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FORESTRY COMMISSION OF N.S.W.

RESEARCH NOTE No. 45

Sydney 1981

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SYDNEY, 1981

95136F–1

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This Paper was originally reported as Technical Paper No. 31 (1978)

Further extensive and detailed work prevented publication in that series, which has now been discontinued.

Australian National Library
ISSN 0085-3984
ISBN 0 7240 6263 7

INTRODUCTION

The chemical constituents of forest tree foliage have been routinely determined for diagnostic and nutrient assessment purposes for many years. There is very little information, on the chemical composition of wood and bark (the major products from forests). A detailed knowledge of the nature and distribution of the inorganic constituents in trees is required to estimate the nutrient contents of forest ecosystems and the nutrient changes which may arise from management procedures such as logging or burning. Further, data are required on differences between species and between sites to allow for extrapolation on a broader scale and this type of information can also be useful when considering plant ecological relationships and environmental problems. The emphasis in the present paper is on this latter aspect.

Previous studies of wood and bark chemical analyses can be grouped into several categories which include the determination of nutrient losses in logging, the study of plant/soil relationships, and the detailed examination of one or two species in relation to ecosystem studies. One other category involves special interest studies such as the monitoring of lead in tree rings or the selection of bark for a root potting medium. A brief survey of typical results from these types of studies reported in the literature has been presented below.

Ecosystem Studies

Projects concerned with ecosystem analysis have mainly been carried out in northern latitude temperate forests. In many of these studies, nutrient concentrations have been determined for stemwood only (Ovington, 1959, Young, 1971, Wood *et al.*, 1977, Bartos and Johnston, 1978) rather than for the individual components, sapwood and heartwood. However changes in concentrations of chemical elements for different positions on the tree radius have also been reported.

Aspen trees from three different clones in two areas were analysed for nitrogen, phosphorus, potassium, calcium, sodium, magnesium, zinc, and iron (Bartos and Johnston, 1978). For all elements, the bark contained higher nutrient concentrations than the bole.

Phosphorus, nitrogen, potassium, calcium, magnesium, and sodium were determined in the wood and bark of trees of various ages of Scots and Corsican pine (*Pinus sylvestris* and *P. nigra* var. *calabrica*) Wright and Will, 1958). In the bark of Corsican pine all nutrients except sodium increased in concentration with increasing tree age but this was not apparent in Scots pine. There were differences in bark nutrient concentrations between the species, with all six nutrients being higher in Scots pine, even though the two species were growing on similar soils. Phosphorus and potassium decreased and calcium increased from the outer sapwood into the heartwood of *P. radiata, P. taeda* and *P. sylvestris* except for the growth rings immediately surrounding the heartwood where phosphorus and potassium increased and calcium decreased (Wright and Will 1958, Orman and Will, 1960). In *P. taeda,* there was an increase in calcium, sodium, magnesium, and potassium from the cambium to the pith (McMillin, 1970). White *et al.* (1972) studied the pattern and magnitude of seasonal fluctuations in the concentrations of eleven elements in the inner bark of loblolly pine (*P. taeda*) growing on three soil types. This study was undertaken because the inner bark of loblolly pine is the host for a number of beetles which are completely dependent on it for food. Most elements reached maximum concentrations in the fall and minimum concentrations in the spring.

Nutrient Losses in Harvesting

In North America, a large volume of work has been carried out on nutrient element concentrations in tree components, particularly on species such as Douglas-fir. For example Heilman and Gessel (1963) found that nitrogen fertilization increased the nitrogen concentrations in the bark but not appreciably in the wood. There was some effect of site but it was relatively low. Cole *et al.* (1968) presented data on nitrogen, phosphorus, potassium and calcium concentrations in bark, current wood and older wood for a range of ten size classes. The separation into individual wood components in all these studies was only sufficient to obtain an estimate of the variation and allow a reasonable estimate of the standing nutrient content in the stands. Harada (1970) found in a study on the effects of fertilization on *Cryptomeria japonica,* that there were differences between bark, sapwood and heartwood and that fertilization changed the nutrient concentrations in both the bark and sapwood but not the heartwood. Some small variation was found between sites for the nutrients so that the within species variation even over a range of sites was not as great as the between species variation (Harada *et al.,* 1972).

In a study of nutrient element concentrations (nitrogen, phosphorus, calcium, magnesium, potassium, and zinc) in an intensively cultured American Sycamore plantation, nitrogen fertilizer treatments resulted in increased nitrogen concentrations in bolewood and bolebark (Wood *et al.,* 1977). Preliminary tables of results for twelve elements (g/ tree) for a single tree from each of seven species in Maine, U.S.A. were reported by Young *et al.* (1965) to give estimations of the amounts of chemical elements removed in complete tree and merchantable bole harvesting operations in terms of five height classes and ten diameter classes.

Orman and Will (1960) have assessed nutrient losses for nitrogen, phosphorus, potassium, and calcium concentrations in bark and different components of the wood of New Zealand grown *P. radiata.* There was some vertical variation in these nutrients and this will be discussed elsewhere. Variation within the species (between trees) appeared to be fairly low. Madgwick *et al.* (1977) studied eight *P. radiata* stands ranging in age from 2 to 22 years to characterize nutrient contents of the above-ground portions of intensively managed *P. radiata* on a good site in New Zealand as a basis for studying the ecological impact and economic limits of continuous forest production. The nutrient concentrations of nitrogen, phosphorus, potassium, magnesium, sodium, and zinc in stemwood and bark tended to decrease with tree age. The reverse, however, was the case for calcium and manganese.

Miller *et al.* (1980) using values for nutrient concentrations, prepared data giving the weights of nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, manganese, and copper that would be removed in harvesting any component. The concentrations of nitrogen, phosphorus, potassium and magnesium in fertilized trees increased with increasing growth rate, whereas calcium decreased.

The weight and proportion of bark and wood are determined in studies which estimate the quantities of nutrients in trees or on a per unit area basis. For example in *P. radiata,* Orman and Will (1960) found that bark constituted 13 per cent of the stem. Under Australian conditions, various species have been assessed for their proportions of bark to wood particularly since these estimates are required for pulping processes. In the case of trees ranging in age from 8 to 12 years, the bark accounted for 10 per cent of the stem of *Acacia dealbata, Eucalyptus globulus* and *E. regnans,* while for *E. delegatensis* and *E.obliqua* the bark was 11.4 and 21.9 per cent of the stem respectively (Sibley *et al.,* 1976). Attiwill

(1972) reported that the bark was 16 per cent of the stem volume for 52-year-old *E. obliqua.* Young (1971) reported percentages ranging from 14 to 25 for a variety of North American tree species. He also indicated that because of the higher concentrations of nutrients in the bark than the wood, removal of the bark at logging removed a larger quantity of nutrients. Even though the bark may only be 25 per cent of the stem weight, it may contain nearly 70 per cent of the stem nutrients.

Ecological Relationships

Ecological relationships in trees have been studied using wood nutrient contents—for example, relationships between nutrient concentrations and wood durability, and between nutrient concentrations and efficiency of nutrient utilization by trees. Ellis (1959, 1965) studied Grand fir and found that nutrient content varied with site and that there was a relationship between decayed and non-decayed trees and nutrient concentrations. In Australia, interest has centred on relationships between species and soil characteristics. Beadle and White (1968) discussed the nutrients (phosphorus, calcium, potassium, magnesium, and sodium) in the bark and wood of fifteen Australian tree species from four major habitats. Marked differences especially in phosphorus were found between species. The within species variation was very much less than the variation between species. The rainforest species had the highest nutrient concentrations and this was supported by Beadle (1968). The nutrient redistribution from heartwood to sapwood, especially for phosphorus, also varied. McColl and Humphreys (1967) found there were significant differences in the concentrations of phosphorus, calcium, magnesium, potassium, and sodium in the bark of *E. maculata* and *E. gummifera. E. maculata* was higher in every nutrient except for sodium.

Wardell and Hart (1973) studied radial gradients of certain elements in ray tissue and non-ray tissue of White Oak (*Quercus alba*) from the cambium to the pith. Levels of calcium, magnesium, and manganese were constant across the sapwood with a significant decrease observed at the sapwood/heartwood boundary. Higher levels of phosphorus, potassium, and magnesium occurred in ray tissue of the sapwood than in non-ray tissue, but in heartwood both tissue types contained similar levels of these elements. These results were consistent with those of Merrill and Cowling (1966) who had previously suggested, with particular reference to nitrogen, that this retrieval and recycling of elements essential for plant growth (nitrogen, phosphorus, calcium, magnesium, potassium and sulphur) may provide trees with a survival and competitive advantage.

Special Interest Studies

Special interest studies on wood nutrient contents vary, but because of the long-lived nature of trees and storage of certain nutrients in wood rings, some interest has centred on the use of tree ring analysis as an indication of element accumulation or increase in pollutants. This is especially true for lead for which this method has been quite successful (Szopa *et al.,* 1973, Lepp, 1975). Other problems include specific accumulations of elements, such as silica, in timbers in relation to timber identification, marine borer resistance and problems of utilization. Amos (1952) tabulated silica concentrations in more than 400 siliceous timbers belonging to 32 botanical families.

At the technological level, wood ash has been used as a glaze material in pottery since antiquity and can lend a quality to glazes which is difficult to obtain with other materials (Rhodes, 1958). Some of the major constituents of wood

ash, such as the oxides of aluminium, silicon, potassium, and calcium are particularly useful in this respect, with potash having the added virtue of being a useful flux. It has been recognized for a long time that ash from different species varies widely in composition and potters have relied upon experimentation with different ashes to obtain different effects. In the Australian context the complexity of the ecosystem results in a very great number of tree species which grow in a wide range of locations. A knowledge of relative differences in the inorganic constituents of various tree species provides a basis for more reliable results.

Aims of Present Paper

The present paper primarily reports a survey of nutrient concentrations in the wood and bark of the major forest tree species in N.S.W. to enable comparisons to be made between species. Samples were separated into bark, sapwood, and heartwood to indicate variation in tissues within a tree and were taken from a range of locations. Nutrient concentrations with respect to tree age (*E. pilularis*) and position along tree stem (*P. radiata*) were also evaluated.

MATERIALS AND METHODS

1. General Survey

A range of major N.S.W. species were selected for sampling from a number of sites. In order to include a wide range of locations, separate samples (in most cases) were taken from various Forestry Districts in N.S.W. In each case, a disc about 5.0 cm thick was cut from the base of a mature butt log. In addition, bark samples from a number of species which had been selected for an ecosystem study in a State Forest north of Batemans Bay, N.S.W. were included together with samples from other parts of Australia and the world. After air-drying, the bark, sapwood, and heartwood were separated from the complete disc or if the disc had been taken from a very large diameter tree, a segment of a complete cross-section was taken and the components then separated. Each sample was finally ground (20 mesh) and stored in a polystyrene jar.

2. Effect of tree age—Eucalyptus pilularis

Twelve 5-year-old trees from an *E. pilularis* plantation in the Taree Forestry District, and twelve 30-year-old trees of the same species from a stand naturally regenerated after a fire, and located nearby, were sampled and separated into sapwood and heartwood components. In this case the bark was discarded. Details of these trees have been described by Bamber and Curtin (1974).

