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Preservation of regrowth marri fence posts using non-pressure techniques

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Contents

Summary

Regrowth jarrah (*Eucalyptus marginata* Donn ex Sm.) and marri (*E. calophylla* R. Br. ex Lindl.) stands growing on private land or in State Forest are often well stocked with saplings and poles. Thinning these stands will increase tree growth and water yield in high rainfall areas and create a large volume of wood for utilisation. Fence posts and strainers are products that can be produced from thinnings. Treating the sapwood with a water-borne or oil-borne preservative is necessary to create a protective envelope around the impermeable heartwood, which gives far greater durability to the timber.

In this study, a 30 year old regrowth marri stand was thinned to a basal area of between 10 and 12 m^2/ha. Thinning material suitable for posts were treated on-site with high temperature creosote (HTC) using either the hot and cold bath method or cold soaking for butts and cold soaking crowns, and using green, partially dry or dry posts. A sample of 30 posts was given the alternative treatment of copper-chrome-arsenic (CCA) by vacuum/pressure impregnation. Green posts treated by cold soaking or hot and cold bath indicated poor retentions, and dry posts had better penetrations and retentions than partially dry posts when treated by the hot and cold bath method. High moisture contents in the sapwood would have restricted HTC uptakes. Although the hot and cold bath method is more effective and quicker (12 to 18 h compared with 12 to 15 days), cold soaking dry posts is an option that needs further investigation.

Costs based on preservative uptake are given and an economic analysis of producing 250 posts, indicated it would cost $2.50 to produce a treated 100 mm small end diameter under bark (s.e.d.u.b) fence post using on-farm treatment methods. On-farm treatment methods and equipment are straight forward, although reasonable care and safety procedures are required to ensure best results. Handling equipment is not essential, but can be used to advantage, particularly with large posts and strainers. Regular assessments of the posts in-service will indicate the durability and performance.

Introduction

Many landowners could use small diameter trees on their properties for fence posts, but the sapwood of such posts would be destroyed in a few years by decay and insects. This problem can be overcome in most timbers by using preservatives to impregnate the sapwood, creating a protective envelope around the impermeable heartwood and giving most timbers a far greater durability. In many cases service life can be extended to 30 years or more. Most hardwood timber species are suitable for preservative treatment, provided that the sapwood band has not split or been damaged by powder post borers (*Lyctus* spp.) before treatment, and is at least 12 mm thick (Anon. 1980).

Strength and durability are the two major properties of timber. Sapwood is far more susceptible to fungal and insect attack than heartwood, owing mainly to its higher starch content. Heartwood contains extractives which are toxic or act as a deterrent to fungi and insects, and its vessels are blocked by tyloses which impede fungal growth. This increases durability but makes the heartwood impenetrable to chemical preservatives. The sapwood vessels are not blocked and therefore can be penetrated by preservatives.

When using young regrowth trees for fencing rounds, irrespective of heartwood durability, it is essential to utilise the sapwood because it can provide more than half the strength to posts (Tamblyn 1978). Brennan (1988) estimated that the sapwood of regrowth jarrah (*Eucalyptus marginata* Donn ex Sm.) with diameters of 150 mm under bark, contributes nearly 60 per cent of the strength.

Structural tests on round wooden posts, split wooden posts, steel posts and concrete posts showed that round posts were twice as strong as split posts of similar cross-sectional area, when similar loads were applied at the same height above ground (Johnstone 1966). Small round posts given proper treatment will be as strong as and last as long as split posts, irrespective of the timber used (CSIRO 1961).

The service life of a fence post is determined by species durability, by whether the sapwood is treated with preservative, and by the biological hazard. Natural durability ratings refer to the relative resistance of the outer heartwood of different timber species to decay and insect attack when used in-ground contact under climatic conditions approximating the average of Australian capital cities.

In the eastern wheatbelt region of Western Australia, fencing timbers have now been replaced by steel posts, however in the south-west, split or round wooden posts are still used. Split posts have traditionally come from mature trees. There are large areas of regrowth jarrah and marri (*E. calophylla* R.Br. ex Lindl.) forest on private land in the south-west and in State Forest, which are well stocked with saplings and poles. Overstocked regrowth stands often experience decline in vigour and diameter growth (Podger 1959; Abbott and Loneragan 1983), and large volumes of small regrowth trees are available for utilisation.

Future fencing material will come from small diameter regrowth trees, rather than split posts from mature trees. In addition it may be possible to increase water yield in high rainfall areas as well as timber production by thinning these regrowth stands.

Fence posts can be treated with oil-borne or water-borne preservatives. Wood preservative oils are resistant to leaching/weathering and are suitable for applications to wood which is to be used in-ground contact. Paintability, odour, appearance and combustibility of treated wood are influenced by the residual oils. High temperature creosote (HTC) was used in this trial to treat regrowth marri posts because:

i) it has a very long and satisfactory service record world-wide (e.g. Australia, Europe, South Africa, U.S.A. and United Kingdom) under a wide variety of conditions (Greaves 1986);

ii) it provides protection against surface weathering and reduced likelihood of splitting and checking. Bleeding of oil into freshly opened checks, helps to prevent decay in the untreated heartwood (Johanson and Da Costa 1963);

iii) it is non-toxic to livestock and to humans but highly effective against wood-destroying fungi and termites. Because it is composed of a wide variety of fungitoxic components, the danger of treated poles being colonised by highly tolerant fungi is minimised (Johanson and Da Costa 1963).

