraft. This is carried out during land-preparation operations or when release spraying trees to control competing vegetation.

Roadside or boundary spraying is usually conducted as high volume gun-and-hose applications from a tractor or other suitable vehicle. This accounts for a further 8.8%. In Nelson some flat areas of amenity/production and ornamental plantings are sprayed using the gun-and-hose.

In some forests back-pack spray units, motorised mistblowers, or a paint brush are used for spot or stump treatment of scattered unwanted vegetation (usually gorse, broom and hawthorn) to prevent later severe infestation. This accounts for the remaining 0.2% of the volume of 2,4,5-T used.

5. *Site Preparation Regimes and Costs*

Southland and Westland deal with a complex weed community in the form of scrub hardwoods in addition to gorse, and, in Southland, Himalaya honeysuckle is present as well. In Nelson and Marlborough the weeds are generally a mixture of gorse, broom, and bracken (*Pteridium aquilinum* var. *esculentum*).

Canterbury's scrubweeds are similar to those of Nelson and Marlborough but they have blackberry and wattle problems as well.

Broom and blackberry are becoming an increasing problem in many areas following clearfelling of the first crop.

One weed common to all regions is gorse. Methods of controlling it vary from region to region. A comparison of contrasting regimes is made in Table 3.

Little use has been made of machinery in preparation of gorse fuels for burning. Southland Conservancy and Dunedin City Corporation are the only organisations using roller crushing for preparing gorse for burning new planting areas. Root raking of cutover sites, where topography allows, is undertaken at Ashley Forest in Canterbury Conservancy. This eliminates the need to burn these areas and also serves as a firebreak to contain fires in burning-off operations in gully or other steeper areas where burning is essential.

In Southland and Canterbury an intensive site preparation regime is used to eliminate, as much as possible, the competitive

TABLE 3: A COMPARISON OF SOME GORSE CONTROL TECHNIQUES USING 2,4,5-T, THE AMOUNT OF TCDD RELEASED AS A RESULT, AND THE COST OF TREATMENT

Region/Forest	*Treatment*	*2,4,5-T (kg/ha)*	*TCDD (g/ha)**	*Cost ($/ha)*
Southland	Roller crush, burn, followed by two post-burn/pre-plant kill sprays (two-year programme)	8.4	0.000168	368
Nelson	Desiccant spray, burn and release spray following planting (two-year programme)	4.7	0.000094	98
Ashley Forest	Desiccant spray, burn, followed by one post-burn kill spray. A release spray is usually necessary (two-year programme)	7.1	0.000142	274

* assuming 0.02 ppm TCDD

effect of gorse, while at the same time allowing ready access for tending.

In the Nelson region (Forest Service), objectives are different and emphasis is only on ensuring that a radiata pine crop is established, hence site preparation is significantly less intensive and less costly. Similarly quantities of 2,4,5-T are much less than those used on gorse areas in Southland and Ashley Forest.

Prescriptions for dealing with indigenous scrubweeds are similar in Southland and Westland. In Westland Conservancy the move is away from a single pre-burn spray of a mixture of 2,4,5-T/diquat/diesel to a double application leaving the diquat out of the first application and using it to desiccate the fine fuels just prior to burning as a second application.

In some replies to the questionnaire, broom was reported in association with gorse. Although, on its own, it can be controlled by applying a mixture of 2,4-D and picloram (thus reducing the dependence on 2,4,5-T), control measures reported were the same as for gorse.

Himalaya honeysuckle, wattle and manuka are controlled well only with 2,4,5-T based herbicides. Blackberry can be controlled by krenite, glyphosate or hexazinone, but mostly it occurs in association with weeds which require 2,4,5-T based herbicides.

Presently, wattle is confined to the Selwyn Plantation Board forests on the Canterbury plains, usually in association with broom, and is sprayed with 2,4,5-T based materials as a releasing operation only.

