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Possum Damage to Pine Plantations in North-eastern New South Wales

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Abstract

The amount of damage caused by possums was assessed in a plantation of southern pine (*Pinus taeda*) in north-eastern New South Wales. Four types of damage were recognized and these were classified according to the area of bark stripped from the tree and the tree structure. Damage was concentrated at the periphery of the plantation and only reached high levels (>60% of trees damaged) where the plantation was adjacent to the wetter types of native forest. These areas are the habitat of the mountain possum *Trichosurus caninus*. Elsewhere damage was generally low and merged into a background level of damage (9.1%) that probably resulted from natural forking. Total damage to the 950-ha plantation was estimated to be 13.9%.

[O.D.C. 451.2 : 174.7 *Pinus* spp. – 228.7 : (944)]

Introduction

Several reports have established that mammals cause damage to exotic pine plantations and regenerating native forest (McNally 1955; Baur 1958; Mollison 1960; How 1968; Cremer 1969). Damage, which takes the form of defoliation, stripping of bark or removing the growing tip, has been attributed to four groups – phalangers, macropods, murid rodents and lagomorphs. Damage by macropods and rabbits can be prevented by fencing. That caused by possums, however, is more serious because it is not limited to the early establishment period of the plantation and because possums cannot be excluded by fencing. Furthermore, damage caused by possums results in permanent loss of timber, not merely a temporary pause in growth as occurs with some types of damage (Storm and Halvorson 1967). Possum damage to the leading shoot generally causes subsequent bifurcation so that the younger the crop when damaged the greater is the loss of timber.

While some reports of damage do not specify how the assessment was made or the nature of the damage category (Baur 1958; How 1968) and do not consider the distribution of the damage within the plantation (McNally 1955) they do indicate that serious levels of damage have occurred in Victoria and parts of New South Wales. Four plantations of *Pinus radiata* D. Don. in Victoria showed between 63 and 88% damage (McNally 1955). In two of these plantations possums were the main agents of damage and in the Narbethong Plantation the mountain possum, *Trichosurus caninus* (Ogilby), was specified. At Clouds Creek in north-eastern New South Wales 45% of 13-year-old *Pinus taeda* Linn. and 60% of 14-year-old *P. elliottii* Engelm. were damaged by possums in 1964 (Dawson, personal communication). These figures indicated that some control was necessary to reduce the level of damage.

Various measures for controlling possums have been attempted in Australia. Poisoning was assessed in Tasmania and an ecological study of possums (Mollison 1960) was recommended. Eight years later poisoning and trapping were still being used to control macropod and possum damage to regenerating mountain ash (*Eucalyptus regnans*) (F. Muell.) forest (Cremer 1969).

How (1972) showed that neither *T. caninus* nor the brush-tailed possum, *T. vulpecula* (Kerr) permanently inhabited pine plantations at Clouds Creek. He recommended that since trees were not damaged by possums until they were older than 9 years the plantings should radiate outwards from the initial plantings so that the younger plantings would provide a buffer between the native habitat and the susceptible older pines. Since these recommendations were made possum damage to 5-year-old *P. taeda* has been observed at Clouds Creek.

This paper analyses the distribution of damage within a pine plantation in relation to distance from the periphery and the type of adjacent native vegetation, the nature of the damage and species preferences, and whether previous surveys have given an adequate background for the need and implementation of control measures.

Survey Areas and Methods

The plantation survey was conducted at Clouds Creek State Forest (30°05′S., 152°37′E.) at an altitude of 500–800 m on the eastern escarpment of the New England Tableland in north-eastern New South Wales. In addition, arboreta were surveyed at Welcome Flat, 25 km north-east of Dorrigo and at Charlies Plain (Fig. 1).

The native vegetation of the region is dominated by forests, with subtropical rainforest, wet sclerophyll forest and dry sclerophyll forest being the three predominant types (Fig. 1). Woodland also occurs in the area and there are some anomalous grassland communities associated with basaltic soils (Baur 1962). A pine plantation, principally of *P. taeda*, has been established on 950 ha of cleared native forest since 1965, but small experimental plantings of this species and *P. elliottii* were made in 1950 and 1951. Of the areas surveyed only compartment 1 had been thinned.

Classification of Damage

'Signs of possum damage are characteristic. After a small area of bark has been gnawed away, long strips are torn off and allowed to fall to the ground ... the animal scrapes the ... cambial layer from the wood [but] the bark itself is not eaten.' [McNally (1955) referring to pine plantations.]