Solutions with tar, distillate or mineral oil in creosote are alternatives which can reduce chemical costs, for example, a 60:40 mixture of creosote and furnace oil.

Water-borne preservatives include a wide range of chemicals. The most successful and widely used is copper-chrome-arsenic (CCA), which is used as a permanent (fixed) treatment for both hardwoods and softwoods against all biological hazards (decay, insects and marine borers). CCA is available only to licensed commercial treatment plants.

A 30 year old regrowth marri stand growing on Gail and Bob Joyce's Collie farm, (Wellington location 2137) was thinned in January 1992, to a basal area of between 10 and 12 m^2/ha. Thinning material suitable for posts were treated on site with HTC using on-farm methods and placed in service to assess long term durability. The hot and cold bath and cold soaking methods developed by the CSIRO Division of Forest Products in the 1950s and 1960s were used to treat the butt and crown ends respectively. This report discusses preserving fence posts with HTC, using these on-farm techniques.

Materials and methods

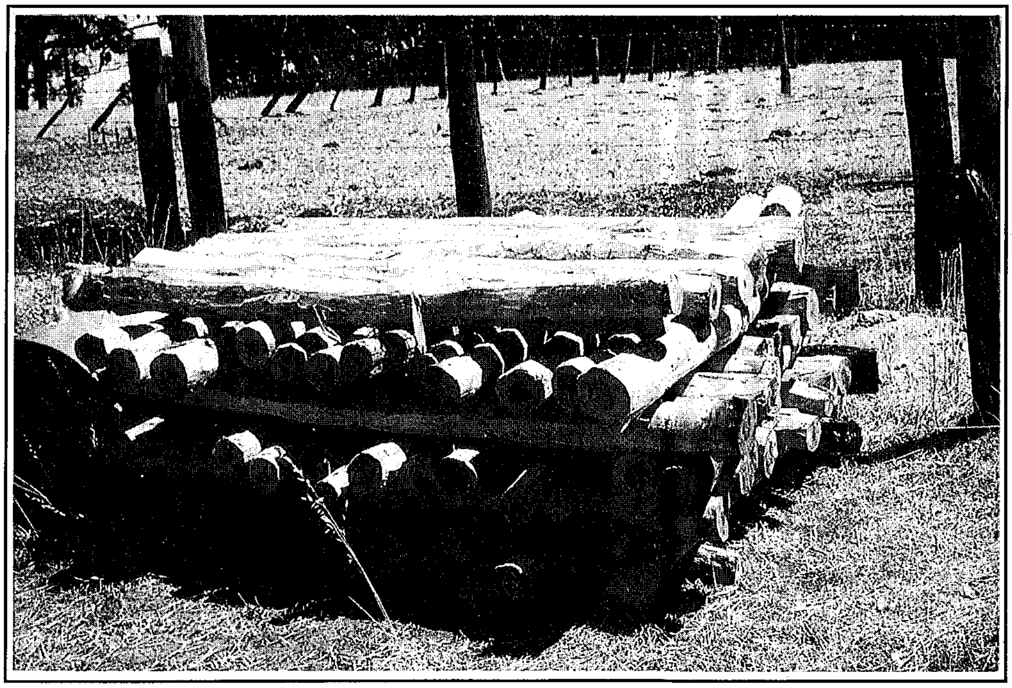
Tree marking and falling

Before thinning, crop trees were marked for retention to a basal area of between 10 and 12 m^2/ha. Unmarked trees suitable for posts and strainers were felled, docked to 1.8 m and manually debarked by axe. Posts were to be treated either green, partially dry (i.e. sapwood moisture contents between 40 and 50 per cent) or dry (i.e. sapwood moisture contents below fibre saturation point (f.s.p.) of approximately 25 per cent). Posts that were to be treated dry were taken to an area exposed to prevailing winds and stacked in rows, with each row having posts at 90° to the preceding row.

Manual debarking is labour intensive, therefore a sample of 30 posts was used to determine the drying time of posts with bark on, and to assess any problems when posts are dried to below f.s.p. before debarking. This will be discussed separately.

Basic density and initial moisture contents

Sample discs (40 mm thick) were cut from 17 regrowth marri posts, wrapped in plastic and delivered to the Wood Utilisation Research Centre (WURC) in Harvey. A radial strip (50 mm x 75 to 100 mm) was cut from each disc using a wood working bandsaw. This radial specimen (40 mm thick) was measured with calipers to 0.01 mm and initial mass determined using digital scales to an accuracy of 0.001 g, and then oven-dried to constant weight. Basic density (BD) was calculated by:



Posts stacked for drying. Note each row is at 90° to preceding row

$$\text{basic density (kg/m}^3) = \frac{\text{oven-dry mass}}{\text{green volume}}$$

and initial moisture content
(based on oven-dry weight) by:

$$\text{M.C. (\%)} = \frac{\text{green mass} - \text{oven-dry mass}}{\text{oven-dry mass})} \times 100$$

Mean basic density was used in converting creosote retentions from percentage mass/mass (m/m) to kg/m^3 by:

$$\text{Creosote retention (kg/m}^3) = \%\ \text{m/m} \times \frac{\text{BD}}{100}$$

Air-dry density is used in Australian Standard AS 1604–1993 (Standards Australia 1993) because the preservation industry is familiar with that parameter, but basic density, which is technically correct, is used in this report.