3. Effect of position along tree stem—Pinus radiata

Complete discs (5.0 cm thichness) were taken at 120 cm intervals along the stem of a mature *P. radiata* tree (34-year-old) from Cumberland State Forest (to give a total of 20 discs). After air-drying, the outer bark, inner bark, sapwood, and heartwood were separated from each disc for sample preparation and storage as previously described. In addition, a *P. radiata* disc was obtained from each of six Forestry Districts and separated for analysis in the same way as the other species in the general survey.

4. Chemical Analysis

Solutions of the samples were obtained by a dry ashing procedure (Lambert, 1976a). The various elements were determined using chemical procedures detailed by Lambert (1976b). Phosphorus was determined using a colorimetric procedure which involves reduction of the phosphomolybdate complex by ascorbic acid. A ferron colorimetric procedure was used for the estimation of aluminium. Nitrogen was determined on a separate sample by a micro-Kjeldahl procedure. Total sulphur was precipitated with barium from a separate solution prepared by dry ashing, and calculated indirectly after estimation of the barium concentration by atomic absorption spectrophotometry. Boron was determined by a carmine method and chloride potentiometrically by titration with silver nitrate. The other elements were determined by atomic absorption spectrophotometry on the solution prepared by dry ashing.

RESULTS AND DISCUSSION

1. General Survey

(a) Eucalyptus

The results for the various eucalypt species (Table 1—subgenus *Corymbia*; Table 2—subgenus *Monocalyptus*; Table 3—subgenus *Symphyomyrtus*) have shown that, even though the study did not specifically set out to test any hypothesis, certain generalized attributes appear to be distinguishable.

In almost every case where bark, sapwood and heartwood from the same tree were analysed, bark had a higher ash content than sapwood which was in turn higher than heartwood. For *E. globoidea* and *E. sieberi*, some bark samples had about the same ash levels as the sapwood. Heartwood samples of *E. dalrympleana, E. fibrosa, E. woolsiana* and *E. melliodora* gave ash yields as high as those for their sapwood.

Decorticating barks had very much higher ash levels than fibrous stringybarks. For example, the ranges of bark ash levels for *E. maculosa* and *E. saligna* were 6.00–12.70% and 6.66–10.47% respectively, while those for *E. globoidea* and *E. muellerana* were 0.50–1.34% and 0.78–1.18% respectively. Persistent barks, such as ironbarks, gave intermediate values (e.g. 4.97–6.02% ash in the bark of *E. paniculata*).

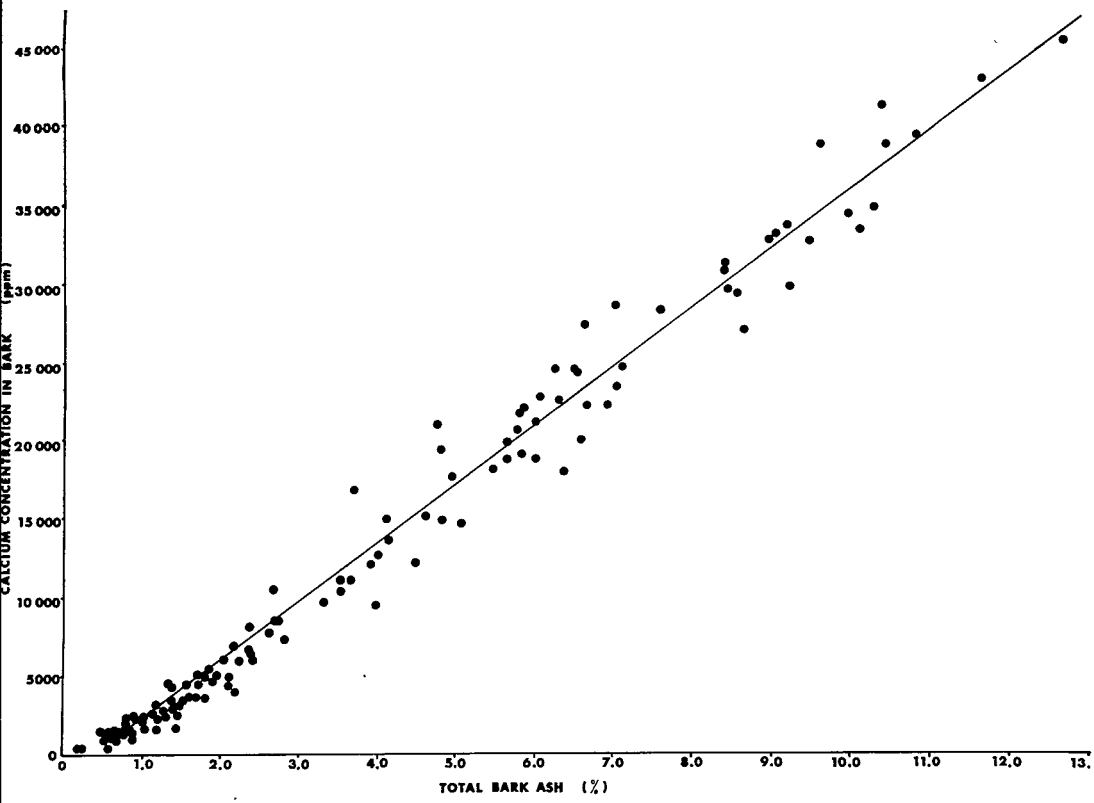
Variation in bark ash content was highly correlated with bark calcium concentration (r = 0.97, see figure 1) and hence a simple gravimetric determination of crude ash in the bark of any of the eucalypts examined would give a good estimation of its bark calcium content using the equation:

Bark calcium concentration (%) = 0.360 (Bark ash content, %)—0.147
(r = 0.985, n = 137)

This was also the case for *E. maculata* heartwood for which:

Heartwood calcium = 0.44 (Heartwood ash content, %)—0.10
concentration (%) (r = 0.892, n = 10)

Figure 1. Relationship between bark concentration (%) and bark ash content (%) in *Eucalyptus* species.



Most heartwood ash levels were very low, generally being less than 0.1%. This was particularly the case with samples from species belonging to the subgenus *Monocalyptus* in which heartwood per cent ash was often an order of magnitude less than that for sapwood. However, *E. maculata* (subgenus *Corymbia*) and *E. dalrympleana, E. viminalis, E. Woolsiana, E. fibrosa, E. melliodora* (subgenus *Symphyomyrtus*) generally had heartwood levels between 0.5 and 1.0%. *E. grandis* also consistently gave heartwood ash yields higher than most other species (about 0.25%).

All species had lower phosphorus levels in the heartwood than the sapwood, often (as with the ash) being an order of magnitude lower. However bark and sapwood phosphorus levels were generally similar. For calcium, bark was in every case much higher than sapwood or heartwood, with sapwood being generally higher than heartwood. The bark potassium was usually higher than sapwood but both were markedly higher than the heartwood in which potassium was extremely low. No significant differences characteristic of a subgenus could be identified for these elements.

Within each subgenus, the phosphorus, calcium and potassium concentrations were examined further for significant differences between species. Although many species had similar values, some significant species differences were apparent. For example, while the three species which are members of the subgenus *Corymbia* (*E. intermedia, E. gummifera, E. maculata*) did not show any marked species differences in their bark, sapwood and heartwood phosphorus levels (considered separately), *E. maculata* had a somewhat higher potash level in the bark and heartwood than *E. intermedia* and *E. gummifera,* while the bark calcium values were characteristic of those found for other eucalypt species. That is, the decorticating bark of *E. maculata* had much larger calcium concentrations (six times) than that of the rough-barked *E. gummifera* and about twenty times that of *E. intermedia.* However, in both the sapwood and heartwood, the calcium levels of the two bloodwoods could not be distinguished, but that of *E. maculata* was very much higher.

The species which were analysed for the three components from the subgenus *Monocalyptus* were *E. laevopinea, E. globoidea, E. pilularis, E. obliqua, E. sieberi* and *E. radiata.* In addition a number of *E. rossii* bark samples together with *E. muellerana* and *E. macrorhyncha* sapwood and heartwood samples were included. The mean concentrations for the sapwood and heartwood (taken separately) for each of the elements were indistinguishable. For the bark, *E. globoidea* appeared to have a marginally lower phosphorus level than the other species. This was also the case for the potassium content of this species. *E. sieberi* was also lower than most of the others for these two elements. As with the *Corymbia* subgenus, the bark calcium concentration was the most important element of difference with the smooth-barked *E. rossii* having significantly higher levels than the remainder, despite the fact that this species is known to grow in soils with very low calcium levels such as those found at Mullions Range S.F. (Humphreys, 1974). Of the remainder, *E. radiata* had significantly higher calcium concentrations and *E. sieberi* lower calcium concentrations than most of the other species in this subgenus.

The species representing the subgenus *Symphyomyrtus* were *E. globoidea, E. saligna, E. cypellocarpa, E. dalrympleana, E. microcorys* (for bark, sapwood, and heartwood) and *E. camaldulensis* (sapwood and heartwood only). This subgenus contains many of the species which have been given common names containing "gum", such as blue gum, river red gum, mountain gum, ribbon gum, flooded gum, etc. The outstanding feature of these species is the extremely high levels of calcium which their barks contain. They all have decorticating barks.

The only species in this group with a fibrous bark is *E. microcorys*. This contained almost 1% calcium, the highest of all species with physically similar barks. There was no correlation between the calcium levels in the bark and the wood. The sapwood calcium levels in each species were similar as were the heartwood calcium levels, although *E. dalrympleana, E. microcorys* and *E. grandis* had marginally higher levels than those in *E. saligna* and *E. camaldulensis*. This group of species had very much higher phosphorus levels than the other two subgenera both in the heartwood and (with *E. saligna*) in the bark. The very high phosphorus levels found in *E. dalrympleana* (and the single sample of *E. viminalis*) could be one of the reasons for the successful use of these species as indicators of suitable sites for *P. radiata* establishment. Although some significant differences were found between mean potassium concentrations, these were not large enough to change the character of the ash. *E. dalrympleana* had the highest potassium level in the bark and heartwood. This element was also higher in the sapwood than in the other components except for *E. cypellocarpa* and *E. camaldulensis*.

Some additional characteristics of certain species were noted. The concentrations of sodium in the bark of *E. obliqua* (grown on the coast) and of *E. grandis* and *E. saligna* were quite high. The concentration of aluminium in all species examined was insignificant despite the fact that almost all were growing in acid soils. The concentrations of most elements in the heartwood of species belonging to the *Monocalyptus* subgenus were extremely low.

(b) Other Species

Other than the eucalypts, the two myrtaceous species which were sampled in the general survey were *Tristania conferta* (Table 4) and *Syncarpia glomulifera* (Table 5), decorticating and rough-barked species respectively. They gave similar analyses to the eucalypts in that the smooth-barked species had a relatively high ash content while the rough-barked species yielded only a low level. The percent ash varied with calcium content as with the eucalypts. In neither species could the ash levels in the heartwood and sapwood be distinguished, the levels found being about the same as for *E. maculata*. However, even though the calcium content of the *Tristania* wood was similar to that of *E. maculata*, that of the *Syncarpia* was very low, presumably because the ash contained a higher level of silica (see Table 11). Both these species showed the same economy in the utilization of phosphorus as did the majority of the eucalupts examined.

