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FORESTRY COMMISSION OF N.S.W.

RESEARCH NOTE No. 16

Published April, 1965

# CHEMICAL CONTROL OF FOREST WEEDS

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## 1. INTRODUCTION

The development and marketing of chemical weedkillers for agriculture during the past few years has gathered momentum at such a rate that today the layman is overwhelmed by an apparent confusion of names, codes and formulations. However, many of these herbicidal\* formulations are well suited to the control of unwanted vegetation on forested lands and their use will supersede manual and mechanical treatments.

Research has been carried out by manufacturers, distributors, governmental and semi-governmental bodies and a great deal of published information is available on the use and effects of the whole range of chemicals.

Foresters are aware that this information exists and the demand for a summary of the use of herbicides under forest conditions is increasing. It is the intention of this Research Note to collate the information available from all sources, and with the results of experiments and semi-routine trials conducted by the authors on the N.S.W. North Coast, to provide a guide to the control of weeds in the forest.

The control of weeds in seedling nurseries is a separate field requiring intensive study of local conditions. Forest managers might also have occasion to use herbicides in non-forest conditions, e.g. to control weeds around buildings, mill yards, etc. To attempt a detailed analysis of all likely weed problems would defeat the purpose of this Note. If information is required beyond the brief references in Sections 3 and 5 reference can be made to appropriate authorities or direct to commercial interests.

Much of the discussion is centred around the "hormone" type weedicides 2,4-D and 2,4,5-T because it is these that, at present, have the widest scope for applications. However the use of chemicals for control of vegetation will not remain static; new and improved chemicals are being developed and some may prove superior for specific uses to those recommended. Also, because of variations in meteorological and geographical conditions and between treated individuals, uniformity cannot be expected. Some local trial will be required to determine optimum dosages for various combinations of species and climatic conditions, but the recommendations made here should prove a reliable starting point.

The recommendations made in the following pages assume that some form of chemical control of the unwanted vegetation is required. The possibility of undesirable side effects developing in the long term with an increasing acceptance and use of chemicals in the field should always be remembered. With the pressure of economics the forest manager cannot be expected to disregard these new tools available, but he can choose the one least likely to involve severe consequences and can be moderate in its use.

\* NOTE: So far as possible the nomenclature and terminology used in this paper follow that proposed by the Weed Society of America (1958). "Herbicide" is defined by the Society as a phytotoxic chemical used for killing or inhibiting the growth of plants. This definition has become accepted in the literature and is retained in this Research Note. A list of definitions proposed by the Society is given as Appendix II.

## 2. GENERAL DESCRIPTION OF HERBICIDES AND THEIR EFFECTS ON PLANTS

### Types of Chemical Herbicides

The chemicals developed and used for killing plants could be grouped according to their method of action, chemical composition or degree of selectivity; but with any system of classification some herbicides would fall into more than one group, so that a broad description of the various types is more relevant than a concise classification.

#### (a) *Translocated, selective organic herbicides*

These herbicides rely for effect on their capacity to interfere with the plants enzyme or metabolic system. Most affect the plant tissue with which contact is first made and are then translocated through the stem. Because plant enzyme systems differ between groups of plants so does the effect of the chemical on the enzyme system; a herbicide which reacts with the metabolism of one plant group may have little or no effect on that of another group. It is this difference in reaction that gives the organic hormone herbicide a degree of selectivity.

Herbicides of the hormone type, especially 2,4-D (2,4-dichlorophenoxyacetic acid) and 2,4,5-T (2,4,5-trichlorophenoxyacetic acid) are the most commonly known and used in forestry.

#### (b) *Water soluble contact inorganic herbicides*

This group contains the water soluble chemicals which may be translocated, and kill the plant by reacting with and killing the cells with which they come in contact.

Because the chemical reactions of these herbicides are basically similar for all plants, they are relatively non-selective. A degree of selectivity might be gained where the lethal dosage varies considerably for two plants occurring on an area, but this cannot be used with any degree of safety.

The commonly used herbicides of this group include arsenic formulations (arsenic pentoxide and sodium arsenite), ammate (ammonium sulphamate) and sodium chlorate.

#### (c) *Oils*

A number of oils, because of their dissolution into the surface cells of the plant and their low surface tension, are able to smother the plant and prevent or limit respiration. These are non-translocated contact herbicides and include the aromatic hydrocarbons, diesel oil, kerosene and mineral spirits. Members of this group have been used as effective herbicides and are also frequently used as a carrier for one of the other groups.

#### (d) *Soil sterilants*

Chemicals of this group are absorbed into the plant and usually either the cells with which they come in contact are broken down structurally or the plant's metabolic processes are interrupted. The chemical is applied to the soil and remains active until either leached by water movement, broken down by bacterial or chemical action, or absorbed by a plant. Thus a herbicide of this group is able to kill not only existing vegetation but may prevent for a considerable time the establishment of any other vegetation on that site.

Some arsenic compounds are included in this group, together with the commonly used borate, urea and triazine compounds.