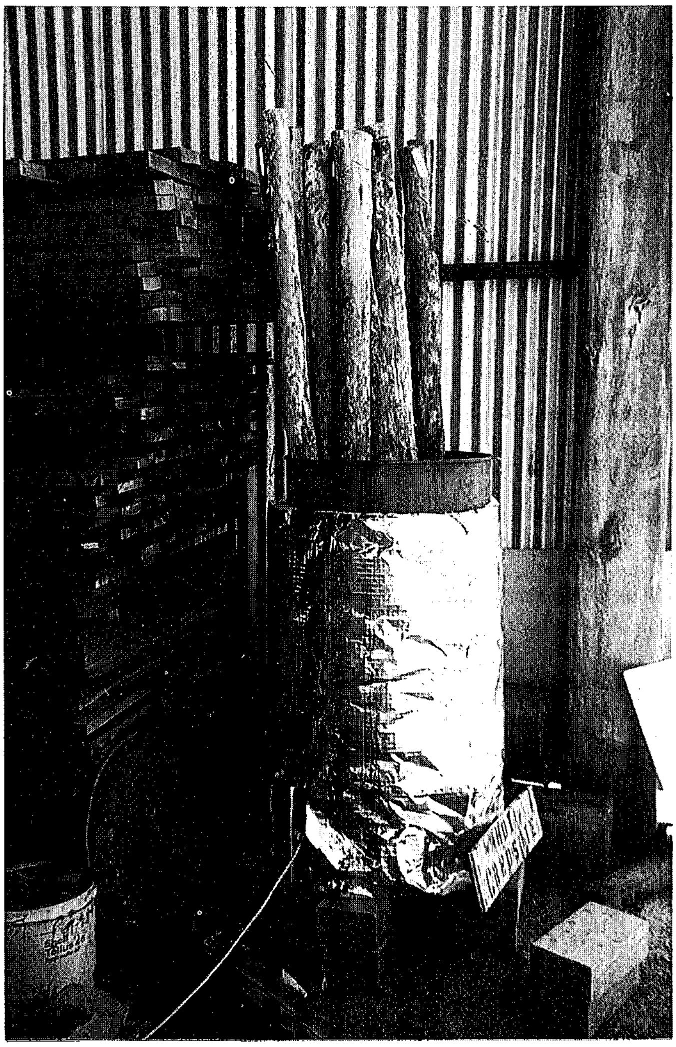
Treatment methods

The CSIRO (1961) recommended a minimum creosote retention of posts used in-ground contact of butt end 160 kg/m^3 and crown end 48 to 64 kg/m^3. A charge retention of 99 kg/m^3 is required for hardwood posts treated to Hazard Level 4, according to AS 1604 - 1993 (Standards Australia 1993). The density of creosote is 1.095 kg/L at 20°C, therefore the recommended liquid uptake for the butt is 146 L/m^3 and crown 44 L/m^3 to 58 L/m^3.

Sapwood volume of individual posts was determined by subtracting the cross sectional area of the post from the cross sectional area of heartwood, and multiplying the difference by the lengths. The volume of sapwood for a batch of posts was estimated by summing the individual post sapwood volumes. Creosote can penetrate the sapwood only when using non-pressure methods, and retentions are based on sapwood volume.

Two methods developed by CSIRO for on-farm treatment of fence posts, are hot and cold bath and cold soaking. Hot and cold bath treatment involves heating the posts in steam, hot water or liquid preservative to drive out most of the air, followed by cooling in preservative, and is recommended for treating butts where higher retentions are required. During cooling, atmospheric pressure assists capillary forces in moving the liquid to replace the air driven out by the initial heating. Heating is best done using steam coils or low temperature electric elements in insulated tanks. Although 205 L drums over an open fire have been used, creosote is flammable and use of an open fire is not recommended. Where time is not critical e.g. in an overnight treatment, it may be expedient to reheat the preservative to 5°C higher than the initial heating temperature the next day to drive off surplus liquid, and to improve surface cleanliness. This is known as an expansion bath, and up to 40 per cent of the HTC can be recovered (Tangye 1974). Temperature in the expansion bath can be controlled by a thermostat installed in the base plate, and monitored by a multimeter or thermometer.

Cold soaking involves soaking the butt or crown ends of the posts in creosote or other oil until they absorb the required volume of preservative, and is suitable for dry radiata pine and low density eucalypt posts. Light crown treatments can be achieved in several days using the cold soaking method. Posts were treated with creosote using the hot and cold bath method or cold soaking for butts and cold soaking crowns, using green, partially dry or dry posts (Appendix 1). A sample of thirty posts was dried to a moisture content below 30 per cent, and taken to Kopper's treatment plant in Picton for vacuum/pressure treatment with copper-chrome-arsenic (CCA) to an oxide retention of 10 kg/m^3, suitable for Hazard Level 4 (H4) conditions. To suit Koppers' current operations, treatment was done in two stages, one with pine posts to a retention of 6.8 kg/m^3,



Batch of posts in the extended 205 L drum, with insulation blanket. Heat by single phase electricity into oil element in base of drum.

and the other with another charge of pine posts to give a total oxide retention of 14.6 kg/m^3. Standard practice would involve treating the posts to the required retention in one operation instead of re-drying between treatments.

CCA is now only available to registered commercial treatment plants. Strict environmental and health standards for the storage and use of CCA can make approval for a new commercial treatment plant expensive and time consuming. This option is not recommended for farmers, although a portable low pressure cylinder for treating posts with creosote has been used by the CSIRO in the past (Moglia 1954 and 1956).