To distinguish possum damage from that by terrestrial species such as macropods and rabbits only damage above 2 m was assessed.

Damage was classified into five types (Fig. 2).

1. Normal – no damage could be detected from the ground. This resulted in a conservative assessment as some damage may have been obscured by foliage.
2. Barked – damage to the bark was insufficient to ringbark the tree.
3. Ringbarked – barking girdled the stem of the tree.
4. Topped – the growing tip had broken off probably following ringbarking.
5. Forked – two laterals had become prominent and no remnant of the original leader could be seen. Without felling each tree it was uncertain whether forking resulted from topping or was natural. By including this category in total damage the amount attributed to possums was overestimated.

Where several types of damage occurred on one tree the damage type of highest classification was recorded (see Fig. 2*b*).

Areas Surveyed

Five compartments of recent plantings around the periphery of the plantation were surveyed for damage. In each compartment two parallel surveys were conducted away from the periphery of the plantation and the type of damage to every tree assessed in about a 6-m wide band according to the above classification and the scores were cumulated every 25 m. The survey usually extended through an entire compartment. Compartment 25 in the centre of the plantation and compartment 1 on the periphery were assessed as blocks of parallel rows.

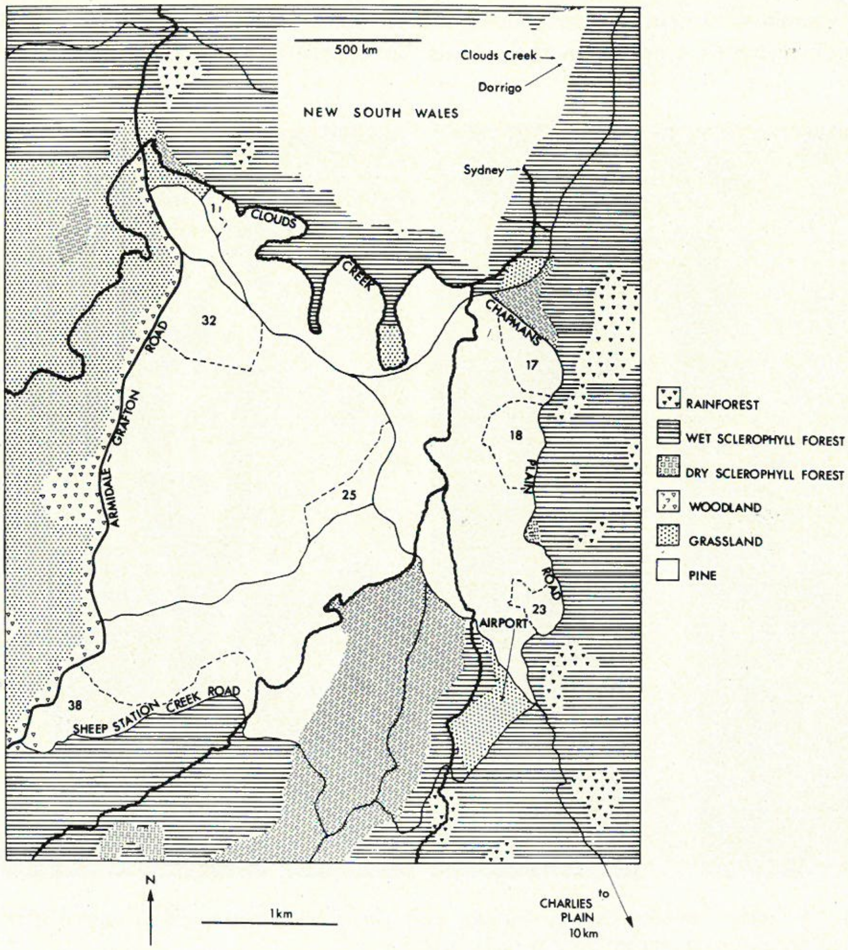

Fig. 1. Map of Clouds Creek study area showing the surrounding vegetation. Dominant species in each vegetation type are as follows. Rain forest: *Ceratopetalum apetalum, Doryphora sassafrass, Araucaria cunninghami.* Wet sclerophyll forest: *Eucalyptus microcorys, E. saligna, E. acmenoides, E. dunnii, Syncarpia glomulifera.* Dry sclerophyll forest: *E. pililaris, E. propinqua, E. siderophloia.* Woodland: *E. campanulata, E. cameronii, E. viminalis.* Pine plantation: *Pinus taeda, P. elliottii.* Numerals show the compartment number. Inset shows outline of New South Wales and localities mentioned in the text.