### 3. HERBICIDES OF IMPORTANCE IN FORESTRY

#### (a) Organic hormone formulations

##### (i) 2,4-D (2,4-dichlorophenoxyacetic acid)

The 2,4-dichlorophenoxyacetic acid is a relatively insoluble crystalline powder and as such is rarely prepared as an end-product and is not commercially used. However, a wide range of commonly used derivatives have been prepared from the acid, including 2,4-D sodium salt, amine salt and several esters. The concentration of the derivatives is usually expressed with reference to the 2,4-D acid; the term "acid equivalent" (a.e.) is used to define the amount of acid required to produce the salt or ester, and has become the accepted means of determining product concentrations.

Sodium salt is the cheapest and most commonly used form. It is highly selective but is the least toxic and so is suited for use on very susceptible species.

Amine salts are very selective and are more toxic than the sodium salt. The amine salts mix readily with water, wet foliage well, and are less affected by rain.

The 2,4-D esters are oil soluble derivatives of 2,4-D acid which form milky emulsions with water; of these the ethyl ester is the most used. The esters are the most toxic but least selective form of 2,4-D and as such are preferred for use on woody plants. They rapidly penetrate the foliage and are consequently only slightly affected by light rain soon after application.

More complex forms such as butoxy-ethanol-esters are available. These are usually similarly toxic but less volatile than the ethyl- or closely related butyl-ester and so are safer to use in the vicinity of susceptible crops. Most tree species are relatively resistant to 2, 4-D preparations and the low selectivity is not usually important under forest conditions.

##### (ii) 2,4,5-T (2,4,5-trichlorophenoxyacetic acid)

The 2,4, 5-T group is closely related to the 2,4-D group and is available in a similar range of salts and esters. It is generally more toxic than 2,4-D and is used in the control of woody plants and trees. Although the salts of 2,4,5-T acid have been prepared, and have been recommended for the treatment of hardwood stems, it is usually used as the butyl-ester, or the low volatile butoxy-ethanol ester.

Butyl-esters are soluble in oil and the use of a light oil as carrier or dilutant is usually recommended. This usually is an advantage in increasing the effect of low volume cut-stump, frill or basal bark techniques but undesirable side effects to operators may be encountered with high volume spraying.

Esters of 2,4,5-T have been blended with emulsifiers to produce an emulsified form which when mixed with water is suitable for foliar spray applications.

A water-in-oil or "invert" emulsion has also been prepared and recommended for use where the drift of spray particles must be limited.

Mixtures of 2,4-D and 2,4,5-T have been recommended and used effectively on many occasions, but for most forestry uses the application of either 2,4-D or 2,4,5-T alone will give the required result.

Most 2,4-D and 2,4,5-T preparations marketed today have wetting agents incorporated to lower the surface tension and ensure maximum coverage and penetration. These preparations can be diluted with water from most sources and the further addition of a wetting agent, unless specifically stated otherwise, is not required. When very hard water with a high calcium or magnesium ion content must be used a sequestering agent may prevent the formation of insoluble salts, but this adds to the cost of treatment.

Hormone herbicides have the advantage of being non-corrosive to metals, may be applied from a wide range of equipment and a relatively small quantity of undiluted material is required. Some disadvantages are associated with the need to choose an appropriate stage of plant development and, for some species, the appropriate weather conditions. The tendency for spray particles to drift can be a serious disadvantage and users should be aware of the damage that could be caused to farm crops, orchards, etc. adjoining treated land.

#### (b) Inorganic herbicides

##### (i) Ammate (*Ammonium Sulphamate*)

Ammate is a yellowish water-soluble crystalline compound which takes up water freely when exposed to air. It is normally used by placing the crystals on the cut stump or in a frill. The material is absorbed into the plant and kills cells with which it comes in contact. Ammate will kill most woody species but is non-toxic to man or animals. It can be applied as a foliage spray but is more costly than 2,4-D or 2,4,5-T and is usually used in the crystalline form on stems of species such as Brush Box which are relatively resistant to the hormone herbicides.

##### (ii) Arsenic Compounds

Few forest weeds are resistant to all of the other chemicals available so that only rarely will arsenic compounds need to be used. The poison hazard to both stock and operator is a real one which can most easily be overcome by using a safer chemical. However precautions can be taken which reduce the hazard and make tree poisoning with arsenic relatively safe. The operator should use gloves and cover exposed parts of the skin with grease or cream. Stock should be kept off sprayed areas and empty containers should be destroyed.

Sodium arsenite ( $\text{NaAsO}_2$ , usually with 54 per cent.  $\text{As}_2\text{O}_3$ ) is the form of arsenic most commonly used for weed poisoning. Arsenic pentoxide ( $\text{As}_2\text{O}_5$ ) has shown superior penetrating ability and is probably superior for the poisoning of tree species.

##### (iii) Sodium Chlorate

White crystalline sodium chlorate can be applied either in solution as a foliage spray or dry as a soil sterilant. It is a general herbicide although some selectivity is gained by the variation in application rate required to kill different species. There is a considerable fire risk associated with the use of sodium chlorate which has been reduced in some commercial preparations by the addition of calcium chloride.

*(iv) Boron Compounds*

Borax and the wide range of associated boron compounds now available are normally applied as non-selective soil sterilants, are slow acting and have little application to forestry field conditions.

*(v) Compounds of Urea*

A wide range of compounds of urea are marketed, primarily as soil sterilants. Some such as urea-bor. include both the urea and boron compounds for increased toxicity. Other types containing dimethylurea (e.g. Diuron) also have application where total vegetation control is required, but generally this group will be rarely used by foresters. One possible exception is Fenuron (3-(phenyl)-1, 1-dimethylurea) which has effectively killed individual woody stems when placed on the surface soil at the base of the stem in powder or pellet form.

