GROWTH OF PAMPAS GRASS (*CORTADERIA* SPP.) IN NEW ZEALAND *PINUS RADIATA* FORESTS

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ABSTRACT

Rate of pampas (*Cortaderia selloana* (Schult.) Asch. et Graeb. and *C. jubata* (Lem.) Stapf) growth in five *Pinus radiata* D. Don forests was only slightly less than in managed agricultural pampas plantations. Number of plants per unit area tended to be higher on phosphate-amended clay soils than on pumice or coastal sands, but the maximum rate of above-ground dry matter accumulation on these soils was similar (7–8 t/ha/year). Greatest accumulation of pampas dry matter (55 t/ha at age 4) was recorded on a coastal sand in an area where no trees were present. The highest dry matter accumulation recorded in a tree stand was 46 t/ha on a pumice soil.

Keywords: biomass; clay; pumice; coastal sand; *Cortaderia selloana*; *Cortaderia jubata*; *Pinus radiata*.

INTRODUCTION

A preliminary account (Gadgil *et al.* 1984) of the problems caused by introduced pampas grasses in plantation forests drew attention to the fact that few measurements had been made on pampas in the forest environment. Agricultural use of pampas (mainly *Cortaderia selloana*) for shelter and as supplementary stock fodder was common in New Zealand between 1930 and 1950 and information about pampas published during that period has been reviewed by Jacques (1957). Data derived from transplants grown in the open on agricultural soils are not necessarily applicable to pampas which invades poorer forest soils. In order to provide a background for studies on pampas control, a productivity survey was carried out in forests where pampas had become particularly aggressive.

METHODS

Five North Island *Pinus radiata* forests were selected (Table 1). A search was made in each forest for areas of pampas which had not been influenced by herbicides, grazing, or silvicultural practice other than clearfelling, and a selection was made which covered a range of pampas ages from 0 to 9 years. Pampas age was assumed to equal the number of years from clearfelling of the previous tree crop.

TABLE 1–Study areas

Forest	Latitude	Longitude	Mean daily air temperature 1941–70 (°C)	Mean annual rainfall 1941–70 (mm)	Soil
Kawhia	38°04' S	174°49' E	15.0	1418	Young yellow-brown sand derived from young coastal sand
Maramarua	37°18' S	175°15' E	13.3	1271	Yellow-brown earth derived from greywacke (clay loam)
Omataroa	38°02' S	176°49' E	14.0	1533	Yellow-brown pumice soil derived from young volcanic ash
Riverhead	36°46' S	174°35' E	14.0	1463	Yellow-brown earth derived from claystone, sandy shale, or mudstone (clay)
Waiuku	37°16' S	174°40' E	14.0	1452	Young yellow-brown sand derived from young coastal sand

Pampas productivity was assessed by marking out plots and cutting and weighing all the above-ground pampas material. The number of plants harvested was also recorded. Subsamples of harvested material were dried to constant weight at 70°C so that total above-ground dry matter production could be calculated. Individual plots were sampled once only.

Early colonisation by pampas seedlings was studied in Cpt 10 Waiuku and Cpt 24A and 27 Maramarua as soon as clearfelling, site preparation, and planting activities had ceased. In each of these compartments a 20 × 20-m representative area was divided into 2 × 2-m plots. For 1 year pampas productivity was assessed every 1–4 months in each of at least 10 plots in each compartment. Error due to trampling was avoided by sampling contiguous plots in succession. This procedure of repeated sampling for 1 year was also carried out in Cpt 24B Maramarua, which had been clearfelled 14 months previously.

Other sites were sampled once only, using a plot size of 4 m^2 up to 3 years from clearfelling. Tussock formation in older plants often necessitated the use of larger plots with dimensions calculated to include an average of at least three plants per plot.

The data were weighted by plot size to estimate above-ground mass per hectare at each site. In a more intensive study of young plants, adjacent plots were examined sequentially at 2- to 3-month intervals during the first year (Cpt 10 Waiuku; Cpt 24A and Cpt 27 Maramarua) or the second year (Cpt 24B Maramarua) after the clearfelling of a previous crop of trees.

The rooting depth of pampas was examined at Waiuku Forest in trenches dug to determine rooting depth of *P. radiata* in 2-, 4-, and 5-year-old tree stands (Parker 1987).

RESULTS

Difficulties associated with distinguishing between the introduced *Cortaderia* species by vegetative features (Knowles & Ecroyd 1985) mean that data for any particular site may represent *C. selloana*, *C. jubata*, or a mixture of these species.