To assess whether possums fed on different tree species selectively, every tree in the two arboreta was assessed according to the above classification. An exception was *P. glabra* which was only assessed along the periphery because of its dense foliage. In the Charlies Plain arboretum the survival of each species was also assessed. Survival was calculated from the number of live trees divided by the number of trees planted and expressed as a percentage. As none of the arboretum had been thinned the figures for species survival were comparable.

Possum Populations

Three species of possum have been studied in the Clouds Creek and Welcome Flat areas since 1966 – *T. caninus, T. vulpecula* (Phalangeridae) and the ring-tailed possum *Pseudocheirus peregrinus* (Boddaert) (Petauridae). Individuals of these three species were examined in captivity and populations of both *Trichosurus* species were studied by mark-recapture trapping in the Clouds Creek area (How 1972, 1976).

Fig. 2. (*a*) *Pinus palustris* showing barking. (*b*) *Pinus taeda* categorized as topped after earlier ring-barking led to subsequent growth of laterals.

Results

Distribution of Damage

The amount of damage to *Pinus taeda* in the main plantation was influenced by the proximity of specific vegetation associations (Table 1). Damage was lowest (5.2%)

Table 1. Assessment of damage to *Pinus taeda* plantations at Clouds Creek in 1976

Compartment number	Date planted	Age (years)	Adjacent forest type	No. of trees assessed	Damage (mean % ±S.E.) Total	Forked	Topped	Ring-barked	Barked
25	1969	7	7-year-old *P. taeda* and *P. elliottii*	599	5.2±1.5	4.1±0.9	1.2±0.6	0	0
17	1969	7	dry sclerophyll	395	7.9±2.1	4.2±1.2	1.9±0.7	1.5±0.5	0.2±0.2
32	1970	6	dry sclerophyll	1701	10.3±1.0	6.2±1.8	2.2±0.4	0.8±0.4	1.2±0.3
38	1971	5	wet sclerophyll	467	10.7±2.1	6.5±1.8	1.2±0.5	0.2±0.2	2.9±0.8
18	1969	7	wet sclerophyll	606	21.1±7.1	5.6±1.9	4.6±1.8	6.1±2.9	8.2±4.7
23	1969	7	wet sclerophyll	816	21.8±4.7	7.6±1.3	4.7±1.7	5.8±1.7	3.7±1.3
1[A]	1951	25	wet sclerophyll	603	69.2±1.2	69.2±1.2	–	–	–

[A] Assessed for forking only

in compartment 25, the most distant of the compartments surveyed from any native vegetation (>600 m). Most of this damage (79%) was in the forked category.

Slightly higher levels of damage occurred in compartments bordering dry sclerophyll forest (Table 1). Thus compartment 17 suffered 8% damage and compartment 32 incurred 10% damage. Total damage was greatest between 25 and 250 m from the edge of the plantation (Fig. 3). Compartment 38 with 11% damage bordered wet sclerophyll forest. The relatively low amount of damage found in this particular compartment, which was the most recent planting surveyed, was attributed to the small size of the trees.