#### 4. PRECAUTIONS IN HANDLING AND STORAGE

*(a) Hormone Herbicides*

None of the common 2,4-D or 2,4,5-T preparations are toxic to man or animals at the concentrations normally applied, and can be used without special precautions. However, like most organic compounds, if swallowed in quantity, or in an undiluted form, then serious illness or even death could result.

Cases of skin irritation have been reported when high volume spraying of 2,4,5-T has been carried out using diesel or kerosene as the carrier, but this is possibly entirely due to the carrier. No harmful effects should arise if hormone herbicides are used in a sensible manner. No damage to stock or other fauna should result if an empty spray tank is washed out into a running stream and humans could drink with safety water from a tanker which had previously contained spray solution, provided that it had been flushed through with clean water. However for obvious reasons herbicide spray equipment should be maintained for that single purpose only, whether hormone or arsenic is used.

Both 2,4-D and 2,4,5-T are toxic to most forms of plant life when in an undiluted form and care should be taken to ensure that seeds, fertilisers and other similar products do not become contaminated during storage.

Special precautions should be taken when containers are opened inside a close space where seeds and fertilisers might absorb the highly volatile fumes.

The hormone herbicides are artificially prepared compounds related to natural plant hormones and have no relationship to, or reactions similar to, animal or human hormones. No hormone controlled human processes are likely to be upset by the association with 2,4-D or 2,4,5-T.

Hormone herbicides are non-corrosive of metal, but as a rule containers should not be used for any other purpose.

**(b) Inorganic Herbicides**

The inorganic herbicides most commonly used under forest conditions are ammate and compounds of arsenic.

Neither ammate nor sodium arsenite are volatile, so can be used with relative safety in respect to adjacent crops. That arsenic is highly poisonous is well known and its compounds should only be used as a last resort and then with extreme caution. Wood from trees poisoned with sodium arsenite should not be used as fuel, because the fumes and smoke could be poisonous.

Ammate is relatively non-poisonous and may be handled with safety, but again it is a wise precaution to ensure that no opportunity exists for it to be consumed by humans or animals.

Both ammate and arsenite will corrode containers and equipment.

**5. METHODS OF APPLICATION**

Such factors as species composition, stem size and height growth, location and size of area all have a bearing on the economics of treatment and ultimately on the treatment method to be adopted.

Before considering the specific herbicide treatment to be used in particular cases it is of advantage to examine the four basic methods by which herbicides might be applied under forest conditions. These methods are:—

- (a) As a spray to the plant foliage.
- (b) In solution or solid form to the stem cut to expose the woody tissue.
- (c) As a spray to the basal section of the plant.
- (d) In solution or solid form to the soil at the base of the plant.

**(a) Foliage Spray Techniques**

The various techniques usually involve the application of a relatively high volume of spray solution under pressure to the foliage of the plant. In a broadcast application where both desirable and undesirable plants will be sprayed, a selective herbicide non-toxic to humans and animals is required. Any implement which will deposit a film of spray material over the foliage of the plant is suitable. Treatment should always be carried out on a calm day to minimise drift. It is important that adequate foliage has developed after a previous slashing treatment or fire, and also that treated stems are not cut or burnt until thoroughly dead.

**(i) Aerial applications**

Fixed wing aircraft or helicopters can be used economically to distribute spray solution where a large area is to be treated uniformly with a consistent concentration of material. Helicopters are preferred in some cases where the down draft is used to force the herbicide through the upper layer of foliage, but fixed wing aircraft have been used with success to spray and poison unwanted hardwood coppice and regrowth in areas cleared for conifer plantation or in young plantations.

For aerial application selective hormone weedicides are usually used as a low volume spray. Examples of effective aerial herbicide treatments include:—

- the reduction of lantana in Hoop Pine plantations using 2,4-D.
- the control of hardwood and wattle regrowth in young Southern Pine plantations using 2,4,5-T butyl ester in dieselene.

The cost of aerial treatment in N.S.W. has been in the order of £2 per acre for hire and fixed charges plus approximately £3 per acre for materials. These costs will vary considerably with the concentration and type of herbicide used and with the area sprayed, but illustrate that the techniques can be competitive with other methods of application.

The disadvantages of aerial spraying are the tendency for spray drift to increase with air currents and flight altitude, and the need to waste materials on small areas with low or nil weed population.

### (ii) *Mobile High Pressure Spray Equipment*

Mobile sprayers are useful where a high volume of herbicide is to be broadcast along a relatively level and firm surface.

Complete mobile spray units are marketed which can be fitted to trucks or tractors. Boom sprays have been mounted on farm tractors, turbine mist-blowers have been used either on or drawn behind tractors and trucks.

The costly problem of roadside weed control can be effectively handled with herbicide delivered from a pump powered by an auxiliary stationary engine and mounted on a truck. The Bedford Fire Fighter built to N.S.W. Forestry Commission design is ideally suited for the treatment of roadside vegetation. The construction of this unit with two live hose reels, a good working platform, sufficient height to obtain effective penetration and coverage of the foliage, and the high capacity easily filled tank lends itself to efficient herbicide application.