The results for *Callitris columellaris* and *Callitris hugelii* (Table 6) indicated high levels of calcium in these species with apparently high bark calcium levels and generally higher heartwood than sapwood calcium concentrations.

The results for Coachwood (*Ceratopetalum apetalum*) which is a relatively smooth-barked species, gave moderately high calcium levels in the bark and tend to indicate a general trend for smooth-barked species. However phosphorus was relatively poorly redistributed from heartwood to sapwood with virtually no removal from old bark to new bark—possibly a function of a primitive species.

In Table 7, the results from other reported studies for elemental concentrations in various species were in agreement with those from the present study. For example, the barks of *E. diversicolor* (Hinston *et al.*, 1979) and *E. campanulata* (Beadle and White, 1968) had high calcium concentrations Some of the minor species such as *Acacia* and *Casuarina* appeared to concentrate calcium in the bark and were fairly efficient at redistributing phosphorus.

2. Effect of tree age—Eucalyptus pilularis

The results for the 5- and 30-year-old *E. pilularis* indicated small variations within the twelve trees in each age group and significant differences between the two age groups and between sapwood and heartwood (Table 8).

(a) Total ash—The sapwood samples had higher ash content than the heartwood. However, whereas in the young trees the difference was not large, the ash content of the sapwood was nine times higher than that in the older trees.

(b) Phosphorus—The sapwood samples for each group had phosphorus concentrations which were about an order of magnitude greater than those in the heartwood. The sapwood samples were similar for the two groups. The heartwood samples were significantly different, the younger material being greater than the older. Both, however, contained very low levels.

(c) Calcium—The sapwood samples for the young and the mature trees were similar, but in the case of the heartwood, the young material was about twice that of the mature. The sapwood samples were higher than the heartwood in the mature trees but not in the younger.

(d) Magnesium—The sapwood samples were very much greater than the heartwood samples. The sapwoods were similar for both groups but the younger heartwood was higher than the mature.

(e) Potassium—The sapwood was very much higher than the heartwood. The younger sapwood was significantly lower than the mature while in the heartwood the younger material was much higher than the mature material in which potassium was a trace element only.

(f) Sodium—The levels of sodium were similar to those found for potassium (as is usual with the foliage of this species) except for the mature heartwood in which the sodium levels were much higher. The sapwoods of both young and mature trees were similar but the heartwoods were different, the younger material having higher concentrations than the older.

The aluminium, iron, manganese, and zinc levels were very low in all samples. An investigation of the occurrence of thirteen trace elements in the wood of thirty-four hardwood and softwood species showed that the distributions over height and cross-section of the stem were similar (Wazny and Wazny, 1964). However the wood of younger trees up to 10 years contained more substantial quantities of the trace elements.

3. Effect of position along tree stem—Pinus radiata

The results for the various components sampled at different positions along the tree stem gave much smaller variations within each component than between components. The inner bark had the highest nutrient levels followed by outer bark, sapwood, and heartwood (Table 9). Calcium was an exception in that higher concentrations were obtained in the heartwood than the sapwood. The phosphorus concentrations in the outer bark had the most obvious trend along the stem with the concentrations increasing fairly regularly and more than doubling from the base to the top of the stem.

The concentrations of all elements in the inner bark, sapwood and heartwood were very consistently similar along the length of the stem and in most cases there did not appear to be any trend from the base to the top of the stem.

Orman and Will (1960) found similarly that phosphorus and potassium decreased and calcium increased from inner bark to heartwood. They found, however, that nitrogen, phosphorus, and potassium increased with height within the tree whereas calcium decreased.

The *P. radiata* samples in the general survey had bark ash levels about 4-5 times the sapwood and heartwood which were almost identical (Table 10). As in the case of the eucalypts, the bark ash content appeared to vary with the bark calcium content. *P. radiata* was reasonably economical in its utilization of phosphorus, but as its sapwood width is very much greater than in any of the eucalypts, this species would contain rather more phosphorus in the total tree bole than most eucalypts of the same size. Each of the other nutrients was within the range found for eucalypts with the exception of aluminium which was much higher in the bark of *P. radiata* than in any of the other species examined. This reflects the high aluminium levels found in the foliage of this species (Humphreys and Truman, 1971).

4. Miscellaneous

During the 1939-45 war period, gravimetric chemical analyses were carried out on samples of wood of various species in connection with the use of charcoal for the generation of producer gas for use in internal combustion engines (Table 11). It can be assumed that, as the wood used to make charcoal at that time was almost always dead timber from old ring-barked trees, the samples would have been composed almost entirely of heartwood. Of the eucalypts which appear in Table 1, *E. pilularis, E. corymbosa* (syn. *gummifera*), *E. microcorys* and *E. propinqua* were analysed in this period. The ash levels reported are consistent with those found in the more recent work. When converted to similar units, the concentrations reported for the other elements are of the same order of magnitude in both studies. Of interest here is the rather high silica levels found for some eucalypts which are not regarded as silicon accumulators (Amos, 1952). These comparisons indicate that some reliance can be placed upon the figures obtained for the earlier reported species which are no longer of interest for timber production.

CONCLUSIONS

1. The morphological characteristics of a species appear to determine nutrient levels rather than family groups.

2. Lower nutrient concentrations were obtained in the heartwood than the sapwood of almost all species for all elements. This differential appears to represent a method whereby the tree redistributes nutrients and can be compared with nutrients being removed from foliage prior to litterfall (Beadle and White, 1968).

3. The variability between different species is very high overall. The highest variability was obtained between the barks of all species with the lowest variability being obtained for the heartwood.

4. The variability within a particular species on any given site appears to be relatively low but is higher for particular species across different sites with widely different nutritional status. The highest variability is obtained with young trees (less than 10 years of age).

5. The variability within a tree for a particular component is very low.

6. The ecological implications of harvesting the studied timbers when they contain large quantities of heartwood are minimal in that very low quantities of chemical elements would be removed from the site.

7. Considering the differences obtained between the various woody components within a tree, the pooling of components such as sapwood and heartwood is not considered advisable.

8. This work has shown that few of the woods examined are a high source of ash. Almost all produce an ash residue which is mainly calcium carbonate, a material much more easily obtained, if required, from limestone. This is particularly the case if large quantities of ash are obtained using the bark which is a rich source of calcium.

9. None of the constituents measured would present a toxic environmental hazard if emitted from stacks or if returned to the soil.

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ACKNOWLEDGMENTS

I wish to thank Monica Cramsie and Joy Jorgensen for assistance with the chemical analyses, Reg Humphreys and John Turner for helpful discussions on the manuscript, and Joan Wall for typing the manuscript.

TABLE 1: Nutrient content of bark, sapwood and heartwood in *Eucalyptus* spp. belonging to subgenus Corymbia.

Species	Location or Forestry District	Component	Ash	N	P	Al	Ca	Mg	K	Na	Mn	Zn	Fe	Total -S	Cl
			%		ppm										
E. gummifera	Nowra	H	0.07		10	5	100	110	230	50	2	5	20		
		S	0.34		55	15	180	230	500	285	10	10	35		
	Queensland	H	0.07		5	5	250	210	120	25	5	5	10		
	Beecroft	H	0.10		2	10	150	150	210	75	1	2	15		
	Casino	B	1.23		130	30	2 200	400	1 850	680	40	5	35		1 490
		S	0.34		60	35	310	110	900	255	30	5	40	500	190
		H	0.08		5	5	160	90	50	20	2	5	30	240	50
	Newcastle	B	0.92		30	15	2 230	370	950	530	25	5	15	640	1 650
		S	0.65		60	30	420	690	1 150	745	20	5	25		1 720
		H	0.18		5	25	410	190	180	115	2	5	35		145
		B	0.67		30	10	1 520	650	600	565	15	10	15		1 265
		S	0.36		45	20	320	420	800	225	30	2	30		655
		H	0.15		5	15	240	200	140	65	5	2	20		25
	South Coast	B	1.81		390	190	3 650	620	1 650	960	35	5	90		
		B	1.37		235	25	4 900	630	2 450	1 385	40	5	130		
		B	2.37		255	200	6 410	740	3 050	940	25	10	85		
		B	2.67		275	25	10 280	240	2 300	940	25	2	135		
		B	1.96		330	25	4 930	890	2 900	1 250	30	5	75		
		B	2.34		240	210	8 060	210	2 550	1 375	20	5	85		
E. intermedia	Kempsey	B	0.89		40	25	870	200	1 450	1 080	40	5	20		3 265
		S	0.24		90	5	280	90	700	65	15	5	45		260
		H	0.02		5	10	100	30	260	25	1	10	20		125
	Wauchope	B	1.30		90	40	2 360	770	1 500	790	80	5	35		2 605
		S	0.30		120	15	360	130	600	140	20	5	25		350
		H	0.07		5	10	160	80	25	20	2	5	15		25
	Taree	B	0.89		95	15	1 180	300	1 950	525	40	10	25		645
		S	0.25		140	20	290	220	900	125	15	5	20		450
		H	0.09		5	10	220	60	25	5	35	5	20		25
		B	0.81		55	15	1 830	500	950	550	15	5	15		1 890
		S	0.55		85	5	880	410	1 000	310	15	10	45		330
		H	0.04		5	5	210	50	80	35	2	5	15		25

TABLE 1—*continued.*

Species	Location or Forestry District	Com-ponent	Ash	N	P	Al	Ca	Mg	K	Na	Mn	Zn	Fe	Total -S	Cl
			%		ppm										
E. intermedia	Coffs Harbour	B	0.58		45	20	400	80	1 200	580	25	2	10		2 810
		S	0.32		40	20	320	100	750	195	30	5	25		665
		H	0.04		5	10	200	30	70	15	1	10	20		75
E. maculata	Glen Innes	B	8.60	0.27	110	25	29 280	2 600	1 900	245	185	35	40	915	2 150
		S	0.55	0.18	50	10	1 240	340	800	140	30	5	20	750	385
		H	0.85	0.10	5	25	2 370	770	220	85	60	10	15	400	670
	Casino	B	6.64		200	50	27 440	960	3 400	570	385	20	20		3 140
		S	0.51		85	15	1 000	280	950	155	45	5	55		670
		H	1.06		5	10	3 140	670	350	160	50	10	35		1 135
	Coffs Harbour	B	8.47		240	65	29 620	2 120	4 350	880	710	10	25		2 710
		S	0.76		115	35	950	160	700	125	40	5	55	770	340
		H	0.88		5	25	2 610	630	180	115	65	10	25	410	740
	Kempsey	S	0.62		70	25	1 160	350	550	315	35	5	30		495
		H	1.08		15	25	3 020	850	300	220	85	10	40		1 515
	Wauchope	B	5.80		145	55	20 720	3 080	2 700	215	165	10	25	870	1 865
		S	0.69		80	20	2 700	360	750	100	15	10	8		240
		H	0.95		5	15	2 700	820	230	110	30	15	45		1 090
	Newcastle	B	6.06		130	95	22 790	1 610	2 150	495	835	35	30		3 125
		S	1.00		70	10	3 360	420	800	210	120	10	40		365
		H	1.07		5	25	3 540	720	230	165	175	10	55		1 610
	South Coast	B	10.84		435	225	39 430	900	4 850	630	640	10	110		
		B	4.00		350	100	11 820	1 870	4 150	885	810	20	110		
	South Coast	B	7.60		415	50	27 980	880	3 150	490	760	10	70		
		B	11.71		415	190	43 020	1 830	4 250	1 015	560	10	95		
		B	9.07		360	25	33 140	1 190	3 250	815	840	10	75		
		B	5.67		440	35	19 830	1 630	3 750	590	520	5	125		
		B	8.43		400	50	30 780	1 750	3 100	555	790	10	85		
		B	9.24		465	230	33 670	1 930	3 550	390	650	10	65		
	South Africa	H	0.26		5	40	610	210	190	180	110	20	25		
	Stroud	H	0.96		5	5	4 680	1 190	100	70	70	10	40		
	Bateman's Bay	H	0.46		5	15	830	610	170	125	70	10	45		
	Queensland	H	1.33		5	20	5 700	550	100	110	40	10	50		

TABLE 2: Nutrient content of bark, sapwood and heartwood in *Eucalyptus* spp. belonging to subgenus Monocalyptus.