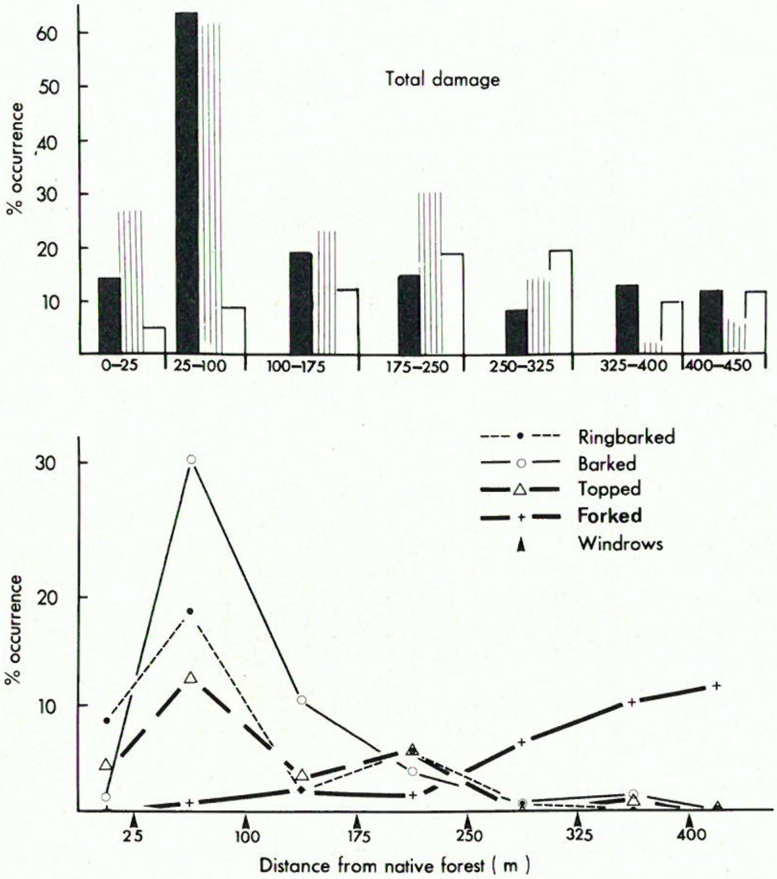

Fig. 3. (*Above*) Relationship between total damage and distance from native forest. Solid columns: compartment 18, 1969 *P. taeda* adjacent to wet forest; hatched columns: compartment 23, 1969 *P. taeda* adjacent to wet forest; open columns: compartment 32, 1970 *P. taeda* adjacent to dry forest. Distance on the histogram is represented within each block by the middle of the solid columns. (*Below*) An example of the distribution of damage categories with distance from native forest (compartment 18, 1969 *P. taeda*).

Greatest damage occurred in those compartments which were closest to wet sclerophyll and rain forest and was dependent on the age of the stand (Table 1), e.g. compartments 18 and 23 which had 21% and 22% damage and compartment 1 with 69%. In compartments 18 and 23 there were obvious edge effects with most damage (*c.* 60%) occurring

Table 2. Assessment of damage to the higher parts of various tree species in Charlies Plain Arboretum in 1976

Species	Age (years)	Date planted	Number planted	Total sample	Survival (%)	Damage (%) in damage category[A]					Total damage (%)
						1	2	3	4	5	
Pinus douglasiana Martineza	14	1962	50	42	84	0	19	12	0	69	100
P. douglasiana	18	1958	100	31	31	0	45	10	0	45	100
P. rigida Miller	12	1964	100	94	94	0	11	55	0	34	100
P. pseudostrobus	12	1964	100	93	93	1	98	35	1	54	99
P. glabra[B]	19	1957	500	81	–	–	–	–	–	–	96
P. palustris	17	1959	150	19	13	5	0	21	0	74	95
P. tennuifolia Benth.	14	1962	49	31	63	6	26	13	3	52	94
P. insularis Endlicher	15	1961	100	56	56	11	21	23	11	34	89
P. virginiana	19	1957	50	41	82	12	20	39	7	22	88
P. pseudostrobus	18	1958	150	80	53	13	30	9	5	44	88
P. massoniana	19	1957	400	332	83	15	47	1	0	38	85
P. radiata	12	1964	100	90	90	24	47	1	0	28	76
P. roxburghii Sargent	18	1958	50	46	92	28	13	37	0	22	72
P. caribaea Morelet	17	1959	42	42	100	36	36	21	7	0	64
P. ayacahuite Ehrenb.	18	1958	25	24	96	58	38	0	0	4	42
P. ponderosa Douglas	12	1964	100	46	46	61	9	7	4	20	39
P. radiata	17	1959	75	37	49	70	11	0	0	19	30
P. pinaster Aiton.	18	1958	50	38	76	71	18	0	0	11	29
Pseudotsuga menziensii (Mirb.)	12	1964	100	29	29	76	17	0	0	7	24

[A] See text for description of categories of damage: 1, normal; 2, forked; 3, topped; 4, barked; 5, ringbarked.

[B] Assessed only peripherally as either normal or damaged.

between 25–100 m from the periphery. In these compartments all types of damage except forking (Fig. 3) were more frequent. The inverse relationship between total damage and forking is probably explained by the increased amount of topping towards the periphery resulting in loss from the forked category. This is born out by the small variation found when the topped and forked categories are summed.