The speed of travel, pump pressure and type of nozzle used determine the volume of solution delivered. Using the standard fog nozzle on each hose at a pump pressure of 200 p.s.i. and with the vehicle moving at 4 m.p.h., approximately 100 gallons of solution is delivered per acre. This equivalent to a treated depth of 8 ft. on both sides of a forest road for one-half mile, and treated in one operation. Constant low speed can be maintained when an electric impulse tachometer is fitted to the vehicle.

The use of specially designed nozzles allow roadside spraying to be carried out at lower pump pressures; with suitable nozzles now being developed, pumps capable of a maximum 100 p.s.i. could be used in conjunction with trucks and portable tanks for most roadside weed control programmes.

### (iii) *Portable Spray Equipment*

Again, a variety of portable spray units can be adapted for herbicide application, but two types have been extensively used.

The misting machine has a light two-stroke petrol engine to produce a forced draught of air which sucks the herbicide through a venturi jet and then carries the atomised particles on to the plant. It is suitable for use on shrubs or trees up to about 8 ft. high and is well suited to areas where mobile equipment cannot be used. Misting machines are used extensively for the control of hardwood regrowth in pine plantations, along transmission line clearings, etc. and can also be used along roadsides from a moving vehicle.

The knapsack spray is also suitable for herbicide spraying to plant foliage, but is usually confined to small areas which might not warrant a more elaborate high pressure unit.

### (b) Frill or Cut-stem Techniques

Foliage spraying is simple, but is not always convenient or desirable. Woody stems can be killed by the direct application of a suitable herbicide to the plant stem. The stem is first either cut off or the bark is frilled to give access to the actively growing cells.

Ammate, arsenic compounds or hormone herbicides are commonly used. Because the chemical is given direct access to the growth tissue water soluble chemicals of the translocated type can be used, but there is little lateral movement of water solutions in a plant stem so the herbicide should be placed around the full circumference of larger trees. It is also important that the herbicide be applied immediately after the cut is made to avoid blockage of the cells by air pockets and subsequent poor absorption of the herbicide.

Ammate is often used in the crystalline form; after application ammate takes up water from the air and moves in solution into the cut surface.

Trees over about 4 in. d.b.h. are usually "frilled" by putting a series of contiguous cuts around the stem. The frill need not resemble a ringbarking, except for resistant species, but should be sufficient to ensure chemical penetration to the full circumference of cambial tissue. Smaller stems can be cut off, preferably to leave a dished or V-shaped stump which will hold the herbicide and ensure full penetration.

Whether the frill or cut stump treatment is used, it is important that the cut and herbicide be placed as low as possible to the ground to restrict coppicing, and that the herbicide be applied immediately after the cut has been made.

Species which tend to coppice strongly can be more completely killed by allowing the herbicide to fill the cut and then run down to cover the rest of the stump. All species should be treated at least to the point of run-off.

Water soluble herbicides may also be "injected" into the woody stem with an implement which in one action punctures the bark of the tree and then deposits a measured volume of herbicide. The injector method has not been used extensively in Australia, and probably holds little advantage over the more common methods of stem treatment. Herbicide may also be placed into holes drilled into the stem with a portable power drill, but again the advantages over more simple treatments would need to be proved.

For all cut-stem treatments it is profitable to add a dye to the herbicide solution so that treated stems will be readily apparent.

### (c) Basal Spray Techniques

Stems of susceptible species can be killed by the application of herbicides in a relatively concentrated form to the lower section of the stem. This is in fact a modification of the cut stem technique which relies upon the ready absorption of the herbicide through the bark tissue to the cambium. The herbicide can be sprayed at low pressure, poured from a can or painted with a brush onto the plant stem. Treatment of the bottom 2-3 ft. is usually sufficient to kill susceptible species but it is necessary to apply the solution to the point of run-off.

The oil soluble hormone herbicides, especially 2,4,5-T, may be used and light oil is an effective carrier and dilutant.

Basal bark spraying may be an effective alternative to cut-stem methods in the treatment of smaller (less than 4 in. diameter), thin barked stems. It has the advantage that axe work is not required, and where stem density restricts movement can be used in combination with the other methods.

Basal bark treatments should not be made during or immediately before bark shed.

### (d) Treatment of Soil Surfaces

Soil sterilants have been mentioned above for areas where total vegetation control is required for a considerable period. Except for the control of weeds around buildings, timber stacks, along fence lines, etc., these have little application in routine forestry management, but techniques are being developed where individual woody stems may be killed by the deposit of herbicide on the soil at the base of the stem.

Herbicides such as Monuron (3-p-chlorophenyl-1, 1 dimethylurea) and Fenuron (3-phenyl-1, 1-dimethylurea) have poisoned hardwood (*Quercus* spp.) trees up to 8 inches diameter when placed on the soil at the base of the tree (Peevy 1960). Fenuron has been effective in powder or pellet form when applied to the soil at the rate of 2 grams active ingredient per 4 inches of stem diameter.

These materials have not been proven in N.S.W. but may become useful for specific purposes.

## 6. TREATMENTS FOR SPECIFIC PURPOSES

### (a) Susceptible Eucalypt Regrowth, Coppice, etc.

Regrowth of native forest hardwoods may need to be controlled along roadsides, around huts and fire towers, in conifer plantations or in dense natural stands. Most Eucalypts are susceptible to 2, 4, 5-T and should be treated at the rates shown below until local results indicate that the concentration of herbicide should be varied.