6. *Influence of a Poor Burn on Subsequent Planting Costs*

In general, to obtain a clean site, devoid of gorse stems, fuel preparation is essential. Failure to prepare fuel for burning inevitably leads to additional costs including further site preparation operations (mechanical clearing on easy country, or line cutting on steep land), poorer planting, slower planting rates and much increased releasing. Earlier reports (Balneaves, 1978; and unpublished FRI data) show the influence a pre-burn application of 2,4,5-T has on moisture content of gorse fuels and in turn the results of this treatment following burning. Comparisons were made with burning green standing gorse and gorse that had been rotary slashed (to simulate crushing). Both pre-burn spraying, with 2, 4, 5-T, and slashing facilitated burning and produced clean sites. Burning green standing gorse left the site unplantable, necessitating line cutting or rootraking.

In the South Island most fuel preparation involves the application of 2,4,5-T as a pre-burn desiccant. Should 2,4,5-T be unavailable poor quality burns of scrubweed areas will result and follow up treatments will be essential. Costs of these range between $100 and $180 per hectare for line raking on easy topography and $225 per hectare for line cutting. Line raking, because of its cultivating effect, results in a 20% reduction in planting costs while planting line-cut areas is usually 40% greater than hard-burnt clean areas. Where no follow-up work has been undertaken and access is difficult, because of a poor burn, planters are able to average only 400 trees/man/day as compared with 800 to 1200 on clean sites.

In the Nelson region, aand Waimate Forest in Canterbury, increased costs because of the need to line-rake or line-cut following poor burns would more than cover the cost of gravity roller crushing. The same can be said for areas under the control of the Marlborough Forestry Corporation. However, the additional use of machinery, especially for tracking to allow a gravity roller to be used, may pose some serious soil erosion problems in this region, a point favouring the use of 2,4,5-T.

While site preparation method does influence the effectiveness of the burning operations, fuel condition related to climatic factors is important too. Westland Conservancy state: " . . . the

degree of cleanliness of the site following burning is influenced more by climatic conditions prior to a burn than the presence of live material in the area although even in a good year the amount of clean up can be slightly improved by the use of desiccant sprays.

"In clearfelled areas in a good dry year when fuel has been down for a sufficient length of time to permit good curing and there is an extended period of drying weather prior to burning, then burns go well even when a fair amount of greenery is present. In a wet to mediocre year all aids are necessary, all fuel must be dead and as dry as possible because the fire will be cold and weak, resulting in poor consumption of green or wet wood. In these conditions chemical treatment with 2,4,5-T followed up with diquat is essential."

7. *Releasing operations*

Aerial releasing operations are generally conducted throughout the South Island to ensure adequate establishment of a radiata pine crop. A combined total of 4981 ha has been release sprayed with 2,4,5-T in the 1978-9 and 1979-80 seasons to control scrubweeds growing in competition with newly planted pine seedlings. 2,4,5-T is essential for this as it is relatively selective, in that it gives some knock down and control of scrubweeds while doing little damage to the radiata pine crop, provided guidelines are followed. In some regions — *i.e.*, Nelson, Hanmer and Ashley Forest — 2,4,5-T is applied as a release spray for up to two years and, in one instance, for three years following planting. In the Dunedin City Corporation areas aerial releasing operations are undertaken only if it is really essential and then as a last resort. The pre-plant use of 2,4,5-T during site preparation is preferred. In the Selwyn Plantation Board plantations aerial spraying is used for post-planting control of wattles. Concern was expressed at the cost of these operations which are not only ineffective to some degree, but also cause damage to and reduce growth of radiata pine. In this situation rotary slashing will play a bigger role in controlling infestation of scrubweeds on the plains forests. The Marlborough Forestry Corporation, on the other hand, consider aerial releasing to be a very cost efficient operation. This is true when comparisons of hand-releasing operations are made with the conventional aerial application of low rates of 2,4,5-T. H. Baigent & Sons Ltd, Nelson, quote aerial releasing costs as $52/ha, whereas hand releasing costs $125/ha.

Prescribed rates of chemical varied considerably through the South Island according to location, timing of spray application (spring or autumn), 1st or 2nd year from planting, and the weed(s) being dealt with. Rates per hectare were 0.54 kg to 2.16 kg of 2,4,5-T alone or, where picloram is added, from 0.56 to 0.80 kg.