Species	Location or Forestry District	Component	Ash	N	P	Al	Ca	Mg	K	Na	Mn	Zn	Fe	Total -S	Cl
			%		ppm										
E. agglomerata	Bathurst	B	1.81		75	35	4 950	360	600	435	190	5	30		1 360
		S	0.16		115	10	460	260	360	145	20	15	5		270
		H	0.02		2	45	400	30	1	20	2	10	15		5
		B	2.24		60	30	6 000	770	800	240	135	5	60		1 435
		S	0.27		215	20	390	310	800	315	35	5	30		535
		H	0.01		5	15	130	100	5	25	2	5	40		5
E. andrewsii	Coffs Harbour	B	0.85		85	45	1 520	460	1 250	415	75	5	55		850
		S	0.16		50	15	240	190	240	200	50	5	30	520	280
		H	0.06		5	10	150	40	80	10	2	5	80	230	90
	Glen Innes	B	1.55		135	80	3 400	1 270	1 550	505	450	5	20		1 070
		S	0.23		80	25	300	240	380	155	30	5	20		350
		H	0.07		5	5	180	100	10	20	1	5	15		20
E. blaxlandii	Bathurst	B	0.68		105	35	930	260	900	650	50	1	30		1 405
		S	0.30		70	10	220	90	420	140	15	5	15		225
		H	0.02		5	25	730	260	30	25	0	5	25		5
E. cameronii	Glen Innes	B	1.28		30	140	2 630	330	1 050	295	170	2	75		850
		S	0.36		100	40	590	240	900	265	45	10	25		560
		H	0.05		20	5	1 360	110	30	30	5	5	2		80
E. consideniana	South East	B	0.72		55	55	1 040	690	1 100	255	65	5	5		1 220
		S	0.17		115	20	460	240	550	160	50	5	5		265
		H	0.14		5	5	510	80	15	50	2	5	40		20
	Naghi S.F.	B	0.73		65	30	1 460	280	500	1 100	25	5	75		780
		S	0.59		105	20	640	170	1 000	435	25	10	10		725
		H	0.22		5	20	970	10	490	20	1	5	35		5
E. delegatensis	Tumut	S	0.17		40	40	410	170	150	105	30	5	30		510
		H	0.20		5	5	370	130	250	65	15	5	55		245

TABLE 2—*continued.*

Species	Location or Forestry District	Component	Ash	N	P	Al	Ca	Mg	K	Na	Mn	Zn	Fe	Total -S	Cl
			%		ppm										
E. dives	Lidsdale S.F.	B	2.19		95	105	6 840	2 260	650	35	130	60	110		
		H	0.04		10	25	340	40	30	10	5	5	65		
		B	1.21	0.13	65	435	3 090	1 340	1 450	240	335	5	15	145	
		S	0.35	0.12	75	125	640	180	1 050	90	65	60	350	245	
		H	0.07	0.07	10	20	180	40	180	15	20	15	80	115	
		B	1.00		70	65	2 180	1 330	1 200	140	100	5	80		
		S	0.24		85	5	760	180	1 350	170	60	5	70		
		H	0.09		10	25	150	30	150	50	5	2	75		
		B	1.36		90	40	4 320	1 200	1 350	165	440	5	25		
		S	0.58		115	30	990	460	1 200	125	170	5	50		
		1H	0.23		15	105	280	90	100	25	5	5	95	115	
		OH	0.07	0.08	10	20	200	40	100	20	10	5	15	90	
		B	0.95	0.12	50	120	2 220	540	800	55	60	20	135	230	
		S	0.66	0.11	60	50	820	520	1 500	105	55	15	55	125	
		H	0.19		15	25	200	110	270	50	15	1	35		
E. fastigata	Newcastle	B	1.89		315	60	4 620	820	1 950	760	45	10	60		880
		S	0.24		105	15	190	160	700	380	10	10	35		630
		H	0.02		10	10	90	70	25	25	2	2	40		30
	South East	B	1.16		80	40	2 400	6 420	1 450	900	55	10	35		1 860
		S	0.39		135	35	270	80	900	280	15	5	25		370
		H	0.06		15	20	120	40	180	60	5	5	20		50
E. globoidea	East Boyd S. F.	B	1.34		75	220	4 400	180	650	1 120	60	5	105		1 310
		S	0.35		85	25	610	140	850	310	30	10	65		470
		H	0.06		5	35	430	30	10	40	0	2	70		25
		B	0.62		75	110	1 500	145	650	710	20	20	80		1 510
		S	0.41		50	15	520	230	700	285	15	5	65		735
		H	0.04		5	15	160	10	10	40	1	2	75		25

TABLE 2—*continued.*

Species	Location or Forestry District	Component	Ash	N	P	Al	Ca	Mg	K	Na	Mn	Zn	Fe	Total -S	Cl
			%		ppm										
E. globoidea	Naghi S.F.	B	0.50		50	0	1 360	100	220	715	30	40	30		1 375
		S	0.65		175	25	340	160	750	525	25	5	95		1 050
		H	0.03		5	30	380	2	60	20	5	10	65		15
E. laevopinea	Casino	B	0.81		90	45	2 270	160	600	330	10	5	35		385
		S	0.34		85	45	460	140	650	450	20	10	50		365
		H	0.03		5	15	390	110	80	25	1	5	20		20
	Kempsey	B	0.60		80	45	1 310	520	900	850	290	2	30	810	2 025
		S	0.31		80	15	270	170	900	145	15	5	60		405
		H	0.03		20	5	110	30	110	15	5	5	20		20
	Taree	B	0.92	0.31	70	85	2 450	280	1 050	980	385	5	45	860	1 455
		S	0.21	0.19	70	20	260	130	650	185	40	5	30	670	210
		H	0.002	0.11	15	20	240	80	20	20	2	5	30	380	25
	Newcastle	S	0.27		95	30	590	240	600	300	45	5	25		500
		H	0.09		20	10	230	100	10	15	1	5	25		15
	Dubbo	B	1.03		105	75	2 180	530	1 500	310	330	5	80		1 700
		S	0.22		85	15	480	230	400	100	15	1	15		335
		H	0.02		35	15	320	100	20	20	2	2	15		10
E. macrorhyncha	Queanbeyan	OB	0.16				200		420						
		IB	0.68				940								
		S	0.48		70	20	270	130	950	60	35	10	35		
		H	0.01		5	10	30	20	30	15	2	2	30		
	Tumut	OB	0.30				310		700						
		S	0.44		130	10	190	70	900	35	15	15	45		
		H	0.01		15	10	60	20	270	25	2	10	15		
	Victoria	H	0.18		10	10	990	280	40	50	2	5	35		
	Bathurst	B	0.79		65	10	1 540	190	2 050	20	95	2	10	900	1 625
		S	0.40		130	30	360	110	950	15	10	10	215		1 265
		H	0.02		10	5	60	20	60	10	2	5	15		60

TABLE 2—*continued.*

Species	Location or Forestry District	Component	Ash	N	P	Al	Ca	Mg	K	Na	Mn	Zn	Fe	Total -S	Cl
			%		ppm										
E. macrorhycha	Bathurst	S	0.21		95	20	540	220	400	65	20	10	35		525
		H	0.11		5	5	150	100	220	45	2	5	5		80
E. muellerana	South East	S	0.15		65	30	260	110	110	185	2	10	45		635
		H	0.04		10	2	180	70	100	10	1	5	10		230
	East Boyd S.F.	B	0.78		165	95	1 220	160	430	965	20	5	135		1 595
		S	0.44		140	15	1 110	390	850	340	15	5	115	510	610
		H	0.01		15	35	320	35	10	30	2	5	105	220	15
	Naghi S.F.	B	1.18		75	10	1 550	140	1 550	1 060	60	10	65		2 505
		S	0.50		185	5	1 100	440	1 150	255	10	5	130		595
		H	0.04		10	30	230	5	130	55	5	5	115		15
	Victoria	H	0.01		5	10	50	10	2	10	1	5	25		
	Eden	H	0.01		10	5	40	5	80	35	2	2	20		
		H	0.16		50	30	310	150	240	85	10	5	60		
	Batemans Bay	H	0.01		20	5	50	20	30	25	2	2	15		
		H	0.06		95	10	190	100	470	110	10	5	30		
E. obliqua	Glen Innes	B	0.74		55	60	1 650	250	390	690	105	1	45		400
		S	0.26		90	20	550	230	400	515	60	5	30		815
		H	0.05		5	5	40	40	25	45	2	5	85		25
	Coffs Harbour	B	0.62		130	90	1 030	280	900	710	25	1	40		915
		S	0.44		125	20	510	270	650	760	10	5	20		1 330
		H	0.08		5	30	15	2	2	15	1	5	15		40
	Kempsey	B	1.41		180	75	2 880	950	1 050	2 460	240	10	30		3 975
		S	0.38		135	10	320	130	1 100	205	20	5	80		470
		H	0.07		5	15	30	30	70	20	2	10	30		10
	Newcastle	B	1.63		85	100	3 720	300	2 050	1 105	75	10	125	950	2 725
		S	0.18	70	20	380	200	600	145	15	5	30	750	300	
		H	0.06		5	15	180	50	45	60	5	5	55	370	20