Foliage spraying should be confined to stems less than 8 ft. high. The optimum size is about 2-3 ft. high and where stems consistently taller than 6 ft. are to be treated they should be either treated with a cut stem application, or slashed down and allowed to re-shoot to 2 ft. high when a foliar spray treatment can be used. However poor kills sometimes result when, because of repeated slashing, the total leaf surface area of the coppice is far less than that of the original stem and out of proportion to the supporting root system. Where practicable plants too tall for economic spraying should be treated by the cut stump method.

Aerial spraying:— 4 lb. a.e. 2,4,5-T ester in 4-6 gallons of water or distillate per acre.

Mobile power spray:— 0.5 per cent. a.e. 2,4,5-T ester\* in water applied at 100 gallons per acre (on roadside spraying this corresponds to a one-mile length of continuous spraying eight feet wide on one side of the road).

Misting machine:— 1-2 per cent. a.e. 2,4,5-T ester in water sprayed to wet thoroughly the foliage. In North Coast conifer plantations this treatment can be applied as a pre-planting spray to weed growth 2-3 ft. high or as a winter treatment in young plantations.

Knapsack:— 0.5 per cent. a.e. 2,4,5-T ester in water to wet foliage.

Cut-stem:— 2-4 per cent. a.e. 2,4,5-T ester in dieselene with Waxoline Red O.S. as marker at 1 teaspoon per 3 gallons, or 1-2 per cent. 2,4,5-T amine salt in water using Malachite Green as marker, applied to recently cut frill or stump. Apply solution from knapsack fitted with coarse tip and cut off valve or low pressure can. Except for basal bark applications a thin stream is preferable to a diffuse spray.

Time of Spraying:— Hardwood stems are killed by hormone herbicides applied during any season, but optimum results are obtained from applications made during the early summer months. Foliage spraying is most effective during December-February but if this is not practicable, e.g. in a young pine plantation when the desired species might also be affected, then a mid-winter treatment at slightly higher concentration should be made. Spraying during the initial spring flush of growth may cause rapid defoliation, resulting in poor hormone absorption and reduced kill.

#### **(b) Non-Susceptible Hardwood Regrowth**

Some native hardwood species are less susceptible to hormone weedicides. Brush Box and Turpentine are often resistant and, although some winter applications of 2,4,5-T ester in water have been successful, other treatment methods are usually required.

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\* See Appendix I for Dilution Table as guide to preparing hormone solution at required concentration.

When small (1-3 ft. high) these species can often be knocked back by a foliage spray but a more complete kill will be obtained by allowing the stem to grow to a size where a cut-stem application is feasible.

Cut-stem treatment:— apply ammate (ammonium sulphamate) crystals dry to the top of the cut stump, to frills or, in the case of larger trees, to the notches cut 4-6 in. apart around the base of the tree.

Apply sufficient crystals to cover the stump lightly, about 1 tablespoon per 2 in. diameter of stump. For bigger trees apply about 1 tablespoon per notch.

Where a clump of stems from a single root stock is to be treated it is sufficient to treat only those stems large enough to hold a dose of ammate crystals.

NOTE: It will often be necessary to treat a given area two or even three times for complete hardwood control. e.g. in Southern Pine plantations weed control could be carried out in three phases:—

- (i) pre-planting spray with 2 per cent. a.e. 2,4,5-T ester in water.
- (ii) cut-stem treatment with 4 per cent. a.e. 2,4,5-T ester in dieselene 12-24 months after planting to kill survivors from the spray treatment.
- (iii) cut-stem treatment with ammate to kill resistant stems.

### (c) *Lantana*

The speed with which *Lantana* encroaches onto roadways and cleared areas is well known. Control by slashing or mechanical clearing is both slow and expensive, while biological control methods are not yet available.

*Lantana* is most effectively controlled by a foliage spray application of 2,4-D amine salt, and better kills are obtained if the canes also are wetted.

*Lantana* responds very rapidly to foliar applications of 2,4-D esters to the extent that leaves are shed before absorption is completed and as a result extensive regrowth may occur. For this reason the less toxic water soluble 2, 4-D salts should be used.

Aerial application:— Aerial spraying might be only poorly effective because of the difficulty of wetting lower leaves and canes, but might reduce the total volume of weed to the extent that more intimate methods of control become practicable.

Apply 4 lb. a.e. 2,4-D amine salt in 20 gallons of water per acre.

Mobile high pressure spray application:— Apply 0.2—0.4 per cent. a.e. 2,4-D amine salt.

*Lantana* to 10 ft. high can be effectively treated from a fire fighter or truck. A spot spraying each 2-3 years is necessary or alternatively an overall treatment after two years can be used to increase the depth of penetration.

Portable spray application:— Apply 0.5 per cent. a.e. 2,4-D amine salt.

Time of spraying:— Best results have been obtained from late summer and early winter treatments. In warm coastal climates satisfactory results have been obtained by spraying during every season.

#### (d) Rainforest Species

Rainforest species are as a rule less susceptible to hormone control than other hardwoods. Roadside treatment can be reduced by mobile or portable spraying. Larger trees can be killed with stem treatments of hormone, ammate or arsenic. Some local trial will be required to determine minimum concentrations for particular species, but suggested rates are:—

For small stems up to 8 ft. high—apply 0.5 per cent. a.e., 2,4,5-T butyl ester in water, preferably as a high volume mobile spray treatment.