Most damage (69%) occurred in compartment 1, which was bordered to the north by Clouds Creek and moist forest, and to the west by the clearing of an abandoned village which is now grassland. The high level of damage probably results from the small size of this compartment (6 ha) and the fact that it has been closely surrounded on three sides by wet sclerophyll forest for 14 years.

Species Preference

The surveys of the arboreta indicate that possums have definite preferences for some *Pinus* spp. Although different species of possums are implicated in the two areas, damage in those tree species common to the two arboreta was in almost the same order. However, the amount of damage differed (Tables 2 and 3). At Welcome Flat damage was greatest to *Pinus elliottii* and *P. taeda* (Table 3) which are the major plantation species in this area. In the Charlies Plain arboretum two stands of *P. radiata* 12 and 17 years old had 76 and 30% damage respectively; the percentage damage is inversely related to the age of the stand. This trend is also seen in *P. pseudostrobus* and may be explained by the greater survival in the younger plantings (Table 2). The influence of survival on damage assessment cannot be determined in the main plantation.

Table 3. Results of a survey of possum damage to trees in the arboretum at Welcome Flat in 1966

This arboretum was fenced so macropod and rabbit damage were eliminated. The possums present were *Pseudocheirus peregrinus* and *Trichosurus caninus* and damage was mostly attributed to the former

Species	Age (years)	Number surveyed	Damage (%) in damage category[A] 1	4	3 and 5	Total damage (%)
Pinus elliottii	9	80	–	–	80	100
P. taeda	9	73	4	1	68	95
P. patula Schl. et Cham.	12	36	9	12	15	75
P. glabra Walter	9	133	50	13	70	62
P. pseudostrobus Lind.	9	87	38	21	28	56
P. virginiana Miller	9	26	12	4	10	54
P. massoniana Lamb	9	105	105	–	–	0
P. palustris Miller	9	25	25	–	–	0
Cypresses lucertanica Miller	12	200	200	–	–	0
Metasequoia glyptostroboides Hu et Chung	9	10	10	–	–	0

[A] For footnote see Table 2.

Possum Distribution and Abundance

Surveys of the Welcome Flat plantation in 1966 showed that *Pseudocheirus peregrinus* was the most abundant possum in that area and was the principal agent damaging pines.

At Clouds Creek only three observations of *P. peregrinus* were made in the 9 years 1967–1976, whereas 2597 captures of 193 *T. caninus* individuals and 593 captures of 98 *T. vulpecula* individuals were made over the same period. These two species are not sympatric in native forest as *T. caninus* populations occur in wet sclerophyll and rain forest and *T. vulpecula* populations occur in dry sclerophyll forest and woodland (Calaby 1966; How 1972). Densities (based on 'known to be alive' population estimates) for these two species in 140 ha of mixed subtropical rain forest and wet sclerophyll forest for *T. caninus* and 50 ha of dry sclerophyll forest and woodland for *T. vulpecula* were 0.30 ha^{-1} and 0.37 ha^{-1} respectively. The only sympatric area for these two species was the 6 ha of *P. taeda* in compartment 1 and 14 ha of *P. elliottii* in the adjacent compartment 2 to the south.

In October 1969 density estimates of both species in pine compartments 1 and 2 and in a similar 20-ha area of native forest gave respective figures of 1.24 ha^{-1} and 0.68 ha^{-1} for *T. caninus* and 0.30 ha^{-1} and 0.50 ha^{-1} for *T. vulpecula*. Despite the higher density of *T. caninus* in pine, no individuals of either species remained exclusively in the plantation and all individuals required native vegetation in their home range. Estimates of the density of *T. caninus* in 6 ha of younger pine in compartment 18 (*P. taeda*) and 6 ha of adjacent moist forest in 1975 gave figures of 0.48 ha^{-1} and 1.28 ha^{-1} respectively. These figures indicate that younger pines, which are adjacent to moist forest, are utilized by the *T. caninus* population to a lesser extent than older pines in a similar location.

Discussion

Mammal damage to conifers is a widespread problem in Europe and North America (Cunningham 1968; Radvanyi 1970) and is mainly caused by rodents and ungulates. In New Zealand pine plantations are damaged by *T. vulpecula* which has been introduced from Australia (Pracy 1964). In Australia the main agent damaging established pine plantations is *T. caninus* in both New South Wales (present work) and Victoria (McNally 1955).