Equipment used for hot and cold bath and cold soaking methods

The following equipment was used for treating 1.8 m posts with creosote:

- a 205 L drum for butt treatment (760 mm) and an extended drum (1300 mm) to treat the crowns.
- draining troughs made by cutting a drum (205 L) in half lengthwise.
- leaning rails for the posts standing in the draining troughs.
- electric base hot plate with a thermostat to control temperature and a multimeter or thermometer to monitor temperature.
- insulation to wrap around the treatment vessel e.g. R 2.0 batts.
- steel mesh or a metal grid cut to fit the base of the drum, to elevate the posts off the bottom of the drum and allow creosote to readily penetrate the ends of the posts.
- temporary roofing should also be erected over the treatment drums in wet weather, as water in oil preservatives is likely to cause sludging and to interfere with penetration.
- dip stick with a lineal tape attached for measuring change in creosote levels.
- miscellaneous equipment including a measuring jug, a thermometer or multimeter and safety wear of full length clothing, gloves, shoes and hat and UV barrier cream for applying to exposed skin.

When cold soaking posts the base hot plate was removed.

Treatment schedules

In this trial, posts treated by the hot and cold bath method were heated for 3 to 4 hours in HTC to a temperature of between 100°C and 114°C (depending on the schedule), held at that temperature for one hour, and then cooled overnight in the same drum. To increase daily production, posts can be transferred to another drum of cold preservative to cool .

Before placing the posts in the treatment drum, a third of the drum was filled with creosote, then posts were measured, added to the treatment drum and the creosote level increased to enable the butt section (760 mm) to be treated. It was important to ensure that the creosote level was 100 mm to 125 mm below the top of the drum, because creosote expands when heated and this can cause spillage. The depth of creosote is recorded before and after treatment at similar temperatures, with and without posts immersed, to estimate the amount of creosote absorbed into the posts. An estimated drop in the level of creosote of 100 mm to 110 mm for the butt and a drop of 45 mm to 50 mm for the crowns was used as a guide to achieving the correct retentions.

Posts were removed from the treatment drums and placed in the drainage troughs to allow any excess creosote to exude from the posts and collect in the troughs, then the volume of this excess was measured and it was returned to the treatment drum. This volume was subtracted from the HTC uptake, as calculated from the drop in creosote level within the treatment drum. A test post from each batch was cross cut at the butt and at 300 mm, 600 mm and 760 mm from the butt to visually assess creosote penetration and distribution. These sections were then split longitudinally to view the radial penetration, and photographs were taken of transverse and radial sections. In some batches the sapwood was incompletely treated and further treatment was required.

After nine batches, the accumulated bark and sludge in the base of the treatment drum, which was restricting creosote uptake, had to be removed before subsequent batches were treated. Before treating Batches 10, 11, 12 and 13, the creosote was agitated to prevent any sludging.

Chemical analysis

Two 20 mm diameter cores were taken from the groundline position (760 mm from the butt) of six CCA-treated marri posts for chemical analysis by the Chemistry and Wood Preservation Laboratory of the Queensland Forest Service. Arsenic, copper, chromium, and total element retentions (in per cent mass/mass and kg/m^3) and depth of penetration were determined. Two sample cores taken 600 mm from the butt of similar creosote-treated posts (three posts from each batch) were also chemically analysed. Creosote retentions in per cent mass/mass and kg/m^3 and depth of preservative penetration were determined. Analysis for both CCA and creosote was done according to AS 1605 - 1974 (Standards Association of Australia 1974). The creosote retentions were compared to the retentions estimated from the drop in creosote level measured for each batch.

Results and discussion

Basic density and initial moisture content

Mean basic density of 30 year old regrowth marri estimated in this trial was 570 kg/m^3, standard error 17.7 kg/m^3 and range 429 to 669 kg/m^3. Kingston and Risdon (1961) quoted a mean basic density of 663 kg/m^3

for mature marri, but no standard deviation or range was given. The variation could be explained by the fact that some samples were taken from the crown, resulting in lower densities than the published figures.

Mean initial moisture contents taken at the time of falling were 91.4 per cent, standard error 3.8 per cent and range 70.9 to 129.7 per cent. Posts treated green would have had moisture contents similar to those measured at the time of falling.

Butt and crown retentions

Table 1 lists mean small end diameter under bark (s.e.d.u.b.), sapwood and log volume per batch and number of posts that were treated in each treatment batch. Change in the number and size of posts treated did not affect sapwood and log volume estimates for each batch. Regression analysis indicated good correlations between sapwood, log volumes, and number of posts with s.e.d.u.b., for batches of posts, with correlation co-efficients of 0.89, 0.80 and 0.95 respectively. These equations were used to predict the number of posts per batch, sapwood volume and expected HTC uptake from s.e.d.u.b. for butt, crown and full length (Table 2).

Table 1. S.e.d.u.b., sapwood volume, log volume and number of posts in each treatment batch

Batch	S.e.d.u.b. (cm) volume (m^3)		Sapwood (m^3)	Log volume per batch	No of posts
	Mean	S.D.			
1	8.0	1.1	0.20	0.22	21
2	7.1	1.1	0.21	0.22	27
3	10.3	1.3	0.20	0.25	15
4	9.3	1.9	0.18	0.22	15
5	8.8	1.6	0.19	0.23	18
7	9.7	1.7	0.17	0.22	14
8	12.7	1.1	0.18	0.25	10
9	13.0	1.2	0.16	0.20	9
10	12.5	1.1	0.19	0.26	10
11	14.2	1.0	0.18	0.25	8
12	11.2	1.6	0.20	0.25	17
13	8.4	1.7	0.19	0.24	20
Mean	10.6	1.5	0.19	0.23	15

Note: Batch 6 was excluded from the results owing to insufficient data.