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TABLE 2—*continued.*

Species	Location or Forestry District	Com-ponent	Ash	N	P	Al	Ca	Mg	K	Na	Mn	Zn	Fe	Total -S	Cl
			%		ppm										
E. obliqua	Metropolitan	B	1.45		140	25	1 530	860	2 550	1 810	50	10	25		4 240
		S	0.47		160	45	420	450	1 400	545	15	10	100		1 160
		H	0.04		5	1	180	50	50	50	1	2	30		20
	South Coast	S	0.09		30	15	600	300	200	145	15	5	45		255
		H	0.05		2	15	160	140	30	55	1	5	20		25
	South East	B	0.82		80	55	1 830	200	1 100	395	175	5	395		1 095
		S	0.56		165	30	430	430	1 750	585	120	5	55		1 785
		H	0.09		5	15	170	70	120	60	5	15	25		115
	East Boyd S.F.	B	1.16		150	70	1 250	460	550	2 325	20	5	60		3 515
		S	1.09		200	65	1 580	660	1 500	1 050	30	10	195		1 780
		H	0.09		10	40	430	30	100	45	2	5	80		25
	East Boyd S.F.	B	0.87		140	35	720	300	1 500	1 865	35	50	65		2 805
		S	0.67		140	25	840	410	850	810	15	10	195		1 780
		H	0.03		10	35	390	15	10	95	1	15	90		15
	Naghi S.F.	B	3.43		645	45	3 050	1 090	2 650	3 505	50	5	350		1 560
		S	0.43		185	15	750	400	800	530	10	5	145		820
		H	0.06		5	35	380	5	60	35	2	5	150		5
	Glen Innes	S	0.17		75	0	180	140	850	220	15	10	30		
	Tallagundra S.F.	S	0.42		155	25	410	100	1 000	285	40	5	15		
		H	0.06		5	35	120	5	40	30	1	40	30		
	Wingello	S	0.37		155	40	240	150	1 150	250	20	30	50		
		H	0.07		15	20	80	10	130	90	1	1	15		
	Victoria	H	0.03		2	10	60	10	20	25	1	15	80		
	South Australia	H	0.02		5	20	80	20	60	50	1	15	25		
	Hobart	H	0.02		5	10	80	30	30	40	2	5	35		
E. oreades	Bathurst	B	1.70		100	60	3 650	1 470	1 550	970	75	10	20		10
		S	0.38		90	25	340	260	760	280	15	20	40		515
		H	0.08		10	25	230	100	5	60	5	2	5		25

TABLE 2—*continued.*

Species	Location or Forestry District	Component	Ash	N	P	Al	Ca	Mg	K	Na	Mn	Zn	Fe	Total -S	Cl
			%		ppm										
E. pilularis	Kempsey	B	0.34		45	25	1 050	810	280	270	145	5	60		1 315
		S	0.32		90	15	260	190	800	145	15	5	120		320
		H	0.04		5	15	70	20	110	100	1	5	25		20
	Wauchope	B	1.57		50	95	4 290	1 060	1 110	685	385	5	20		1 550
		S	0.18		30	30	190	110	130	160	10	5	35		110
		H	0.03		2	5	220	80	260	90	1	5	30		15
	Taree	S	0.35		65	15	190	180	180	635	25	5	30		985
		H	0.09		10	2	220	110	150	175	5	2	20		365
	Newcastle	B	1.59		40	95	2 530	960	1 050	570	155	10	85		710
		S	0.48		85	55	400	420	980	330	30	5	10		285
		H	0.17		5	60	180	100	140	85	5	2	65		55
	South Coast	B	2.11		375	25	4 940	900	3 350	1 580	185	5	80		
		B	1.01		250	125	2 190	650	1 900	795	210	5	50		
E. piperita	Metropolitan	B	1.59		70	70	2 310	1 330	1 050	1 350	550	5	25		5 150
		S	0.39		100	15	300	170	860	350	40	5	60		645
		H	0.08		15	15	170	50	190	90	5	5	40		130
E. radiata	Naghi S.F.	B	1.45		90	115	2 510	890	1 750	1 020	160	5	55		6 605
		S	0.51		115	25	790	320	1 000	305	30	5	185		550
		H	0.08		5	45	460	30	60	55	2	10	165		740
	Bago S.F.	B	2.10	0.35	105	95	4 290	1 350	2 800	25	405	5	115		
		S	0.64	0.18	110	10	580	210	1 400	60	50	5	130		
		H	0.32	0.15	30	25	410	120	350	40	40	25	120		
		B	3.23	0.33	130	90	4 360	1 370	2 700	20	660	2	75		
		S	0.40	0.31	190	10	290	190	1 300	100	40	2	75		
		H	0.12	0.18	20	2	180	10	200	25	2	5	70		

TABLE 2—*continued.*

Species	Location or Forestry District	Component	Ash	N	P	Al	Ca	Mg	K	Na	Mn	Zn	Fe	Total -S	Cl
			%		ppm										
E. radiata	Bago S.F.	B	2.85	0.27	165	35	4 570	1 420	2 750	40	345	15	75		
		S	0.53	0.28	180	10	470	270	1 450	50	15	5	70		
		H	0.06	0.22	20	2	380	120	250	20	20	10	90		
		B	2.04	0.24	80	50	6 020	770	1 700	40	215	5	65		
		S	0.58	0.27	155	15	190	280	1 550	150	15	5	65		
		H	0.09	0.26	10	25	450	110	400	35	15	5	55		
		B	1.39	0.25	100	25	3 000	1 150	2 050	25	310	2	45		
		S	0.35	0.32	210	5	210	180	1 000	55	45	10	70		
		H	0.02	0.13	25	2	110	80	250	35	20	10	80		
E. regnans	Victoria	H	0.01		2	15	60	60	10	35	5	5	20		
		H	0.08		5	15	160	60	150	60	10	5	30		
	Tasmania	H	0.04		2	2	180	40	190	50	10	2	40		
E. rossii	Lidsdale S.F.	B	8.64	0.12	100	295	27 080	1 920	2 750	80	410	80	155	150	
		S	0.42	0.15	100	10	2 540	610	1 750	225	265	45	135	265	
		H	0.05	0.07	15	65	320	250	150	195	55	50	55	80	
		B	4.10	0.14	85	60	14 800	1 510	2 100	525	885	10	25	195	
		S	1.15	0.17	110	10	2 210	270	1 150	320	85	10	2	245	
		H	0.12	0.10	15	5	620	20	50	35	5	10	2	125	
		B	5.85	0.20	110	45	21 840	2 090	1 950	245	1 030	10	30	250	
		S	1.40	0.15	100	15	4 210	340	1 300	320	50	15	80	150	
		H	0.06	0.08	10	5	260	10	50	45	5	5	25	80	
		B	3.51		110	45	10 880	2 130	1 600	200	630	5	80		
		S	1.00		110	20	2 010	370	1 200	340	40	5	40		
		H	0.09		5	25	290	10	80	60	5	1	55		
		B	3.65		120	40	10 950	1 810	2 700	210	640	5	5		
		S	0.83		135	20	1 300	420	2 050	270	65	10	85		
		H	0.08		35	10	320	20	140	75	10	5	70		
		B	5.79		325	70	21 560	4 250	2 000	520	320	25	75		
		S	1.14		180	20	3 690	480	1 550	240	90	15	265		
		H	0.04		25	10	410	60	90	35	10	2	55		

TABLE 2—*continued.*

Species	Location or Forestry District	Component	Ash	N	P	Al	Ca	Mg	K	Na	Mn	Zn	Fe	Total -S	Cl
			%		ppm										
E. rossii	Lidsdale S.F.	H	3.98		95	40	13 160	2 170	1 300	695	640	5	20		
		S	0.60		165	10	970	310	1 400	550	45	5	140		
		H	0.02		10	10	220	0	50	30	2	1	65		
	Black Mountain A.C.T.	B	2.40		90	20	5 990	2 010	1 700	150			155		
		B	2.18		100	75	3 810	3 780	2 300	65			195		
		B	2.36		75	45	6 720	2 280	1 400	70			110		
		B	2.81		125	105	7 300	2 220	1 950	110			140		
		B	1.73		70	130	4 320	1 620	1 750	70			65		
		B	3.52		70	75	10 180	2 310	2 500	110			165		
	Mt Ainslie A.C.T.	B	7.14		130	60	24 540	3 270	1 950	115			75		
		B	4.80		525	45	14 620	4 150	1 750	95			60		
		B	2.63		160	15	7 650	2 040	2 300	65			40		
		B	3.89		150	40	11 780	3 070	1 650	70			45		
		B	5.83		250	40	19 000	3 570	1 750	145			60		
		B	4.61		150	45	14 920	2 620	1 900	140			50		
E. sieberi	Balarang	S	0.09		55	15	120	110	500	110	10	5	50		
	Nowra	H	0.04		10	40	110	40	2	35	2	10	35		
	Bathurst	S	0.05		30	15	230	110	45	90	5	5	20		20
		H	0.03		2	15	130	150	10	60	2	5	15		5
	Metropolitan	B	0.22		30	20	400	160	380	165	10	5	20	870	675
		S	0.28		70	15	390	140	800	275	20	5	15		770
		H	0.10		5	10	210	100	70	45	5	5	50		15
	South Coast	S	0.25		80	15	420	320	450	285	25	2	20		540
		H	0.08		5	5	220	90	45	60	1	2	10		90
	East Boyd S.F.	B	0.60		70	40	1 050	330	700	345	20	5	50		1 290
		S	0.36		70	10	370	90	650	305	15	5	180		530
		H	0.02		10	35	530	10	70	135	2	5	95		25
		B	0.54	0.18	50	30	980	300	700	300	10	5	30	880	770
		S	0.74	0.11	125	35	950	240	900	755	10	5	190	510	690
		H	0.29	0.07	50	35	750	340	160	120	5	5	100	310	475

TABLE 3: Nutrient content of bark, sapwood and heartwood in *Eucalyptus* spp. belonging to subgenus Symphyomyrtus.

Species	Location or Forestry District	Component	Ash	N	P	Al	Ca	Mg	K	Na	Mn	Zn	Fe	Total -S	Cl
			%		ppm										
E. camaldulensis	Tumut	S	0.57		315	30	470	140	1 650	245	40	5	25		
		H	0.17		50	40	440	60	140	50	15	10	40		
	Florida	S	0.72		110	15	700	430	1 250	190	5	5	45		
	Riverina	S	0.44		220	20	570	170	1 950	245	95	5	20		965
		H	0.03		10	1	240	160	15	25	5	5	5		125
	Forbes	B	9.65		385	125	38 970	2 770	4 200	1 060	415	15	70		2 455
		S	0.54		90	20	790	270	1 800	360	70	5	55		910
		H	0.10		20	15	230	50	90	40	10	5	30		320
	Victoria	H	0.06		10	20	140	20	70	45	5	2	15		
	Spain	H	0.13		40	10	220	30	10	50	5	5	15		
	South Africa	H	0.08		5	5	110	10	50	50	25	5	25		
	California	H	0.11		10	130	30	30	100	85	10	20	35		
E. cypellocarpa	Metropolitan	B	4.12		150	65	13 640	360	2 150	600	335	5	35		2 950
		S	0.64		325	25	510	630	1 550	160	75	5	75		610
		H	0.20		135	5	350	250	65	70	5	5	90		210
	South East	B	5.07		120	75	14 540	1 420	4 050	830	1 365	5	30		4 915
		S	0.51		325	30	640	470	1 100	125	90	10	50		275
		H	0.18		145	35	330	240	100	160	2	20	20		290
	East Boyd S.F.	B	5.48		95	25	18 200	1 850	1 500	895	1 005	10	50		5 570
		S	0.78		170	30	620	460	1 700	235	55	10	150		1 140
		H	0.13		5	35	670	170	75	140	5	5	155		750
	Naghi S.F.	B	3.69		90	30	16 640	1 250	3 000	1 850	100	10	35		5 580
		S	0.72		315	2	780	560	2 500	660	60	2	120		1 720
		H	0.07		5	25	170	5	30	60	2	5	80		15
E. dalrympleana	Bago	B	7.00	0.28	185	80	28 690	1 990	4 250	20	1 255	5	35		
		S	0.79	0.20	615	10	580	470	2 250	20	80	15	75		
		H	0.62	0.10	870	15	1 430	360	600	35	85	15	120		