8. *Pruning and Thinning Costs increase because of Scrubweed Competition*

In many areas within the South Island where gorse is allowed to grow up with the trees, pruning regimes are considered impractical. Where weed problems cause severe hindrance, pruning man-hours (15.5 man-hours/ha) are double those of a relatively clean block (7.8 man-hours/ha) resulting in cost increases of 80 to 90%. In stands where the initial stocking has been greater than 800 stems per hectare, early thinning is essential to maintain vigorous growth and achieve economic piece sizes. Where stands are gorse-infested, thinning is delayed until gorse suppression has occurred — *i.e.,* generally until age 10 years or more. Thinning at the normal time (6 to 7 years from planting) takes 12 to 15 man-hours/ha. At 10 years, providing access through the dead gorse costs from 5.5 to 10.7 man-hours/ha, while the thinning operation itself costs over 20 man-hours/ha. In gorse areas, in the Blenheim Ranger District, pruning costs are increased by as much as 18-24 man-hours/ha when compared with clean sites.

Similarly, gorse competition at Otago Coast, in Southland Conservancy, reduces man-hour productivity by 34% for pruning and 61% for thinning. Comparisons of costs between weed-free and weed-infested sites are not available for Westland Conservancy or Ashley Forest in Canterbury Conservancy.

In other regions within the South Island, increased costs because of severe weed infestation are a major problem. In some instances access is restricted completely, in which case the stand of trees cannot be pruned until 3 or 4 years later than the optimum unless an expensive "underscrubbing" is undertaken. Thinning costs are influenced to a much greater degree than pruning costs and have been stated to increase in a range from 61 to 163% in areas other than Blenheim.

9. *Loss of Growth resulting from Scrubweed Competition*

Uncontrolled scrubweed growth can virtually exterminate a newly planted tree crop.

The loss of growth from scrubweed sites has not been quantified but, from observations, stands on these sites have more uneven growth and survival than clean sites. For example, areas of low stocking with smaller trees usually occur in heavy gorse areas. Further, there is a loss of potential growth owing to a delay in thinning while waiting for weed suppression. This results in reduced crop tree diameter due to inter-tree competition as well as scrubweed competition. The loss of crop tree diameter growth was reported to be as much as 5 cm as a result of a delay in thinning by 3 years.

Table 4 shows two examples of the substantial gains possible from scrubweed control.

TABLE 4: GROWTH RESPONSE OF RADIATA PINE TO SCRUBWEED CONTROL IN SELWYN PLANTATION BOARD (SPB) PLANTINGS (TRANTERS BLOCK) AND IN ASHLEY FOREST (Balneaves and Zabkiewicz, 1981)

Location	*Site Condition*	*Crop Age (yr)*	*Tree Height (m)*	*Tree Diam. (cm)*	*Bulk Index ($D^2 \times Ht$)*
SPB	Weed infested (broom with some wattle and grasses)	4	1.46	2.9	12
	Weed free		2.68	8.2	180
	% Increase		84	183	1367
Ashley	Gorse infested	9	7.99	13.6	1478
	Weed free		10.91	17.4	3303
	% Increase		36	28	123

10. *Silvicultural Options for Gorse Sites without 2,4,5-T*

The following options exist and in some cases are aready employed:

(1) Untended regime — plant and hand release 800 trees/ha; no pruning or thinning; clearfell at age 26-28. (This is followed at Golden Downs Forest on gorse problem areas except that 2,4,5-T *is* used to get the crop established.) The regime produces wood more cheaply than a tended regime and achieves a similar rate of return. However, the produce is unlikely to meet all regional quality requirements and management plans may call for substantial areas of more intensively managed forest involving high cost alternatives to 2,4,5-T as in (2).

(2) Board regime — employ additional expensive mechanical or manual means of ensuring adequate stocking and access for all silvicultural operations implicit in a board regime.

(3) Modified board regime — plant 1850 trees/ha (instead of 1430) — relies on early canopy closure to kill gorse out; delay all three pruning lifts until this occurs, then thin to final crop stocking. (This has been adopted at Herbert and parts of Rai-Whangamoa Forests.) Dollar expenditure is reduced compared with (2) but there is a real cost increase (no data) in lost final crop diameter and clearwood in the lower 4 m of the tree.