When a farmer treating his own posts has measured the mean s.e.d.u.b., then the number of posts that can be treated in a batch, sapwood volume and estimated HTC uptakes can be read from Table 2. For example, if the mean s.e.d.u.b. of a batch of posts is 10.0 cm, the estimated number of posts in that batch is 15, sapwood volume is 0.2 m^3 and expected HTC uptake of creosote for the butt, crown and full length is 12.3 L, 6.5 L and 18.8 L respectively.

Chemical analysis – CCA vacuum/pressure impregnation

Australian Standard AS 1604 - 1993 requires a minimum of 0.70 per cent mass/mass retention of total CCA active elements for Hazard Level 4 which is equivalent to 19 kg/m^3 (salt) or 11.2 kg/m^3 (oxide). For Hazard Level 5 a minimum retention of 1.2 per cent mass/mass (equivalent to 32 kg/m^3 (salt) or 19.2 kg/m^3 (oxide)) is required. The

Table 2. Predicted number of posts, sapwood and log volume from s.e.d.u.b. and the expected uptake of HTC when treating butts to retentions of 160 kg/m3 and crowns to retentions of 56 kg/m3

Mean s.e.d.u.b. (cm)	No of posts per batch	Log volume per batch	Sapwood volume per batch	Butt expected uptake (L)	Crown expected uptake (L)	Total expected uptake (L)
7.0	22	0.17	0.16	9.8	4.7	14.5
8.0	20	0.22	0.19	11.6	6.2	17.8
9.0	18	0.25	0.20	12.3	6.5	18.8
10.0	15	0.25	0.20	12.3	6.5	18.8
11.0	13	0.26	0.19	11.6	6.2	17.8
12.0	11	0.25	0.18	11.0	5.8	16.8
13.0	9	0.24	0.17	10.4	5.5	15.9
14.0	7	0.20	0.14	8.6	4.5	13.1
Mean	14.4	0.23	0.18	11.0	5.7	16.7

- Butt treatment is the bottom 760 mm and crown treatment the remaining 1040 mm in each post.
- Retentions of 160 kg/m3 and 56 kg/m3 for butt and crown respectively are recommended by CSIRO.
- Retention in kg/m3 is converted to L/m3 by dividing by the density of creosote (1.095 kg/L at 20°C).

overall charge retention was 14.6 kg/m^3 (oxide) and the mean retention for the sample cores was 1.14 per cent mass/mass. All samples passed the retention and penetration requirements for Hazard Level 4 and half passed the retention requirement for Hazard Level 5.

Chemical analysis – HTC treatment

Results of chemical analysis are listed in Table 3. Samples were taken 600 mm from the butts because the ground line position is at greatest risk from insect and fungal attack. Treatment batches were combined into the following groups:

- hot and cold bath – green posts
- cold soaking – green posts
- hot and cold bath – partially dry posts (sapwood moisture contents 40 to 50 per cent)
- hot and cold bath – dry posts (sapwood moisture contents below 25 per cent).

Samples taken from the posts cold soaked green (Batches 2, 4 and 5) had nine samples sent for analysis, but only three had sufficient creosote for analysis. The mean creosote retention of the three samples analysed was 4.7 per cent mass/mass, but with only 29 per cent of sapwood fully penetrated. This retention is below that required by AS 1604–1993, which requires a minimum creosote retention of 10 per cent mass/mass or 99 kg/m^3 for hardwoods treated to Hazard Level 4 (i.e. for placing in or resting on the soil in a moderate decay and termite hazard) (Standards Australia 1993).

High moisture contents within the sapwood would have restricted HTC uptakes. Batch 2 had been soaking for 14 days and Batches 4 and 5 for 21 days, therefore it is unlikely that retentions would improve by extending the soaking time.

Posts treated green (Batch 1) or dry (Batches 10, 11, 12 and 13) by the hot and cold bath method produced higher retentions and penetrations than posts treated partially dry (Batches 7 and 8), but all passed the Hazard Level 4 requirements. Batches 6 and 9 were not assessed by chemical analysis, because Batch 6 had limited field data and posts in Batch 9 were difficult to treat owing to a build up of bark and sludge in the base of the drum which restricted HTC uptake. Four sample cores from Batch 3 and one sample from Batch 1 had insufficient creosote for analysis. Owing to the inconsistent penetrations and

Table 3. Depth of creosote penetration and retentions of regrowth marri posts, as determined by chemical analysis of butt samples

Treatment	Batch No.	Mean creosote penetration (% sapwood treated)		Mean creosote retention	
		Fully treated	Partially treated	% m/m	kg/m^3
Hot and cold bath – green posts	1 (3)	75	92	18.8	107.4
Cold soaking	4 and 5 (3)	29	76	4.7	26.7
– green postsHot and Cold bath – partial dried posts (mc 40 - 50%)	7 and 8 (6)	23	73	10.8	61.9
Hot and cold bath – dry posts (m.c. below f.s.p.)	10, 11,12 and 13 (12)	84	100	25.4	145.1

Notes:
- All samples from Batches 2 and 3, one sample from Batches 1 and 4 and two samples from Batch 5 had insufficient creosote for analysis.
- Samples from Batches 6 and 9 were not sent for analysis.
- Figures in brackets are the number of samples analysed.
- Per cent mass/mass is converted to kg/m3 using a basic density of 570 kg/m3 and using the formula:

$$\text{piece retention (kg/m3)} = (\text{\% total elements}) \times \frac{\text{density}}{100}$$

- AS1604 - 1993 uses the air-dry density of spotted gum (Euca*lyptus maculata* Hook.) i.e. 988 kg/m^3, for hardwoods.

retentions in the sample cores from Batches 1 and 3, treating green posts using the hot and cold bath method is not recommended.