TABLE 3—*continued.*

Species	Location or Forestry District	Component	Ash	N	P	Al	Ca	Mg	K	Na	Mn	Zn	Fe	Total -S	Cl
			%		ppm										
E. dalrympleana	Bago														
		B	4.74	0.22	230	100	21 120	1 570	3 250	25	1 160	5	60		
		S	1.13	0.54	2 090	5	790	380	3 000	15	75	15	70		
		H	0.50	0.14	1 125	15	670	310	700	25	60	5	95		
		B	6.23	0.18	235	140	24 740	1 640	3 850	15	1 715	15	15		
		S	0.72	0.35	1 240	15	560	530	2 400	15	70	20	80		
		H	0.47	0.13	895	25	440	330	700	30	45	15	180		
		B	4.79	0.13	175	115	19 200	1 400	4 250	20	1 195	0	115		
		S	0.68	0.33	725	35	750	450	1 800	30	60	5	300		
		H	0.81	0.19	640	195	620	240	750	75	40	10	915		
E. deanii	Glen Innes	B	22.88		785	285	68 790	2 560	5 050	55	1 345	5	70		1 830
		S	0.52		135	35	700	440	1 100	100	55	5	20		360
		H	0.05		10	5	270	110	130	10	5	5	15		70
E. fibrosa	Coffs Harbour	B	3.32		70	50	9 650	1 570	650	135	215	5	85		2 045
		S	0.18		40	25	560	1 190	490	75	35	5	5		90
		H	0.38		10	10	380	220	90	30	35	5	50		20
E. grandis	Casino	B	8.45	0.24	115	45	31 500	750	1 750	1 220	145	5	5	1 010	2 740
		S	0.50	0.31	130	25	650	200	1 250	525	30	5	30	630	1 160
		H	0.26	0.15	5	10	750	230	200	160	5	5	25	410	220
	Kempsey	B	10.14		80	90	33 430	710	1 650	1 200	140	5	75	990	2 560
		S	0.55		110	5	590	170	1 350	430	20	5	40		650
		H	0.24		15	30	570	220	290	215	10	5	75		205
	Wauchope	B	6.32		145	45	22 250	1 800	850	1 390	410	5	25		2 695
		S	0.28		45	15	700	270	650	335	45	5	5		525
		H	0.22		5	5	720	260	100	170	25	5	30		200
	Taree	S	0.31		95	20	710	250	1 000	180	25	5	20		770
		H	0.37		45	5	620	190	800	90	20	5	30		610

TABLE 3—*continued.*

Species	Location or Forestry District	Component	Ash	N	P	Al	Ca	Mg	K	Na	Mn	Zn	Fe	Total –S	Cl
			%		ppm										
E. grandis	Bucca Creek	S	0.78		105	15	470	250	1 090	1 290	20	15	35		
		H	0.23		5	5	290	40	240	415	2	5	35		
	South Africa	H	0.14		5	20	480	100	30	35	15	5	15		
	Queensland	H	0.25		5	5	460	125	170	35	2	10	30		
E. maculosa	Lidsdale S.F.	B	7.03		245	110	23 780	3 010	4 050	115	1 500	10	45		
		S	1.13		130	20	1 800	580	2 550	150	155	10	45		
		H	0.37		120	15	750	150	230	210	45	5	115		
		B	10.30	0.20	150	205	34 810	1 920	3 550	40	1 865	70	70	190	
		S	1.22	0.22	140	80	2 180	730	2 400	95	120	55	50	235	
		H	0.22	0.10	60	5	650	500	400	285	15	85	110	90	
		B	9.48		175	125	32 680	2 670	4 550	55	2 110	25	40		
		S	1.18		150	20	2 120	440	2 850	405	90	25	165		
		H	0.32		35	50	660	160	240	95	10	5	65		
		B	12.70		210	150	45 340	1 450	4 750	50	2 860	15	25		
		S	1.05		155	15	2 220	310	1 950	150	175	10	70		
		H	0.18		45	30	310	180	110	90	40	20	70		
		B	6.00		220	110	18 660	1 970	3 650	35	1 410	20	40		
		S	0.77		80	20	1 570	290	1 150	60	95	5	45		
		H	0.23		55	20	550	110	260	75	30	5	35		
E. melliodora	Forbes	B	3.47		120	115	9 450	3 400	2 800	45	800	15	25		5 205
		S	0.43		75	25	860	350	850	30	75	10	20	590	365
		H	0.49		10	5	280	140	25	20	5	5	20	230	5
E. microcorys	Glen Innes	B	4.47		25	240	12 020	360	2 800	570	210	5	110		2 060
		S	0.55		105	25	550	70	550	210	40	5	35		585
		H	0.14		5	5	410	420	5	20	0	5	20		20
	Casino	B	2.75		35	35	8 400	340	2 000	950	50	15	90	810	2 115
		S	0.54		120	25	710	240	1 600	490	35	5	35		1 255
		H	0.21		5	1	920	300	5	20	5	5	20		130

TABLE 3—*continued.*

Species	Location or Forestry District	Com-ponent	Ash	N	P	Al	Ca	Mg	K	Na	Mn	Zn	Fe	Total -S	Cl
			%		ppm										
E. microcorys	Coffs Harbour	B	2.73		85	25	8 500	540	2 350	650	340	5	120		2 740
		S	0.46		70	20	600	135	900	235	45	20	5		640
		H	0.17		3	40	830	230	15	55	2	2	5		20
	Kempsey	S	0.33		55	25	510	160	800	150	15	5	20		310
		H	0.22		2	1	730	220	100	65	2	15	25		100
	Wauchope	B	4.00		130	50	12 750	270	2 900	680	145	10	85		1 540
		S	0.44		80	30	720	185	1 150	290	35	5	50		430
		H	0.06		5	1	380	270	45	20	2	5	25		15
	Newcastle	B	1.85		215	35	5 240	970	1 550	430	145	5	30		45
		S	0.59		85	285	660	150	500	155	25	5	310		275
		H	0.09		5	1	500	250	50	10	2	5	20		10
	Craven S.F.	S	0.32		80	1	260	80	550	290	25	5	30		
		H	0.09		10	2	140	190	40	30	10	10	50		
	Nowra	S	0.75		130	5	310	190	1 400	1 225	20	5	25		
		H	0.18		10	5	270	150	250	230	0	5	15		
	South Africa	S	0.53		5	25	1 600	340	1 000	70	15	5	30		
	Queensland	H	0.04		2	5	110	180	140	20	2	1	30		
	Newcastle	H	0.06		10	10	325	210	20	15	2	2	10		20
E. paniculata	South Coast	B	6.02		450	40	21 020	1 230	2 650	1 270	1 100	5	95		
		B	4.97		405	40	17 550	1 060	2 750	955	1 310	5	85		
E. propinqua	Casino	B	6.48		405	155	18 050	3 100	1 550	1 495	2 620	5	25		5 435
		S	0.37		90	25	680	200	650	200	80	10	10		810
		H	0.14		10	5	320	90	20	60	2	5	35		75
E. rubida	Lidsdale S.F.	B	6.91	0.19	170	150	22 050	1 850	4 250	35	1 020	5	55	245	
		S	0.78	0.15	155	5	1 470	620	1 950	80	100	5	60	185	

TABLE 3—*continued.*

Species	Location or Forestry District	Component	Ash	N	P	Al	Ca	Mg	K	Na	Mn	Zn	Fe	Total -S	Cl
			%		ppm										
E. rubida	Lidsdale S.F.	H	0.33	0.06	15	15	900	260	200	125	55	10	95	85	
		B	6.60	0.27	195	40	19 800	1 910	7 150	35	1 445	10	20	290	
		S	0.83	0.16	130	15	1 260	510	2 350	335	155	5	35	190	
		H	0.39	0.07	30	5	830	140	200	255	160	5	55	45	
		B	5.66		165	135	18 600	1 180	2 750	20	2 720	5	10		
		S	1.12		170	25	2 280	510	2 250	35	260	10	105		
		H	0.18		15	30	380	330	90	30	220	5	30		
		B	9.00		155	170	32 750	1 200	1 650	20	3 900	20	55		
		S	0.90		155	15	1 520	700	2 300	40	155	5	140		
		H	0.44		150	25	1 130	380	230	60	60	5	85		
		B	6.52		160	145	24 340	1 510	2 600	50	2 790	5	50		
		S	1.97		165	45	5 270	860	2 850	90	200	5	90		
		H	0.37		130	25	890	370	180	80	55	5	80		
		B	6.57		165	100	24 200	1 180	2 670	40	1 830	5	55		
		S	1.33		230	20	2 180	770	3 900	65	140	5	55		
		H	0.24		155	15	780	380	400	75	40	5	50		
E. saligna	Glen Innes	B	10.45		240	80	41 580	1 190	4 200	2 165	420	5	35		2 870
		S	0.42		175	20	620	170	1 250	255	15	10	30	660	500
		H	0.04		5	1	260	100	10	30	1	5	40	340	5
	Casino	B	10.47	0.30	195	140	38 820	1 670	4 400	1 430	245	10	145	1 660	2 140
		S	0.52	0.20	75	25	640	240	750	235	15	15	85	680	440
		H	0.09	0.12	5	2	250	100	60	90	2	5	30	330	95
	Coffs Harbour	S	0.25		40	10	610	250	390	175	15	5	5		440
		H	0.10		5	25	520	20	240	55	10	5	15		75
	Kempsey	B	6.66		115	110	22 050	2 270	1 200	2 270	330	10	50		2 840
		S	0.53		100	10	700	350	1 250	200	20	5	85		380
		H	0.04		5	10	90	30	100	60	2	5	15		20
	South Coast	B	9.99		555	100	34 470	1 580	4 150	2 685	280	10	110		

TABLE 3—*continued.*

Species	Location or Forestry District	Component	Ash	N	P	Al	Ca	Mg	K	Na	Mn	Zn	Fe	Total -S	Cl
			%		ppm										
E. saligna	Ourimbah	S	0.53		105	30	860	240	720	500	50	5	35		
		H	0.05		10	25	120	10	5	185	2	15	20		
	Craven S.F.	S	0.40		60	25	430	140	890	285	40	10	20		
		H	0.06		15	25	110	130	130	95	2	5	15		
	Pennant Hills	S	0.45		100	40	670	330	690	315	20	5	40		
		H	0.15		10	20	340	90	120	135	1	5	15		
	South Africa	H	0.05		1	50	160	70	50	95	5	5	15		
E. sideroxylon	Forbes	B	1.48		95	85	3 110	830	1 050	25	200	5	60	1 190	1 555
		S	0.44		80	20	750	220	1 500	100	60	10	40		770
		H	0.05		10	5	350	40	70	30	5	10	20		20
E. smithii	East Boyd S.F.	B	1.37		125	2	3 420	630	2 000	715	70	5	40		1 315
		S	0.77		145	25	1 000	370	1 000	940	90	10	170		1 290
		H	0.03		5	15	260	15	90	155	10	10	80		375
E. viminalis	Newcastle	B	6.41	0.27	205	100	22 450	3 720	1 600	150	570	5	35	1 210	2 410
		S	0.72	0.20	160	30	730	800	1 150	215	60	5	30	570	1 160
		H	0.71	0.09	145	40	200	870	70	190	15	5	60	350	695
E. woollsiona	Forbes	B	9.28		225	95	29 170	2 980	2 900	15	1 350	15	40		3 390
		S	0.49		90	45	500	450	1 100	15	120	5	20		390
		H	0.79		10	10	3 060	160	110	10	30	5	30		20

