ABOVE-GROUND BIOMASS, NUTRIENTS, AND ENERGY CONTENT OF TREES IN A SECOND-GROWTH STAND OF AGATHIS AUSTRALIS

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ABSTRACT

A 130-year-old pole stand in which over 90% of the trees and the basal area were **Agathis australis** Hort. ex Lindl. (kauri) was estimated to include 10 t foliage/ha, 17 t branches/ha, and 105 t stems/ha in the tree layer. The foliar nutrient concentrations suggested deficiencies of both nitrogen and phosphorus. The trees contained 187 kg N/ha, 27 kg P/ha, 391 kg K/ha, 511 kg Ca/ha, 56 kg Mg/ha, 32 kg Mn/ha, 0.1 kg Cu/ha, and 2.2 kg Zn/ha. Energy values ranged from 19 kJ/g for dead branches to 22 kJ/g for older foliage.

INTRODUCTION

Active regeneration of kauri has occurred over considerable areas of logged old-growth stands in the northern part of the North Island of New Zealand. Little information on nutrient uptake is available, though studies by Peterson (1962) of foliar nutrient levels suggest that nitrogen deficiency may be widespread among forest trees. Additional unpublished data we have collected also indicate low levels of nitrogen and, to a lesser extent, of phosphorus in planted kauri. The installation of a thinning and fertiliser experiment by the Auckland Regional Authority in a naturally regenerated stand of kauri has been used to obtain information on the dry matter, nutrients, and energy content of a pole-stage stand.

MATERIALS AND METHODS

The stand is located in the Mangatangi area of the Hunua Ranges (lat. 37° 07′ 20″S, long. 175° 12′ 35″E). The experimental area is located on a north-facing slope and had a closed canopy. Three sample plots in the vicinity of the sample kauri trees cut for weight determination averaged 10.5 m in height and contained 1440 stems/ha with a basal area of 29.1 m^2/ha. Ring counts indicated a stand age of about 130 years. Over 90% of the stems and 93% of the basal area comprised kauri, the remaining trees being tanekaha (*Phyllocladus trichomanoides* D. Don). For the purpose of estimating stand values it was assumed that the tanekaha weighed the same and had the same energy and nutrient contents as kauri of similar diameter.

Six sample kauri trees were felled in February 1980 and their diameter at breast height and their total height were measured. Height increment for the previous 10 years was estimated from the presence of bud scars on the main stem. Each sample tree was separated into current and older foliage bearing twigs, branches, cones, and stems, and then weighed. Only one tree carried branches without green leaves (dead branches).

Field and laboratory handling of samples were according to methods previously described (Madgwick *et al.* 1981).

In addition to the trees sampled in detail, the heights of 45 other trees felled as part of the thinning treatment were recorded. These data were used to calculate a height-diameter curve in order to estimate the height of the remaining (uncut) trees.

RESULTS AND DISCUSSION

Unweighted average concentrations of nitrogen, phosphorus, calcium, magnesium, and copper in current foliage (Table 1) were within the range of values found by Peterson (1962). Potassium concentrations were higher than those of Peterson, possibly because our sampling date was earlier in the season and our trees were older (Peterson 1961). Comparison with Peterson's work suggests that the study area is deficient in nitrogen and phosphorus. Energy values on a weight basis were very similar to those for a range of *Pinus* species (Madgwick 1970).

TABLE 1—Unweighted average nutrient concentrations and energy values of six kauri trees

	Current leaves	Older leaves	Live branches	Dead branches	Cones	Stem wood	Stem bark
Nutrients							
N (%)	0.81	0.66	0.25	0.11	0.36	0.05	0.14
P (%)	0.089	0.053	0.038	0.010	0.049	0.008	0.036
K (%)	1.04	0.54	0.64	0.19	1.33	0.08	0.68
Ca (%)	0.78	1.49	0.82	1.10	0.10	0.06	0.95
Mg (%)	0.14	0.10	0.11	0.14	0.06	0.01	0.11
Cu (ppm)	3.4	1.8	1.5	0.6	3.7	0.5	0.8
Mn (ppm)	543	1383	510	303	61	44	261
Zn (ppm)	27	67	42	25	14	4	24
No. of obs.	6	6	6	1	4	6	6
Energy (kJ/g)	21.8	22.2	19.4	19.3	20.2	19.7	18.4
No. of obs.	3	3	3	1	2	3	3

Dry weight and stand nutrient and energy contents are given in Table 2. The dearth of information on second-growth native forests in New Zealand means that there is little basis for comparison except with plantations of introduced species. The weight of current leaves was 1.2 t/ha which is low compared with expected foliage production at the latitude of the sample plot as suggested by the world summary of litter fall by Bray & Gorham (1964) and compared with annual litter fall in native forests (Miller 1963; Daniel 1975). The total foliage weight of 10 t/ha is comparable to values for closed stands of both *Pinus radiata* D. Don and *Eucalyptus* spp. in the central North Island (Madgwick *et al.* 1977, 1981). The weight of live branches was similar to that expected for closed stands of *P. radiata* at similar stocking (Madgwick *et al.* 1977).

TABLE 2—Above-ground dry weight, nutrients, and energy content of trees* in a pole-stage kauri stand

	Current leaves	Older leaves	Live branches	Cones	Stem wood	Stem bark	Total
Dry weight (t/ha)	1.2	9.3	17.1	1.0	84.8	20.2	133.6
Energy (10^{11} J/ha)	0.3	2.1	3.3	0.2	16.7	3.7	—
Nutrient content (kg/ha)							
N	11.1	63.6	39.3	3.3	43.2	28.1	186.6
P	1.1	5.1	6.3	0.4	6.9	7.1	26.5
K	13.3	49.8	104.4	12.5	67.1	147.6	391.1
Ca	9.0	140.8	136.9	0.9	54.2	171.8	510.7
Mg	1.7	7.8	17.6	0.6	9.0	20.2	56.5
Mn	0.7	14.0	8.6	0.1	3.8	5.3	32.3
Nutrient content (g/ha)							
Cu	4.1	16.7	23.8	3.4	41.4	14.9	103.2
Zn	33	726	612	13	360	442	2162

* Includes small percentage of tanekaha, values assumed to be similar

Compared with *P. radiata* stands of comparable weight (Madgwick *et al.* 1977), the kauri stand contained the same order of magnitude of total weight of nitrogen, phosphorus, magnesium, and zinc, but it contained more potassium and manganese and much more calcium.

Current annual growth and nutrient uptake are both difficult to estimate because of the nature of the stand. The four dominant or co-dominant trees sampled in detail had grown approximately 24 cm/year in height over the previous 10 years and it was clear from examination of growth rings that the trees had remained in a suppressed state for a long period before that, and so the estimated mean annual growth rate of 1 t/ha is well below the current growth rate. However, the broad comparability of the total tree nutrient contents compared with *P. radiata* plantations of the same dry weight suggests that nutrient demands on the site are lower than for planted pines, which would be expected to attain the same above-ground weight in about one-tenth the time.

Our information on kauri dry matter and nutrient contents is limited but should prove useful in the study of fertiliser response. We trust our data will provide a stimulus to further work with this important native species.

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