Plant frequency (defined as the number of plants or tussocks per unit area) was very variable during the first year, both within and between compartments of the same forest (Table 2; Fig. 1). At this early stage of development differences within a forest (e.g., Cpt 24A and 27 at Maramarua) were sometimes greater than those associated with different soil type (e.g., Cpt 24A Maramarua, Cpt 10 Waiuku). Total productivity and individual plant dry weight during the first year were both lower at Waiuku than in either of the clay forests. Productivity at Riverhead appeared to be similar to that at Omataroa and much greater than at Maramarua during the second year (Table 3; Fig. 2).

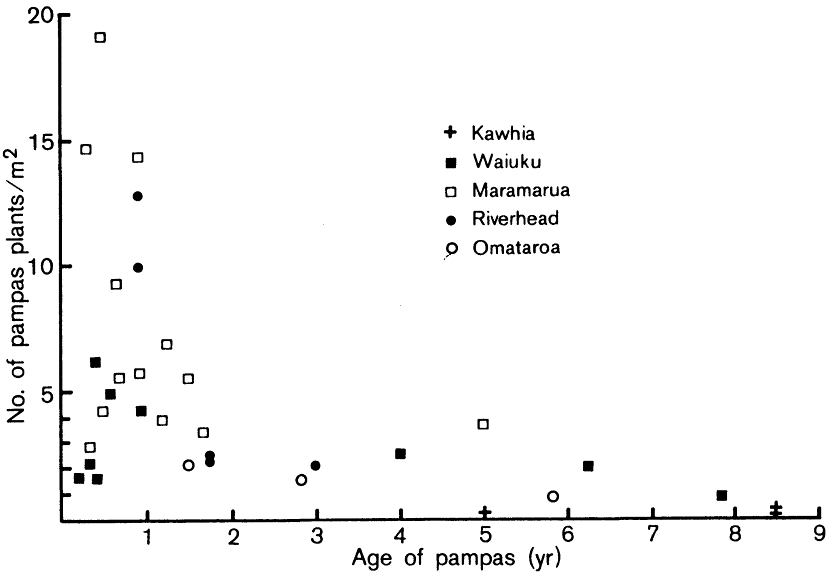

FIG. 1—Relationship between pampas age and pampas plant frequency in five North Island *Pinus radiata* forests.

The highest value for accumulated dry matter was 55.1 t/ha, recorded in 4-year-old pampas growing in the open at Waiuku. Values exceeding 40 t/ha were recorded at Waiuku and Omataroa in 4- to 8-year-old pampas, those at Waiuku again being free of trees.

The highest estimates of dry matter production rate were recorded for 3- to 6-year-old pampas: Cpt 22 Waiuku (no trees) 13.8 t/ha/year; Cpt 47B Omataroa 7.9 t/ha/year; Cpt 16 Riverhead 7.7 t/ha/year; Cpt 44 Maramarua 7.6 t/ha/year; Cpt 15 Kawhia 3.9 t/ha/year. Pampas between 4 months and 2 years old was characterised by low dry matter increment (0.004–3.0 t/ha/year). The highest mean weight per plant (13.1 kg) was recorded in 5-year-old pampas at Kawhia where there were no trees.

Pampas roots were commonly present at a depth of 1.8 m in a 2-year-old tree stand, 2.1 m in a 4-year stand, and 2.4 m in a 5-year stand. Maximum rooting depth was not determined.

TABLE 2–Dry matter and plant frequency in pampas stands less than 1 year old (sample plot size 4 m^2)

Forest	Compartment	Fertiliser applied* (kg/ha)	Fertiliser applied* (year)	Age of pampas stand (years)	Dry weight of pampas above-ground (g/m^2) Mean	Dry weight of pampas above-ground (g/m^2) s.e.	Pampas frequency (No. plants/m^2) Mean	Pampas frequency (No. plants/m^2) s.e.
Maramarua	24A	SP230	1983	0.33	ND		2.86	0.01
	24A	SP230	1983	0.50	0.64	0.01	4.24	0.05
	24A	SP230	1983	0.67	5.64	0.08	5.54	0.05
	24A	SP230	1983	0.92	17.45	0.56	5.70	0.10
	27	SP230	1983	0.33	2.97	0.36	14.72	0.42
	27	SP230	1983	0.50	7.45	0.31	19.16	0.47
	27	SP230	1983	0.67	18.23	0.55	9.27	0.18
	27	SP230	1983	0.92	153.39	4.96	14.40	0.38
Riverhead	8	SP630	1958	0.92	122.63	13.26	9.92	0.89
		TSP150	1983					
	8	SP630	1958	0.92	413.46	17.32	12.73	0.98
		TSP150	1983					
Waiuku	10			0.17	ND		1.62	0.01
	10			0.33	ND		2.17	0.04
	10			0.42	ND		1.17	0.03
	10			0.42	0.18	0.01	6.15	0.63
	10			0.58	0.23	0.01	4.97	0.08
	10			0.92	4.83	0.26	4.24	0.21