Stems up to 12 in. d.b.h.: fall or ring and apply ammate as crystal at 1 tablespoon per 2 in. stem diameter to frill or stump. Alternatively apply 5 per cent. a.e. 2,4,5-T butyl ester to stump or frill to point of run-off.

Stems over 12 in. d.b.h.: frill the stem and apply 10 per cent. a.e. 2,4,5-T to point of run-off or arsenic pentoxide diluted at 1 lb. per gallon of water.

All frill treatments should in fact approach a sap-ringbarking, especially for more resistant species. When hormone herbicides are used it might take two to three years before the stem eventually dies, but during this time it is probably not offering serious competition to the surrounding vegetation.

#### (e) *Callicoma*

*Callicoma* is a common pioneer species occurring along roadsides and other cleared areas in moist eucalypt forest and rainforest types. Effective control occasionally proves difficult but high volume foliar spraying with 0.5 per cent. a.e. 2,4,5-T ester during the summer and early autumn is usually adequate.

In moist coastal areas satisfactory results have been obtained with 0.5 per cent. a.e. 2,4-D amine salt.

#### (f) Wattle (*Acacia* spp.)

Wattle is particularly susceptible to 2,4,5-T formulations. Where it occurs amongst hardwood regrowth then treatment of the regrowth will also control the wattle. Where wattle occurs as a major component of the weed population, e.g. immediately after an area is cleared and burned, it can be effectively controlled at lower than normal application rates.

Foliage spray:— 0.2 per cent. a.e. 2,4,5-T ester in water will control wattle in young stages (up to 3 ft. high). Use 1 per cent. a.e. 2,4,5-T ester in water for control of well developed wattle stems.

**(g) Blackberry (and other *Rubus* spp.)**

Blackberry has been controlled effectively with either 2,4,5-T or mixtures of 2,4-D and 2,4,5-T. Considerable argument has been presented as to which is to be preferred, but it is now generally accepted that 2,4,5-T ester (butyl or butoxy-ethanol) will give the most effective and economic control.

The hormone can be applied aerially or by mobile or portable spray equipment. Preferably the chemical should be applied at relatively low pressure using a coarse spray.

Foliage spray:— Apply 0.075—0.1 per cent. a.e. (1 in 500 for 40 per cent. concentrate or 1 in 1,000 for 80 per cent. concentrate) 2,4,5-T ester, spray thoroughly to wet leaves and canes. At this rate one acre of Blackberry will require about 300 gallons of solution.

In cold climates or towards the end of the growing season slightly higher concentrations could be needed.

Time of spraying:— Blackberry should be sprayed during the season of active growth but after the initial burst of spring growth has been completed. The best period for spraying is January to March, but this may be extended a month on either side, especially in warmer climates.

NOTE: Some regrowth must be expected in large clumps and may be either grubbed out if the area is small or re-sprayed during the following January-March.

### ACKNOWLEDGEMENTS

The authors have drawn much of the information included in Sections 2 and 3 from "Weed Control with Chemicals" by K. R. Green and "Control of Brush and Undesirable Trees" by Arthur W. Sampson and Arnold M. Schultz. Reference has also been made to a number of other publications and these are listed below.

The results of experiments and routine use with herbicides carried out during the past few years by numerous officers within the N.S.W. Forestry Commission have been freely drawn upon. In particular the ready assistance of Mr. Bob Truman of the Division of Wood Technology, initially by way of advice in the planning of several trials and then by comment and criticism on this Note, is appreciated and readily acknowledged.

## REFERENCES

- GREEN, K. R. (1958). Weed Control with Chemicals. N.S.W. Dept. of Ag. Handbook.
- HENRY, N. B. (1961). Aerial Application of Herbicides for Control of Eucalypts and *Acacia* Spp. in Exotic Pine Plantation Establishment. Queensland For. Serv. Res. Note No. 9.
- PEEVY, Fred A. Basal Application of Herbicides for Control of Woody Plants. Reprinted from The Use of Chemicals in Southern Forests Ninth Annual Forestry Symposium, Louisiana State University.
- PEEVY, Fred A. (1960). Controlling Southern Weed Trees with Herbicides. Jour. of For. Vol. 58 No. 9.
- QUEENSLAND FORESTRY DEPARTMENT (1959). Control of Resistant Coppice in Plantations. Circular No. 1499.
- SAMPSON, A. W. and SCHULTZ, A. M. (1957). Control of Brush and Undesirable Trees III. Unasylva Vol. 10 No. 4.
- TERMINOLOGY COMMITTEE—WEED SOCIETY OF AMERICA (1958). Report. Weeds Vol. 6 No. 1.
- TIMBROL (Union Carbide). Brush Control with 2,4,5-T and 2,4-D. Technical Information Bulletin.
- TRUMAN, R. (1958). Tree Poisoning with 2,4-D and 2,4,5-T. N.S.W. For. Comm. Divn. of Wood Tech. Bulletin No. 2.