(4) Framing regime — plant as for board regime; clear access for low pruning and a first, and only, thinning. Again expenditure is reduced but there is no effective clearwood production. Volume will suffer and the unit value of the produce will be much lower.

11. *Alternatives to 2,4,5-T for Scrubweed Control*

There are currently no effective alternative chemicals for 2,4,5-T for development of land out of scrubweeds into exotic forests. Many respondents described the use of diquat, paraquat or hexazinone. None of these chemicals will substitute for 2,4,5-T to aid burning gorse, broom, manuka, wattle and most other woody weeds. Any post-burn/pre-plant application of paraquat or diquat would result in very short-term control — *i.e.*, 3-6 weeks. Paraquat, especially, probably offers a greater health risk to operators than 2,4,5-T. Hexazinone or atrazine may provide control of germinating and very young gorse and broom seedlings, but are generally ineffective against established plants and resprout material. Also, other competing vegetation (*e.g.*, grasses) would be eliminated, allowing ideal conditions for scrubweed reinfestation.

Machinery and hand methods have their drawbacks. For machinery they are their high cost and topographic limitations. Costs are also high for hand methods, and the logistics of deploying the large labour forces necessary to cope with the work on time are formidable. The task is unpleasant, monotonous, sometimes hazardous, often ineffective, and represents an inefficient use of the labour resource.

CONCLUSIONS

1. Forestry used only 14% of the total South Island sales of 2,4,5-T.

2. The amount of TCDD released into the environment through forestry programmes was very small, in the order of 0.5 g in both the 1978-9 and 1979-80 spraying seasons.

3. 2,4,5-T is used to prepare gorse, broom, Himalaya honeysuckle, wattle, blackberry, indigenous scrubweeds fuels for burning, as well as to control regrowth following burning.

4. There is no satisfactory alternative for controlling the brushweeds encountered in forestry.

5. Ninety-one percent of the 2,4,5-T used in forests is applied by helicopters and fixed-wing aircraft. Roadside or boundary spraying (8.8%) is usually conducted as high volume gun-and-hose applications from a vehicle. Back-pack spray units, motorised mistblowers or paint brush are used (0.2%) for treatment of scattered vegetation before severe infestation results.

6. In Southland and Canterbury Conservancies intensive site preparation is used to eliminate (as far as possible) competition from scrubweeds (especially gorse) and to allow access for tending. In the Nelson region (N.Z. Forest Service) the emphasis is to ensure that a radiata pine crop is established, hence site preparation and 2,4,5-T use is significantly less than on gorse areas elsewhere. Less 2,4,5-T could be used if there was a greater use of roller crushing for preparation of scrubweed areas for burning.

7. Since fuel preparation for burning currently involves the application of 2,4,5-T as a pre-burn desiccant, poor burns will result if 2,4,5-T is unavailable. Subsequent costs would be high as follow-up line raking or line cutting would be necessary. Where no follow-up work has been undertaken and access is difficult, because of a poor burn, daily planting rates may be reduced to less than 50% of normal.

8. In scrubweed release spraying to ensure adequate establishment of a radiata pine crop, 2,4,5-T is essential as it is relatively selective provided guidelines are followed.

9. Because of severe scrubweed infestation of many stands of radiata pine, silvicultural operations are either impractical, costly or delayed.

10. The loss of growth to the crop trees from scrubweed competition is not very well quantified, though the effect is obvious. Severe scrubweed competition results in low stocking, uneven growth of radiata pine and reduced basal area.

11. Many regions adopt a policy of planting greater numbers of trees/ha where scrubweeds may become a major problem. This is to suppress the weeds earlier so that access for silviculture is not seriously delayed. In other regions only 800 stems/ha are planted to avoid the need for early thinning so that silvicultural costs are minimised. Regional management aims usually require a proportion of the established crop to be intensively tended so other measures will be necessary to meet these aims should the right to use 2,4,5-T be withdrawn.

12. There are no effective techniques or chemicals to replace 2,4,5-T for development of land out of scrubweeds into exotic forests. Roller crushing of scrubweed fuels in some regions does offer some scope for reduction in the use of 2,4,5-T but it will still be essential for post-burn or post-plant weed control.

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