Posts treated partially dry (Batches 7 and 8) had a mean retention of 10.8 per cent mass/mass, and despite having two posts with retentions below the minimum requirement of 10 per cent mass/mass, overall they passed the minimum requirement of AS 1604-1993. The problem of sludge and bark accumulation in the base of the treatment drum, observed in Batch 9, would also have been experienced to a lesser extent in Batches 7 and 8, restricting the uptake of HTC into the posts. Moisture in the cells would also have restricted preservative uptake.

Posts used in Batches 10, 11, 12 and 13 were dried to below f.s.p. by initial air drying in the summer, then final drying for about six weeks in a solar kiln at W.U.R.C. Minimal drying degrade (i.e. surface checks and end splits) resulted, and all posts were considered suitable for rural fencing. A mean retention of 25.4 per cent mass/mass and a range of 3.3 to 58.0 per cent mass/mass was determined by chemical analysis. Two samples failed the AS 1604–1993 requirement.

Dry posts treated by the hot and cold bath method had greater retentions and penetrations than green posts, treated by either hot and cold bath or cold soaking methods. Although the hot and cold bath method is more effective and quicker than cold soaking (12 to 18 hours compared with 12 to 15 days), cold soaking dry posts is an option that needs further investigation.

Table 4 summarises the creosote uptakes and retentions in the posts, based on the measured drop in creosote levels with post immersed, for both butt and crown ends.

Based on the retentions calculated from the chemically analysed butt samples, and using a recommended retention of 160 kg/m^3 (146 L/m^3), an uptake of 27.7 L is required for treating the butts of a batch of marri posts which is equivalent to a drop in creosote level (with butts immersed) of 218 mm.

Crown retentions had a good correlation with drop in creosote with posts immersed. Using the CSIRO (1961) recommended crown retention of 48 to 64 kg/m^3 or 44 to 58 L/m^3, an uptake of 5 L to 7 L is required, which is a drop in level with crowns immersed of 39 mm to 52 mm. Total

Table 4. Creosote uptakes for butt and crowns based on drop in the creosote level (with posts immersed)

	Butt				Crown		
Batch no.	Creosote uptake (L)	Drop in creosote level with posts immersed (mm)	Calculated sapwood retention (kg/m^3)	Chemical analysis sapwood retention (kg/m^3)	Creosote uptake (L)	Drop in creosote level with posts immersed (mm)	Calculated sapwood retention (kg/m^3)
1	23.3	200	294.1	107.4	15.45	115	145.9
2	7.6	70	94.4	ID	7.2	55	64.7
3	26.1	–	340.2	ID	10.7	85	101.0
4	11.2	95	162.3	37.3	8.0	60	83.9
5	19.7	–	270.4	16.2	7.2	60	71.9
7	13.7	110	210.1	71.4	7.2	65	79.9
8	14.4	140	208.6	52.3	5.8	55	60.9
9	25.5	180	415.6	NS	10.7	75	126.3
10	15.5	140	212.6	83.3	–	–	–
11	12.3	65	178.2	142.8	–	–	–
12	17.05	132	222.3	127.7	7.75	43	73.2
13	16.1	147	220.9	227.3	9.15	75	90.9

ID = Insufficient data
NS = Not sent to Queensland for analysis

Notes:
- Chemical analysis based on butt samples.
- When converting from L/m3 to kg/m3 multiply by the density of creosote (1.095 kg/L at 20°C).
- Batch 12 had the butts re-treated because of poor initial uptakes.
- A basic density of 570 kg/m3was used to convert retention in per cent mass/mass to kg/m^3 .

uptake for the full length would be 32.7 L to 34.7 L. A batch of posts with a mean s.e.d.u.b. of 100 mm, i.e approximately 15 posts in the treatment drum, would require 2.2 to 2.3 L/post.

Errors in estimating HTC retentions

Errors in estimating the change in the creosote levels while treating Batches 1 to 10 could have been caused by rain entering the drums or spillage. Creosote expands when heated, and in the initial batches the creosote level before heating was only about 25 mm below the drum top, and HTC could have expanded and spilt over. The good correlations between the creosote level drop for crown treatments and retentions indicated negligible effects from spillage. Both the drop in creosote with posts immersed and chemical analysis methods for determining creosote retentions have errors. Measuring the drop in the HTC with posts immersed requires reading a dip-stick to the nearest millimetre, but owing to the large surface area of the treatment drum a difference of one millimetre leads to inaccuracies. The data indicated that measurements need to be taken at similar temperatures because of creosote expansion at different temperatures. Inaccuracies can occur in determining log and sapwood volume, because generally the boundary between sapwood and heartwood is very difficult to see in light coloured timber species such as marri. Chemical analysis was based on sampling three posts per batch and the retention for the butt section was determined by two small 20 mm diameter cores taken at one position. The results of analysis of retention at that position would be accurate but provide only an indication of the whole butt section.

The mass gain method is more accurate because individual posts are weighed before and after treatment, and any weight gain is the result of preservative uptake. This method of determining HTC retentions is recommended for future trials.