We have established that more damage occurs when the adjacent native forest is wet sclerophyll forest merging with subtropical rain forest; this is the habitat of *T. caninus*. When the adjacent vegetation is dry sclerophyll forest or woodland, damage is less severe. This is the habitat of *T. vulpecula*, which utilizes pine less frequently than its congener, although it has a denser population in native forest areas. The major plantings of *P. radiata* in Australia are south of Clouds Creek and generally in areas where only *T. vulpecula* occurs. This may explain the much lower incidence of damage in these areas (How 1968). However, apparently severe damage to *P. radiata* does occur when plantings are in areas where *T. caninus* occurs (McNally 1955).

Damage is highest in the peripheral 200 m of the plantation and within this zone of increased damage there is a border of lower damage in the outer 25 m (Fig. 3). No reason can be advanced to account for this as roads bordering the plantation are infrequently used and pines in the outer 25 m are of similar form to the remainder. As a consequence of this pattern, an assessment of damage derived from an examination of the periphery will underestimate the damage within the outer 200 m of the plantation but overestimate the damage to the whole.

Although our observations suggest that at Clouds Creek damage is limited to a peripheral zone about 200 m wide, it should be noted that at the Bo Bo plantation in north-eastern New South Wales possum damage was restricted to the peripheral 100 m when first reported in 1952. By 1964, however, it extended 200 m into the plantation, and damage occurred throughout the 242-ha plantation by 1968 (How 1972) representing a penetration considerably in excess of 200 m.

Our results clearly indicate that any assessment of damage depends on the section of the plantation being considered. The areas assessed for damage which were peripheral or central to the plantation, the percentage of damage occurring in those areas and the proportion of the whole plantation in those categories are given in Table 4. More than 200 m from the edge of the plantation the level of damage falls to a fairly constant minimum (Fig. 3). Damage in the centre of the plantation consists primarily of forking and for three reasons this kind of damage is considered to result from causes other than possums and represents 'natural background damage'. Firstly, possums strip only the smooth bark between 50 and 300 cm from the growing tip, and the injury remains visible for several years; all central pines examined during this study were less than 7 years old and very few of the forked trees showed signs of barking. Secondly, no possums were trapped in the centre of the plantation. Thirdly, it is unlikely that the few possums traversing the plantation would alter their feeding strategy in central areas. 'Natural background damage' varied from 5% in compartment 25 to 11% in compartment 38, with an overall mean of 9.1%. Of the total area of the plantation (950 ha), 355 ha are less than 200 m from the periphery and damage here averages 22% when all the transect data (Table 1) are considered (Table 4). Extrapolation of data from specific locations to the whole plantation yields estimates varying by a factor of up to 3.6 (32.8–9.1; Table 4). This factor is even higher if smaller areas are considered, e.g. a factor of 12.3 when areas of maximum damage are compared (64%; Fig. 3) with compartment 25 (5%), an area of low damage.

Table 4. Assessment of damage to pines calculated from data from all transects in the Clouds Creek plantation (Table 1)

Location within plantation	Area considered (ha)	Damage (%)	Total area (ha)
Area >200 m from periphery	54.2	9.1	595.4
Area <200 m from periphery	78.4	22.0	354.6
Peripheral 200 m next to:			
wet forest	59.5	32.8	181.5
dry forest	18.9	10.9	173.1
Total	132.6	13.9	950.0

While localized areas of high damage were found at Clouds Creek, a 'best estimate' of total damage to the whole plantation [(9.1 X 595.4) + (22.0 X 354.6)/950; from Table 4] of 13.9% is obtained. Of this 13.9%, 9.1% is considered 'natural background damage' and the remainder (4.8%) is attributed to possum damage. Clearly, damage by possums must be distinguished from 'background damage' if a reliable assessment of pest status is to be obtained. Even if we assume that all categories of damage result from possums, then the total damage of 13.9% is still considerably less than levels reported elsewhere (cf. 63–88%, McNally 1955).

Obviously any assessment of damage must take into account the biology of the causative species and its distribution before the species can be regarded as a 'pest' warranting control. Classification of a species as a pest normally rests on economic arguments beyond the scope of this paper, and in forestry, in particular, such classifications are open to different interpretations (Routley and Routley 1974). Whether control of possums is warranted by the level of damage estimated by us is doubtful, but it is still not known whether the possums will penetrate further into the plantation as it matures.

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