TABLE 4: Nutrient content of bark, sapwood and heartwood in *Tristania conferta.*

Species	Location or Forestry District	Component	Ash	N	P	Al	Ca	Mg	K	Na	Mn	Zn	Fe	Total -S	Cl
			%		ppm										
Tristania conferta	Glen Innes	B	3.16	0.28	100	20	6 680	750	2 200	285	35	10	15		1 730
		S	0.84	0.18	75	15	800	130	1 050	95	20	5	15		550
		H	1.06	0.17	5	10	1 750	600	1 050	2 000	10	5	50		4 080
	Casino	B	4.18	0.37	130	90	8 850	640	2 600	195	115	50	55		1 480
		S	0.70	0.17	5	5	1 730	460	300	165	5	5	45	380	2 710
		H	1.44	0.22	70	30	3 780	680	1 400	185	15	10	60	1 080	3 080
	Coffs Harbour	B	2.96	0.31	105	40	6 020	700	2 400	90	60	15	10	4 830	1 245
		S	0.76		90	25	570	180	1 150	150	25	5	35		1 080
		H	1.12	0.16	10	20	1 830	720	750	470	15	15	125		3 870
	Kempsey	B	1.66	0.27	65	40	3 230	1 140	1 450	185	50	30	5		1 220
		S	0.61	0.23	75	10	840	260	1 350	155	30	5	155		
		H	1.12	0.26	10	15	1 180	450	350	830	5	5	10		1 700
	Newcastle	B	4.03		90	105	10 340	940	650	140	175	10	115		
		S	0.94	0.24	50	15	1 190	550	850	340	10	5	25		1 630
		H	1.24	0.13	10	2	2 260	730	850	2 540	5	5	55		2 600
	Craven	S	0.83		15	15	820	300	470	185	35	15	25		
	Craven	S	0.84		60	50	630	170	780	170	65	5	45		
	Cambenaria	S	0.40		15	55	540	450	60	210	40	55	25		
	Queensland	H	0.67		5	15	1 150	590	210	2 120	15	5	30		
	Wauchope	H	0.81		10	15	1 630	600	790	2 360	35	2	40		

TABLE 5. Nutrient content of bark, sapwood and heartwood in *Syncarpia glomulifera*.

Species	Location or Forestry District	Component	Ash	N	P	Al	Ca	Mg	K	Na	Mn	Zn	Fe	Total -S	Cl
			%		ppm										
Syncarpia glomulifera	Casino	B	1.35		60	20	950	210	500	235	30	5	55	860	850
		S	0.91		260	30	340	280	1 400	475	20	5	35		1 570
		H	0.50		5	1	160	70	25	20	5	5	60		160
	Coffs Harbour	B	1.12		30	5	1 320	240	160	105	30	2	30		490
		S	0.77		70	25	600	250	950	235	20	10	60	430	975
		H	0.68		5	5	130	75	45	15	5	5	80	280	115
	Kempsey	B	0.69		80	10	1 020	220	180	50	30	5	30		135
		S	0.48		50	10	290	200	80	15	15	5	60		130
		H	0.52		10	20	120	30	70	15	5	5	15		205
	Wauchope	B	0.81		60	25	980	200	1 150	350	35	5	50		970
		S	0.72		85	20	450	220	1 250	240	20	5	45		955
		H	0.83		10	5	170	110	70	15	5	5	70		290
	Newcastle	B	0.95		50	45	1 420	280	270	245	20	5	35		510
		S	0.43		85	20	350	220	800	490	25	5	25		880
		H	0.44		5	10	210	90	30	20	10	5	30		235
	Taree	S	0.60		65	15	700	200	800	130	20	2	10		430
		H	0.46		10	5	130	80	80	40	5	2	20		305
	Beecroft	S	0.40		110	25	240	100	550	270	10	25	45		
		H	0.27		5	1	10	5	70	35	2	5	20		
	Turmeil	S	0.45		50	2	130	70	400	260	10	2	15		
		H	0.41		10	2	5	2	60	40	5	5	10		
	Queensland	H	0.34		5	2	90	20	5	20	5	5	30		

TABLE 6: Nutrient content of bark, sapwood and heartwood in *Callitris* spp.

Species	Location or Forestry District	Component	Ash	N	P	Al	Ca	Mg	K	Na	Mn	Zn	Fe	Total -S	Cl
			%		ppm										
Callitris columellaris	Glen Innes	S	1.01		10	50	3 170	460	320	10	70	5	20		0
		H	1.16		10	50	3 710	510	230	20	55	5	5		5
	Dubbo	B	4.93		65	145	16 500	560	1 800	135	25	5	200		425
		S	0.75		55	25	3 290	250	550	55	55	5	30		275
		H	1.05		10	15	3 800	420	350	15	10	5	20		10
	Barradine	S	0.76		20	20	250	170	310	75	50	5	30	650	165
		H	0.78		5	15	2 160	390	240	20	90	5	15	450	20
	Wedding Mt	S	0.45		10	15	2 780	490	250	20	65	5	25		
		H	0.54		20	20	2 700	170	500	15	35	5	45		
	Queensland	S	0.25		40	15	1 450	200	900	60	70	5	45		
		H	0.38		10	20	2 680	330	210	25	5	5	50		
	Boulder, W.A.	H	0.69		10	30	4 140	660	540	15	10	2	30		
	Mt Binya	H	0.84		10	25	5 800	440	480	50	95	10	20		
Callitris hugelii	Baradine	B	9.50		180	165	36 480	450	1 000	115	115	20	130		
		S	0.79		55	15	2 960	160	600	50	45	5	35		
		Red H	1.07		10	5	4 710	480	380	35	55	5	15		
		Yellow H	0.99		10	5	4 630	350	310	20	40	2	20		

TABLE 7: Nutrient content of bark and wood in various species from published data.

Species	Component	N	P	Ca	Mg	K	Na	Mn	Zn	Fe	S	Cl	Reference
		%	ppm										
Acacia aneura	OB		150	14 000		520							Beadle and White (1968)
	IB		190	33 000		3 300							
	OW		83	2 500		590							
	IB		11	5 800		25							
Acacia spp.	B	0.62	210	7 300	1 100	2 000	200						Feller (1980)
	SW	0.16	160	400	200	400	200						
Ackama paniculata	OB		190	2 000		2 300							Beadle and White (1968)
	IB		160	4 400		3 000							
	OW		53	610		1 100							
	IW		53	490		210							
Banksia aemula	B	0.20	50	3 500	1 230	500	2 020	62	7.0	252		2 800	Westman and Rogers (1977)
	SW	0.10	50	1 500	210	100	740	12	4.2	110		1 250	
Banksia serratifolia	OB		75	2 500		2 300							Beadle and White (1968)
	IB		71	2 000		2 900							
	OW		58	580		1 300							
	IW		15	710		170							
Casuarina cristata	OB		63	50 000		770							Beadle and White (1968)
	IB		190	72 000		1 400							
	OW		70	8 800		770							
	IW		43	8 600		1 800							
Casuarina torulosa	S		40	630	120	450		10	5				Present study (Beecroft)
	H		10	720	140	10	10	15	2				
	S		70	3 180	360	700							Present study (Queensland)
	H		10	1 180	200		25	10	3	35			
Ceratopetalum apetalum	B	0.27	110	13 040	1 070	2 850	155	475	25			415	Present study (Wauchope)
	S	0.17	45	3 210	240	800	175	45	25			180	
	H	0.14	40	1 930	370	1 100	220	25	30		260	180	

TABLE 7—*continued.*

Species	Component	N	P	Ca	Mg	K	Na	Mn	Zn	Fe	S	Cl	Reference
		%	ppm										
Ceratopetalum apetalum	OB		177	5 300		3 900							Beadle and White (1968)
	IB		175	3 150		3 900							
	OW		209	187		1 940							
	IW		113	944		1 695							
Ceratopetalum apetalum	OW		222	438		1 120							Beadle and White (1968)
	IW		100	1 902		3 016							
Ceratopetalum apetalum	OB		225	8 900									Beadle and White (1968)
	IB		190	9 000									
	OW		613	500		2 000							
	IW		228	1 073		1 920							
Ceratopetalum apetalum	OB		85	5 770		1 018							Beadle and White (1968)
	IB		154	3 930		1 000							
	OW		72	2 615		1 240							
	IW		36	2 688		1 685							
E. calophylla	B	0.17	80	4 700	1 400	3 200	1 200	3	2		220	6 100	Hingston *et al.* (1979)
	SW	0.067	20	1 400	1 100	810	350	2	<1		70	1 500	
E. cameronii	OB		120	550		1 800							Beadle and White (1968)
	IB		92	11 000		1 200							
	OW		53	240		370							
	IW		3	30		25							
E. campanulata	OB		140	52 000		4 300							Beadle and White (1968)
	IB		390	53 000		7 700							
	OW		53	60		160							
	IW		3	25		32							

TABLE 7: Nutrient content of bark and wood in various species from published data.

Species	Component	N	P	Ca	Mg	K	Na	Mn	Zn	Fe	S	Cl	Reference
		%	ppm										
E. diversicolor (Red Earth Site)	B	0.18	180	20 900	2 400	4 100	1 300	506	2		220	4 900	Hingston *et al.* (1979)
	SW	0.039	40	650	300	330	70	18	<1		20	370	
E. diversicolor (Yellow podzolic Site)	B	0.17	140	20 600	2 900	2 900	1 010	100	2		200	4 800	Hingston *et al.* (1979)
	SW	0.055	50	730	420	560	110	11	<1		50	470	
E. dives	B	0.46	160	4 800	1 500	1 300	600						Feller (1980)
	SW	0.15	30	300	100	300	200						
E. obliqua	B		138	4 299	2 318	2 664							Attiwill (1980)
	S		128	225	227	588							
	H		16	76	48	60							
	B	0.16	70	1 500	200	500	600						Feller (1980)
	SW	0.08	20	300	100	100	100						
E. oleosa	OB		64	7 000		6 800							Beadle and White (1968)
	IB		88	33 000		5 700							
	OW		45	1 600		1 600							
	IW		3	2 700		540							
E. regnans	B	0.13	160	6 300	1 000	3 600	600						
	SW	0.02	20	300	200	1 800	100						
E. saligna	OB		160	1 000		1 300							Beadle and White (1968)
	IB		97	12 000		2 500							
	OW		110	500		1 000							
	IW		3	100		35							
E. signata (live)	B	0.26	80	15 000	2 000	16 000	2 020	172	11.0	144		4 400	Westman and Rogers (1977)
	SW	0.21	50	750	30	100	1 710	4	2.4	70			
E. signata (dead)	B	0.38	100	9 000	1 000	600	900	18	12.0	350		700	Westman and Rogers (1977)
	S	0.27	50	1 750	430	200	620	4	9.4	150		350	
E. umbra (live)	B	0.31	50	5 500	420	700	2 120	76	7.6	288		1 700	Westman and Rogers (1977)
	S	0.20	50	1 500	30	100	760	18	12.0	195		250	