An alternative method of determining HTC uptake

An alternative method to the drop in creosote with the posts immersed for determining preservative uptake is the 'top-up method' described by CSIRO (1955) which involves:

a) Estimating the amount of preservative that a batch of posts should absorb during butt or crown treatment (based on sapwood volume).

b) Measuring this quantity of preservative into a container.

c) Marking on a dip-stick the level of the preservative in the drum at the beginning of the butt treatment (use a metal dip-stick because the creosote will be absorbed into a dry wooden stick, leading to errors).

d) Ensuring the level is approximately 775 mm (which is above the critical level of 760 mm), but at least 75 mm below the top of the drum, to allow for expansion when heated.

e) As the treatment proceeds add measured quantities of creosote from the container to the drum, bringing the level back to the original.

f) When all the preservative from the container has been used, treatment is complete.

The 'top-up method' allows the creosote level to be maintained at a set level and ensures that no untreated gaps occur. However, regular attention is required during treatment, particularly if using the hot and cold bath method.

Costs

High temperature creosote is manufactured by Koppers - Hickson Timber Protection Pty Ltd in the eastern States and costs $176.20 for a 205 L drum (ex Sydney). Transport to the south-west of Western Australia increases the cost to $241.70/drum or $1.18/L based on purchasing a pallet of four drums (October 1993 prices). It is more economical to purchase a pallet of drums because average transport costs are lower than for individual drums. Based on the limited number of posts treated in this trial, and using the CSIRO recommended uptakes of 146 L/m^3 (butt) and 51 L/m^3 (crown) and average size of post of 100 mm s.e.d.u.b. (i.e. 15 posts per batch), an uptake of 33.7 L would be required or 2.25 L/post i.e. $2.66/post. If smaller posts for electric fences are used e.g. 70 mm s.e.d.u.b. (i.e. 22 posts per batch) an uptake of 33.7 L is required, at a cost of $1.81 a post.

Using the AS 1604-1993 minimum retention of 99 kg/m^3 for Hazard Level 4 (91.3 L/m^3), 17.3 L/batch is required for the butts, and with the CSIRO (1961) recommended crown retentions of 5 to 6 L/batch, the full length uptake would be 22.3 to 24.3 L/batch. If the average size post treated is 100 mm s.e.d.u.b. (15 posts per batch) the cost would be $1.75 to $1.91/post. Treating smaller posts for electric fences the cost per post is reduced to $1.20 to $1.30/post. These costs are for preservative treatment only, and exclude harvesting, debarking, equipment, posts (if not readily available to the land owner) and labour costs.

In 1961, the CSIRO Division of Forest Products found the cost of creosote for an average 100 mm diameter post was equivalent to $0.10/post based on $18 per 205 L drum. Using the October 1993 price given above, and based on the equivalent 1961 price of HTC it would cost $1.34/post for creosote. In a large scale production the cost of treating posts today could be reduced to as low as $1.30/post. CCA treated pine posts can be purchased from local hardware outlets for $4.58 (75–95 mm s.e.d.u.b.) to $9.58 (125–145 mm s.e.d.u.b.), and strainers $13.11 to $17.22, based on purchasing a pack of posts.

The cost of posts is usually only about one-quarter of the total cost of a fence, so it is economical to install the best posts available to increase the fence life (CSIRO 1961). Unlike split posts, round timbers treated with preservative last for many years before decay or termite attack becomes a problem, so retain their full strength longer than split posts. The outer sapwood layer of a post contributes most of its strength, so if this layer is treated, posts will have a longer service life. Consequently the posts can be much smaller without reducing the life of the fence. Posts cut on farms, or obtained cheaply from local sources, form the ideal basis for economic treatment.

An economic analysis of this trial, in which 250 posts were produced, indicated that it would cost \$2.50 to produce a treated 100 mm s.e.d.u.b. fence post using on-farm treatment methods. This cost included the use of a tractor, truck, chainsaw, treatment equipment (hot plate, drums and safety wear) and HTC. In addition, each post had a labour component of 24 minutes i.e. 15 minutes for felling, trimming, debarking and stacking and 9 minutes for treating and final stacking. Compared with costs of purchasing alternative posts e.g. 1.65 m steel star pickets at \$3.50 for black or \$4.70 for galvanised, there is a saving of between \$1.00 and \$2.20 per post. In addition, treated wooden posts have an expected life, in ground contact, of 50 years, compared with 15 years for steel posts and less in salt affected soils. Using standard net present value (NPV) techniques and a discount rate of 8 per cent, the cash saving of preparing and treating fence posts on farms would be \$7.50 per post location compared with the cost of steel posts over a 50 year time period. At the estimated 24 minutes to cut and prepare each post, this equates to \$18.75 per hour spent on this activity by the land owner. Provided land owners do not have another activity that can yield higher returns than a net \$18.75 per hour, it will benefit land owners to obtain and treat their own fence posts from trees growing on their properties (Longson 1993).

Koppers Australia in Picton W.A. charge \$160/m^3 (\$95/m^3 for treatment and \$65/m^3 for debarking and preparation) to treat pine fence posts with copper-chrome-arsenic (CCA) to a retention of 7 kg/m^3 (oxide) which is to Hazard Level 4. Two other south-west treatment plants, located at Bridgetown (Timber Treaters) and Mundijong (Bunnings Forest Products) have similar prices. Using a commercial treatment plant, the land owner would have the additional cost of harvesting and transport to and from the plant.

'Do-it-yourself' treatment procedures and equipment are straight forward, although reasonable care and safety procedures are required to ensure best results. Unless many posts are needed in a short time, treatment can often be scheduled between other jobs. Handling equipment is not essential, but can be used to advantage, particularly on large posts and strainers.