* SP = superphosphate (8–10% phosphorus)
TSP = triple superphosphate (20% phosphorus)
ND = not determined

TABLE 3–Dry matter and plant frequency in pampas stands more than 1 year old

Forest	Compartment	Tree age (years)	Fertiliser applied* (kg/ha)	Fertiliser applied* (year)	Mean plot size (m^2)	Age of pampas (years)	Dry weight of pampas above-ground (t/ha) Mean	Dry weight of pampas above-ground (t/ha) s.e.	Pampas frequency (No. plants/m^2) Mean	Pampas frequency (No. plants/m^2) s.e.
Kawhia	15	–	?	?	22.5	5.00	19.64	1.91	0.15	0.04
	19	8	CAN200	?	59.5	8.50	6.04	0.22	0.19	0.01
	20	8	CAN200	?	16.0	8.50	22.04	0.94	0.32	0.02
Maramarua	24B	1	SP230	1983	4.0	1.17	0.24	0.01	3.93	0.09
	24B	1	SP230	1983	4.0	1.25	0.39	0.03	6.85	0.42
	24B	1	SP230	1983	4.0	1.50	0.28	0.02	5.50	0.19
	24B	1	SP230	1983	4.0	1.67	0.42	0.01	3.44	0.05
	44	5	?	?	4.0	5.00	37.84	5.48	3.63	0.30
Omataroa	43	1	–	–	4.0	1.50	3.13	0.07	2.15	0.04
	47A	2	–	–	8.5	2.83	17.03	0.79	1.51	0.07
	47B	5	–	–	18.0	5.83	45.96	2.82	0.84	0.11
Riverhead	8	1	SP630	1958	4.0	1.75	2.09	0.09	2.41	0.12
			TSP150	1983						
	8	1	SP630	1958	4.0	1.75	5.20	0.34	2.25	0.19
			TPS150	1983						
	16	3	SP630	1959	4.0	3.00	23.10	1.77	2.00	0.11
			TSP325	1982						
			TSP160	1984						
Waiuku	22	–	–		4.0	4.00	55.10	9.07	2.50	0.88
	24A	–	–		4.0	6.25	52.14	5.21	1.90	0.34
	24B	–	–		17.7	7.83	48.39	5.13	0.78	0.09

* CAN = calcium ammonium nitrate
SP = superphosphate (8–10% phosphorus)
TSP = triple superphosphate (20% phosphorus)
? = uncertain

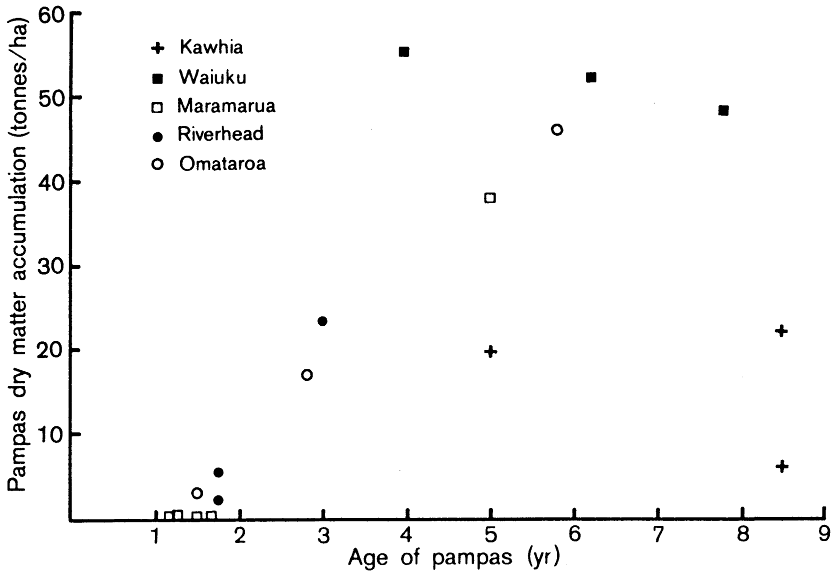

FIG. 2—Pampas productivity (above-ground only) in five North Island *Pinus radiata* forests.