TABLE 7—*continued.*

Species	Component	N	P	Ca	Mg	K	Na	Mn	Zn	Fe	S	Cl	Reference
		%	ppm										
E. umbra (dead)	B	0.41	50	3 500	1 100	200	600	28	9.4	140		350	Westman and Rogers (1977)
	S	0.23	50	1 750	430	300	640	44	5.0	140		800	
Flindersia maculosa	OB		63	16 000		580							Beadle and White (1968)
	IB		190	23 000		10 000							
	OW		70	4 200		900							
	IW		43	3 500		790							
Geijera parviflora	OB		320	31 000		1 500							Beadle and White (1968)
	IB		520	32 000		6 700							
	OW		190	15 000		900							
	IW		120	11 000		3 200							
Laportea gigas	OB		890	11 000		23 000							Beadle and White (1968)
	IB		760	24 000		39 000							
	OW		330	1 100		12 000							
	IW		470	1 900		18 000							
Orites excelsa	OB		360	81		1 300							Beadle and White (1968)
	IB		140	380		2 800							
	OW		94	92		1 300							
	IW		27	270		400							
Owenia acidula	OB		120	30 000		2 400							Beadle and White (1968)
	IB		450	29 000		17 000							
	OW		81	4 900		1 000							
	IW		11	7 000		290							
Tarretia actinophylla	OB		240	1 700		900							Beadle and White (1968)
	IB		150	16 000		2 200							
	OW		91	760		2 600							
	IW		80	750		900							

Legend: B Bark; SW Stemwood; S Sapwood; OB Outer Bark; IB Inner Bark; OW Outer Wood

TABLE 8: Mean nutrient concentrations and coefficients of variation for twelve 5- and 30-year-old *Eucalyptus pilularis* sapwood and heartwood.

Stand age	Component		Ash	P	Al	Ca	Mg	K	Na	Mn	Zn	Fe
			%	ppm								
5 years	Sapwood	Mean	0.23	62	38	151	128	327	221	10	10	33
		C.V.	36	32	180	30	49	38	38	35	4	44
	Heartwood	Mean	0.17	13	43	100	89	146	179	6	14	33
		C.V.	13	42	129	40	63	74	42	49	49	58
		P0.05	0.04	10	N.S.	N.S.	29	62	N.S.	1	N.S.	N.S.
30 years	Sapwood	Mean	0.23	43	8	173	121	494	187	13	7	30
		C.V.	32	39	63	19	35	29	22	51	64	33
	Heartwood	Mean	0.03	4	4	63	14	8	64	2	5	40
		C.V.	52	46	37	39	65	42	38	78	34	35
		P0.05	0.06	10	3	16	26	83	28	4	N.S.	N.S.

TABLE 9: Mean and coefficients of variation for chemical analyses of outer bark, inner bark, sapwood and heartwood of twenty discs sampled at 120 cm intervals along a mature *P. radiata* stem.

Component		Ash	P	Al	Ca	Mg	K	Na	Mn	Zn	Fe
		%	ppm								
Outer Bark	Mean	0.68	89	248	1 872	426	718	93	39	21	90
	C.V.	26	29	10	25	34	28	15	30	20	42
Inner Bark	Mean	4.56	699	380	9 385	1 868	743	389	188	78	221
	C.V.	10	10	28	17	18	10	23	9	15	163
Sapwood	Mean	0.40	50	7	900	459	937	28	49	11	37
	C.V.	21	17	120	25	21	21	74	15	35	66
Heartwood	Mean	0.30	7	665	1 149	477	280	25	54	69	58
	C.V.	33	64	111	31	16	14	67	22	1	64

TABLE 10: Chemical analyses of bark, sapwood and heartwood from mature *P. radiata*.

Location or Forestry District	Component	Ash	N	P	Al	Ca	Mg	K	Na	Mn	Zn	Fe	Cl	Total S	Reference
		%	%	(ppm—O.D. wt basis) in each component											
Glen Innes	B	1.21		100	630	2 190	380	1 380	55	50	10	150	110		
	S	0.30		35	35	880	270	750	15	65	5	30	65	530	
	H	0.25		10	20	480	140	220	20	55	5	25	45	360	
Bathurst	B	1.85		70	315	3 610	360	1 270	90	70	15	90	80		
	S	0.34		45	40	940	220	890	20	115	10	50	10		
	H	0.32		7	35	900	150	290	55	75	15	20	20		
Metropolitan	B	0.83		50	220	3 490	320	1 240	75	60	10	25	100		
	S	0.42		65	45	940	250	1 150	50	50	15	55	45		
	H	0.17		15	2	590	330	340	10	50	10	25	10		
South East	B	1.55		90	225	4 950	230	1 500	90	40	15	75	55	710	
	S	0.34		30	50	520	125	690	50	35	10	90	10		
	H	0.33		10	10	760	370	300	15	30	10	45	20		
Tumut	B	1.65		80	240	3 120	310	1 230	80	50	10	70	170		
	S	0.35		20	30	510	195	610	130	20	5	35	240		
	H	0.25		25	2	570	280	520	90	45	5	15	50		
Riverina	B	2.09		80	155	5 920	360	1 490	325	135	15	135	355	430	
	S	0.46		60	40	720	220	780	55	115	10	45	20		
	H	0.38		10	15	1 070	490	270	20	100	10	65	25		
A.C.T.	B (old)			60											Crane and Raison (1981)
	B (new)			502											
	S (outer)			163											
	S (inner)			80											
	H			29											

TABLE 10—*continued.*

Location or Forestry District	Component	Ash	N	P	Al	Ca	Mg	K	Na	Mn	Zn	Fe	Cl	Total S	Reference
		%	%	(ppm—O.D. wt basis) in each component											
Kaingaroa, N.Z.	B		0.390	680		2 000		5 700							Orman and Will (1960)
	S (outer)		0.059	100		250		900							
	S (inner)		0.045	70		330		570							
	H		0.045	20		420		440							
Victoria	B		0.262	290	405	2 400	920	2 990		27	9.8	52			Stewart *et al.* (1981)
	SW*		0.082	130	<50	520	220	920		20	3.3	15			

* Age = 15 years hence stemwood mostly sapwood.

TABLE 11: Nutrient content of heartwood from various species, expressed as percentages of the pure ash. The analyses were carried out gravimetrically within the Forestry Commission of N.S.W. during the period 1939–1945.

Species	Spec. gravity air-dry	Percent of wood		Percentage of pure ash										
		Crude ash	Pure ash	P_2O_5	Al_2O_3	CaO	MgO	K_2O	Na_2O	MnO	Fe_2O_3	SO_5	Cl	SiO_2
Amoora nitidula	.86	1.452	.942	3.14	.01	46.04	9.32	31.68	3.48	.76	.30	2.96	.70	1.62
Angophora spp.	.90				6.70	62.88		9.33						
Auracaria cunninghamii	.56	1.071	.685	1.05	1.19	48.69	10.38	17.89	10.45	.06	1.03	2.13	1.24	5.91
Casuarina torulosa	.93	.681	.437	1.65		64.64	10.28	11.90	4.24	.90	.36	3.58	1.59	1.18
Cedrela australis	.53	1.102	.840	9.39	1.05	59.21	14.37	19.73	6.61	.20	.73	1.31	.72	6.69
Cinnamomum camphora		1.300	1.011	6.35	1.58	23.04	19.49	36.31	5.04		1.65	1.88	.19	4.47
Dissiliaria baloghioides	1.04	1.035	.708	2.62	.38	52.56	7.95	23.36	4.68	.83	.29	1.01	.20	6.13
Eucalyptus acmenioides	1.02	.065	.060	2.08	3.81	9.49	4.38	9.49	10.98	.34	4.53	3.17	.23	51.51
Eucalyptus corymbosa	.99	.089	.075	1.98	1.73	12.50	6.96	12.74	14.64	.42	4.18	3.49	.68	40.66
Eucalyptus corymbosa	.99	.164	.115	.84	.17	13.05	18.01	25.93	11.68	.09	3.66	1.67	.71	24.19
Eucalyptus microcorys	1.01	.131	.103	.97	2.16	26.98	34.16	3.95	3.31	.38	1.55	3.34	.18	23.06
Eucalyptus microcorys	1.02	.251	.183	.40	1.09	52.15	25.58	2.41	6.84	.18		1.93	.58	8.96
Eucalyptus pilularis	.88	.119	.098	2.74	2.06	14.36	11.05	15.92	18.73	.79	3.11	3.51	.69	27.05
Eucalyptus propinqua	1.06	.180	.162	6.51	2.96	28.88	7.74	11.39	9.08	.79	2.31	4.12	.87	25.36
Eucalyptus resinifera	.98	.054	.047	.76	1.61	17.30	4.81	9.16	14.41	.25	4.79	6.24	.49	40.18
Eucalyptus siderophloia	1.12	.085	.078	3.87	3.33	22.80	8.39	6.44	12.19	1.38	2.78	5.75	.47	32.60
Eucalyptus tereticornis	1.01	.140	.131	14.04	3.34	19.18	3.62	9.14	11.68	1.21	2.74	3.77	.46	30.85
Eucalyptus tesselaris	1.01			15.65		55.75		8.61						
Euroschinus falcatus	.48	.926	.629	2.92	.29	37.76	18.82	33.88	1.65	.90	.25	1.09	.94	1.50
Flindersia oxleyana	.74	.446	.325	2.25	.27	45.23	17.14	14.47	3.02	2.45	.47	10.16	.44	3.51
Flindersia schottiana	.64	.781	.517	2.25	.12	51.88	15.77	20.54	2.40	1.68	.20	1.56	.21	3.40
Myrtus hillii	.89	2.043	1.125	1.85		64.42	24.37	6.65	1.02	.07	.20	.93	.07	.44
Naba fasciculosa	.89	2.792	1.859	1.77	.72	62.78	21.78	8.32	1.40	.87	.39	1.50	.06	.42
Polyalthia nitidissima	.90	.768	.678	12.23	.28	28.31	28.31	13.10	8.31	2.81	.43	2.62	.24	2.65
Sideroxylon pohlmanianum	.93	.822	.589	3.43		45.84	22.16	19.87	.86	.91	.68	4.24	.49	1.51
Syncarpia laurifolia	1.00	.367	.367	.35	1.26	1.88	1.83	1.20	4.08	.08		.82		89.74
Tarrietia argyrodendron	.96	1.494	.921	2.72		52.62	22.25	15.50	1.33	.73	.23	3.29	.03	1.62
Tristania conferta	.86	.970	.830	.34	.65	31.13	9.10	7.90	6.83	.46		.70	5.15	38.90
Vitex ligmun-vitae	.89	1.135	.706	4.15	.02	54.71	9.56	26.26	2.57	.14	.19	1.29	.06	1.06
Weinmannia lachnocarpa	.94	1.444	.902	2.70	.14	51.45	27.21	9.96	1.25	1.02	.21	4.96	.06	1.02

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