## APPENDIX I

## DILUTION TABLE FOR 2,4-D and 2,4,5-T CONCENTRATES

Per cent 2,4-D or 2,4,5-T acid equivalent (a.e.)	Add 1 pint concentrate to indicated volume of water to obtain desired concentration (a.e.) of solution.					
	0.1% a.e.	0.2% a.e.	0.5% a.e.	1% a.e.	2% a.e.	5% a.e.
	galls.	galls.	galls.	pts.	pts.	pts.
10	12.5	6.25	2.5	10	5	2
35	44	22	8.75	35	17.5	7
36	45	22.5	9.0	36	18	7.2
40	50	25	10	40	20	8
45	56	28	11.25	45	22.5	9
48.4	60	30	12.1	48.4	24.2	9.7
50	62.5	31.5	12.5	50	25	10
74	93	46.5	18.5	74	37	15
80	100	50	20	80	40	16
100				100	50	20

## APPENDIX II

## Report of the Terminology Committee—Weed Society of America

(Weeds. Vol. 6[1]1958)

## DEFINITIONS OF TERMS USED IN WEED CONTROL

Term	Definition
<i>Annual.</i>	A plant that completes its life cycle from seed in one year.
<i>Band application.</i>	An application of spray or dust to a continuous restricted area such as in or along a crop row rather than over the entire field area.
<i>Basal treatment.</i>	A woody plant treatment applied to the stems of plants at and just above the ground line.
<i>Bed.</i>	1. A narrow flat-topped ridge on which crops are grown with a furrow on each side for drainage of excess water. 2. An area in which seedlings or sprouts are grown before transplanting.
<i>Bed-up.</i>	To build up beds or ridges with a tillage implement.
<i>Biennial.</i>	A plant that completes its life cycle in two years. The first year it produces leaves and stores food. The second year it produces fruits and seeds.
<i>Broadcast application.</i>	An application of spray or dust over an entire area rather than in a band only on rows, beds, or middles.
<i>Blind cultivation.</i>	Cultivating before a planted crop emerges.
<i>Brush control.</i>	Control of woody plants.
<i>Carrier.</i>	The liquid or solid material added to a chemical or formulation to facilitate its field use.
<i>Compatible.</i>	Two compounds are said to be compatible when they can be mixed without affecting each other's properties.
<i>Concentration.</i>	Refers to amount of active material in a given volume of diluent. Recommendations and specifications for concentration of herbicides should be on the basis of pounds per unit volume of diluent.
<i>Contact herbicide.</i>	A herbicide that kills primarily by contact with plant tissue rather than as a result of translocation.
<i>Defoliant or defoliant.</i>	A compound which causes the leaves, or foliage, to drop from the plant.
<i>Diluent.</i>	Any liquid or solid material serving to dilute an active ingredient in the preparation of a formulation.

## APPENDIX II—continued

- Directed application.* An application of spray or dust to a restricted area such as a row, or bed at base of plants.
- Duckfoot cultivator.* A field cultivator equipped with small sweep shovels.
- Emulsifying agent.* A surface active material which facilitates the suspension of one liquid in another.
- Emulsion.* The suspension of one liquid as minute globules in another liquid; for example, oil dispersed in water.
- Epinasty.* The twisting or curling of leaves and stems caused by a differential rate of growth of cells. (A state of growing in leaves in which the upper surface grows faster than the lower surface and thus causes the leaf edges to curve down).
- Growth stage of cereal crops.*
- (1) Tillering stage—when a plant produces additional shoots from a single crown.
  - (2) Jointing stage—when the internodes of the stem are elongating.
  - (3) Boot stage—when the seed head of a plant begins to swell and emerge from the sheath.
- Herbaceous.* A plant that does not develop woody tissue.
- Herbicide.* A phytotoxic chemical used for killing or inhibiting the growth of plants.
- Miscible.* Two or more liquids which, when mixed together, form a uniform mix.
- Perennial.* A plant that lives for more than two years.
- Noxious weed.* A weed arbitrarily defined by law as being especially undesirable, troublesome, and difficult to control. Definition of the term "noxious weed" will vary according to legal interpretations.
- Phytotoxic.* A substance toxic to plants.
- Post-emergence treatment.* Any treatment made after the crop plants emerge.
- Pre-emergence treatment.* Any treatment made after a crop is planted but before it emerges.
- (1) *Contact pre-emergence.* An application made after weed emergence.
  - (2) *Residual pre-emergence.* An application which kills weeds as the seed germinates or as they emerge either before or after the crop has emerged.
- Pre-planting treatment.* Any treatment made before the crop is planted.
- Rate and Dosage.* These terms are synonymous. "Rate" is the preferred term. Rate usually refers to the amount of active ingredient material (such as 2, 4-D acid equivalent) applied to a unit area (such as one acre) regardless of percentage of chemical in the carrier.
- Selective herbicide.* A compound that is more toxic to one plant than to another.
- Soil sterilant.* A herbicide that prevents the growth of plants when applied to the soil. Soil sterilization effects may be temporary or relatively permanent.
- Spray drift.* The movement of airborne spray particles from the intended contact area to adjacent areas.
- Surfactant.* A material which facilitates, and accentuates the emulsifying, dispersing, spreading, wetting, and other surface-modifying properties of herbicide formulations.
- Suspension.* A system consisting of very finely divided solid particles dispersed in a solid, liquid or gas.
- Synergism.* Cooperative action of different agencies such that the total effect is greater than the sum of the two effects working independently.
- Systemic herbicide.* A phytotoxic compound is translocated within the plant.
- Vapor drift.* The movement of herbicidal vapors from the area of application to adjacent areas.
- Volatile.* A compound is said to be volatile when it evaporates, or vaporizes (changes from a liquid to a gas) at ordinary temperatures on exposure to the air.