DISCUSSION

Direct comparisons between most agricultural yield data and our values for undisturbed stands should be treated with caution. Jacques (1956) showed that pampas yield is inversely proportional to frequency of cutting, and it is clear that most agricultural data were derived for growth after a previous cut. Most managed pampas plantations on farmland contained 0.2–0.3 individuals/m^2 with a physiological age at least 1 year in advance of the plantation age (Lynch & Osborn 1948).

The highest rate of dry matter production claimed for an agricultural pampas plantation in New Zealand is 19.4 t/ha/year in an undisturbed 2-year-old stand (Aston 1934). Jacques (1957) regarded this value as exceptionally high and unrelated to average productivity in managed stands. Our data for pampas as a forest weed indicate that values of 7–8 t/ha/year can be expected in infested stands after age 3. This is only slightly lower than the expected yield from a mature, managed, agricultural plantation (9 t/ha/year—Dunlop & Coup 1951). It is still a formidable rate of dry matter production, being approximately half of that calculated for close-spaced 5-year-old *P. radiata* growing on a highly productive site (Madgwick 1981). Intensively managed ryegrass/clover (*Lolium perenne* L./*Trifolium repens* L.) pasture in the North Island of New Zealand produces 9–11 t/ha/year, with an estimated year-to-year variation of 1–4 t/ha (Baars 1982).

Agricultural surveys (Lynch & Osborn 1948; Jacques 1951) have suggested that, although distribution of pampas plantations was not determined primarily by soil type, best growth was associated with deep well-drained soils, especially rich alluviums, pumice, and stabilised sands (Jacques 1957). Our data show that dry matter accumulation can be as rapid on a poorly drained (but phosphate-amended) clay as on pumice or coastal sand.

The influence of tree age and density on pampas development is difficult to assess from the present survey. A study of tree stand effects (including shading) would require experimental sites where the influence of pampas control measures could be kept constant. Rooting depths of *P. radiata* in 2-, 4-, and 5-year-old stands in Waiuku Forest were reported by Parker (1987) to be 0.60 ± 0.02 m at age 2, 1.80 ± 0.04 m at age 4, and 1.90 ± 0.07 m at age 5. Pampas root observations reported here were made in the trenches used for the pine study. They show that pampas rooting depth was greater than that of *P. radiata* at ages 2 and 4, but not necessarily at age 5.

Most pampas mortality occurs during the first 2 years, when the tree effect would be negligible. Pampas plants surviving beyond age 2 are remarkably persistent and develop into large tussocks as numbers of new tillers are produced. With the exception of one site at Maramarua, mean plant frequency was not greater than 2.5/m^2 after age 2. Even so, the accumulation of 22–46 tonnes of pampas dry matter per hectare in stands 3–9 years old was associated with tree densities of 656 stems/ha at Kawhia, 1150 stems/ha at Maramarua, 949 stems/ha at Riverhead, and 500 stems/ha at Omataroa. Pampas growth of these proportions almost certainly has some negative effect on tree growth. Competition for physical and nutritional resources must occur and it is possible that growth of both pampas and trees is limited on some unamended forest soils. Under such conditions, fertiliser amendments designed to increase *P. radiata* productivity are likely to increase the growth and competitive ability of pampas. This could account for high initial plant frequency and subsequent high dry matter accumulation of pampas in forests on clay soils. Higher pampas productivity at Riverhead than at Maramarua was associated with (but not necessarily caused by) a longer history of site amendment with phosphate fertiliser.

The adoption and maintenance of control measures (herbicides, grazing) will ensure that pampas growth of the magnitude documented here does not occur in managed forests. Presentation of our data is intended as a reminder of what could happen if vigilance is relaxed.

CONCLUSIONS

The following inferences can be drawn from the results of the productivity survey:

(1) Mortality of pampas plants is greatest during the first 2 years.

(2) Plants surviving for 2 years or more in forest stands are highly persistent.

(3) Pampas dry matter accumulation rates of 7–8 t/ha/year can be expected after age 3 in infested forest stands.

(4) These rates can be expected on clay soils amended with phosphate fertiliser as well as on coastal sand and pumice soil.

(5) The highest recorded accumulation of pampas dry matter in a tree stand is 46 t/ha on a pumice soil at Omataroa Forest.

(6) At any given age, pampas plant frequency tends to be higher on phosphate-amended clay soils than on coastal sand or pumice soil.

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