Durability in-service

Regular assessments, initially every one to two years for the first five years, then every three to five years, will determine the in-service performance of the marri posts treated in this trial and installed on the Joyce property. This will allow a comparison between the posts treated with creosote using on-farm techniques, and CCA treated posts commercially treated by vacuum/pressure impregnation.

The overall post condition, whether it is still servicable and the reason/s for any post failures will be recorded. Assessment will be done by manually pushing each post, with the assessor maintaining a uniform loading. A close inspection of the posts below ground line, after scraping away the soil, will indicate the presence of any fungal or insect attack. Any damage to the exposed section of the post from weathering or mechanical damage will also be recorded.

Tasmanian blue gum (*Eucalyptus globulus* Labill subsp. *globulus*), maritime pine (*Pinus pinaster* Ait.) and radiata pine (*P. radiata* D. Don) fence posts have been treated with HTC or pigment emulsified creosote (PEC) in other trials and will be reported separately. These posts have been placed in-service, and regular assessments on their overall condition will determine performance.

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Appendix 1

Treatment schedules for posts treated green (Batches 1, 2, 3, 4, 5 and 6), partially dry (Batches 7 and 8) and dry (Batches 9, 10, 11, 12 and 13)

Batch 1.	Green posts	- mean moisture content 91.4 per cent.
	Butt treatment	- Hot and Cold bath.
		- heat creosote to 100°C with posts immersed (approx 7.5 h).
		- hold the temperature 93 - 100°C for 2 h.
		- cool overnight for approx 12 h to 60°C.

Poor treatment was observed, because of high sapwood moisture contents, therefore the batch was re-treated.

	Re-treat butts	- heat creosote to 110°C (post immersed) (approx 5.5 h).
		- hold the temperature at approx. 110°C for 1 h.
		- cool overnight for approx. 12 h to 60°C.
	Crown treatment	- cold soaking for 9 days.
Batch 2.	Mean moisture content	- 91.4 per cent.
	Butt treatment	- cold soaking for 16 days.
	Crown treatment	- cold soaking for 7 days
Batch 3.	Butt treatment	- hot and cold bath.
		- heat creosote and posts to 110°C.
		- hold temperature at 108 - 110°C for 2 h.
		- overnight cool for approx. 12 h to 66°C.
	Crown treatment	- cold soaking for 6 days.
Batch 4.	23 days air-drying before treatment.	
	Butt treatment	- cold soaking for 21 days.
	Crown treatment	- cold soaking for 11 days.
Batch 5.	23 days air-drying before treatment.	
	Butt treatment	- cold soaking for 21 days.
	crown treatment	- cold soaking for 11 days.
Batch 6.	49 days air drying before treatment.	
	Butt treatment	- cold soaking for 10 days.
	Crown treatment	- cold soaking for 7 days.

This batch contained only half the required number of posts for a full charge, therefore results are not included.

Batch 7.	60 days air drying before treatment.	
	M.C. between 40 and 50 per cent.	
	Butt treatment	- hot and cold bath.
		- heat creosote and posts to 110°C approx. 4 h.
		- 3 days at 110°C.
		- cool overnight for 12 h.
	Crown treatment	- cold soaking for 12 days.

Batch 8. 63 days air-drying before treatment.
M.C. between 40 and 50 per cent.
Butt treatment - hot and cold bath.
- heat creosote and posts to 110°C (approx. 2 h).
- cool for 4 days.
Crown treatment - cold soaking for 9 days.

Batch 9. 68 days air-drying before treatment.
M.C. between 40 and 50 per cent.
Butt treatment - hot and cold bath
- heat creosote and posts to 100°C (5 h).
- hold temperature at 100°C for 1 h.
- overnight cool of 12 h.

Re-treat butt - heat creosote and posts to 114°C.
- hold temperature at 114°C for 1 h.
- cool overnight for 12 h.
- repeat this cycle.

Poor penetration in the initial run required two retreatments for the butts.
Crown treatment - cold soaking for 6 days.

Batch 10. 99 days air and kiln drying.
Average M.C. 25.7 per cent, sapwood of all posts below f.s.p.
Butt treatment - hot and cold bath.
- heat creosote and posts to 110°C.
- hold temperature at 110°C for 1 h.
- cool overnight for 12 h.
- 4 days soaking after cooling.
Crown treatment - cold soaking.

Batch 11. 105 days air and kiln drying.
Average M.C. 30.3 per cent, sapwood of two posts above f.s.p.
Butt treatment - heat creosote and posts to 114°C.
- hold temperature at 114°C for 1 h.
- cool overnight for 12 h.
- 4 days soaking after cooling.
Crown treatment - cold soaking for 16 days.

Batch 12. Average moisture content below 25 per cent.
Butt treatment - heat creosote and posts to 100°C (approx. 4 h).
- hold temperature at 100 -110°C for 1 h.
- cool overnight for 17 h.

Poor penetration of HTC occurred above 600 mm from the butt so a retreatment was required.
Retreat butt - heat creosote to 100°C (approx. 5 h).
- hold temperature between 100 and 110°C for 1 h.
- cool over the weekend (3 days).
Crown treatment - cold soaking for 4 days.

Batch 13. Average moisture content 22.9 per cent.
Butt treatment - heat creosote and posts to 100°C (approx. 2 h).
- hold temperature at 100 - 105°C for 1 h.
- cool overnight for 18 h.
Crown treatment - cold soak for 2 days.