APPENDIX II—*continued*

*Wetting agent.* A compound which when added to a spray mixture causes it to contact plant surfaces more thoroughly.

*Weed.* A plant growing where it is not desired.

*Crop.* A plant growing where it is desired.

*Weed eradication.* The complete elimination of all live plants, plant parts, and seeds of a weed infestation from an area.

*Weed control.* The process of inhibiting weed growth and limiting weed infestations so that crops can be grown profitably or other operations can be conducted efficiently.

## RESEARCH NOTES—

- No. 1. Field Identification of Seedlings of the Major Tree Species in the Blackbutt and Flooded Gum Areas .. .. . A. G. FLOYD, 1958.
- No. 2. Investigations in Sowing of Flooded Gum .. .. . A. G. FLOYD, 1960.
- No. 3. N.S.W. Rainforest Trees. Part 1: Family Lauraceae.  
A. G. FLOYD and H. C. HAYES, 1960.
- No. 4. Raising and Planting of Flooded Gum .. .. . G. N. BAUR, 1959.
- No. 5. Nursery Spacing and Grading of Slash Pine Seedlings.  
G. N. BAUR, 1960.
- No. 6. The Effects of Low Pruning on Increment in Radiata Pine Plantation  
K. R. SHEPHERD, 1961.
- No. 7. N.S.W. Rainforest trees. Part 2: Families Capparidaceae, Exalloniaceae,  
Pittosporaceae, Cunoniaceae, Davidsoniaceae.  
A. G. FLOYD and H. C. HAYES, 1961.
- No. 8. Forest Vegetation in Northeastern New South Wales.  
G. N. BAUR, 1962.
- No. 9. Silvicultural Practices in Rainforest of Northern N.S.W.  
G. N. BAUR, 1962.
- No. 10. Investigations into the Natural Regeneration of Blackbutt (*Eucalyptus pulularis*) .. .. . A. G. FLOYD, 1962.
- No. 11. Entomological Research on the Cause of Mortalities of *Eucalyptus saligna* (Sydney Blue Gum) .. .. . K. M. MOORE, 1962.
- No. 12. Insect Attack on *Pinus* spp. .. .. . K. M. MOORE, 1962.
- No. 13. The Cypress Pine Sawfly Subspecies: *Zenarge turneri turneri* and *Zt. rabus*  
K. M. MOORE, 1963.
- No. 14. The Effect of Pretreatment on Germination of Slash Pine Seed.  
W. G. FORREST, 1964.
- No. 15. Relationship of Vessel Diameter to Lyctus Susceptibility in some N.S.W. Hardwoods .. .. . R. K. BAMBER and RUTH ERSKINE (in press).

**PAPERS FOR BRITISH COMMONWEALTH FORESTRY CONFERENCES—****7th CONFERENCE (Australia and New Zealand)—**

Forest Utilisation—Less Valuable Species.

L. S. HUDSON and P. T. COOKE, 1957.

Timber Sales Policy and Procedure ..

R. J. RITCHIE, 1957.

Defoliation of Alpine Ash (*Eucalyptus delegatensis*) by Phasmids.

K. R. SHEPHERD, 1957.

Principal Exotic Forest Trees in N.S.W.———, 1957.

**8th CONFERENCE (East Africa)—**The application of Basal Area Control to thinning of *Pinus radiata* Plantations in New South Wales.

S. W. GENTLE, J. L. HENRY and K. R. SHEPHERD, 1962.

**TECHNICAL PAPERS—**

(This series contains limited numbers of papers, primarily intended for distribution within the Forestry Commission).

No. 1. Seminar on Management of Low Site Quality Plantations. Moss Vale \_\_\_\_\_, 1963.

No. 2. Observations on the Growth of Coachwood (*Ceratopetalum apetalum*) in a Selection Forest .. .. . G. N. BAUR, 1963.

No. 3. Seminar on Economics of Forestry, conducted by A. J. Leslie. Bathurst \_\_\_\_\_, 1963.

No. 4. Pre-emergent Weedicides in Forest Nurseries, Green Hills State Forest P. A. CASTMIR, 1963.

\*No. 5. Future of Rainforest in N.S.W. .. .. . G. N. BAUR, 1964.

\*No. 6. Forestry as an Economic Form of Land Use .. W. D. MUIR, 1964.

No. 7. Germination Test Methods for Tree Seeds .. A. G. FLOYD, 1964.

**OTHER PUBLICATIONS—**

Climatological Basis of Forestry .. W. A. W. DE BEUZEVILLE, 1943.

Forest Resources, Regions and Trees of N.S.W. .. \_\_\_\_\_, 1965.

Watershed Management in the United States of America. K. M. GRAY, 1958.

A. Contribution towards a Watershed Management Research Programme for the Hunter Valley, N.S.W. .. .. . K. M. GRAY, 1959.

Log Extraction by Crawler Tractor. A report of Logging Operations in Eastern New South Wales .. .. . C. H. GRUGEON, 1961.

(Also various publications on forest products issued by the Division of Wood Technology, Forestry Commission of N.S.W.)

\* Papers out of print.