CHAPTER 9

MANAGEMENT AND CONCLUSIONS

The aim of this study was to examine the ecology of *Trichosurus* spp. populations and determine a satisfactory management procedure for them in *Pinus* spp. plantations. The management procedure has to be effective in preventing possum damage, yet not detrimental to the survival chances of the possum populations.

In order to achieve this aim the study was conducted along three complementary approaches; firstly, from a review of forestry records, by means of a questionnaire and from surveys it was possible to determine the distribution, extent, significance and type of damage attributable to these species in pine plantations (Chapter 3). Secondly, by capture-recapture methods it was possible to determine the structure of and regulation in the populations of both species (Chapters 5,6 and 7); and thirdly, an assessment was made of the effects of various perturbations on populations (Chapter 8) and these will be evaluated with respect to their worth in formulating effective management procedures for possums in pine plantations.

In Chapter 3 it was established that the most severe damage to pine plantings in New South Wales occurred in the north-eastern area of the state. The areas damaged were generally small (<50 ha.) except at Brooklana where nearly 250 ha. was attacked. Moist hardwood forest or sub-tropical rainforest generally surrounded the areas affected. It was also noted that *Trichosurus* damage was restricted to plantations with trees that were at least 10 years old, and these usually had an interlocking canopy and a much reduced ground cover of grass or small shrubs.

The trees most frequently damaged were *P.elliottii* and *P.taeda*, although in many arboreta nearly all species planted were attacked. Some species such as *P.patula* and *P.radiata* were occasionally attacked but were not as severely damaged as either *P.elliottii* or *P.taeda*.

Damage was always associated with the stripping off of bark, though this varied in height and intensity. The significance of this damage also varied, from a loss in the millable length of log due to deformation of the tree, to a complete destruction of whole compartments.

Surveys of some damaged plantations and arboreta served to confirm many of the criteria outlined in returns from the questionnaires (How, 1968). Nearly all damaged areas surveyed were completely surrounded by native forest, usually of the wet sclerophyll or rainforest type.

The deductions that were drawn from this first approach alone, were sufficient to propose a satisfactory control measure for *Trichosurus* spp. in pine forests.

In an annual report to the N.S.W. Forestry Commission in 1968, How proposed that possum attack in pine plantings could be eliminated by alterations to the planting programme during the establishment of plantations. This proposal may be stated briefly as follows: since trees were not susceptible to attack until theywere at least 10 years of age or older, it was suggested that a plantation should radiate outwards from the initial planting, such that younger plantings surrounded older ones. These younger plantings, which are not susceptible to attack, would provide a buffer region between the possums natural habitat and the older susceptible plantings, and thus prevent damage occurring.

Several questions remain unanswered by this management recommendation that are of great importance in understanding the role of possums in pine plantations. Firstly, and of prime importance is, can and do possums live exclusively in pine plantations? Secondly, what is the habitat preference rating of pine plantations to both species of possum? Thirdly, over what distances and through what vegetation types will individuals move to enter plantations? And fourthly, what was the effect of previous management procedures on possum populations?

These questions can only be answered with the knowledge provided by a detailed study of the ecology of the two species and the effect of different perturbations on them.

In answer to the first question - no resident individual of either species remained exclusively in the Clouds Creek plantation during its trap record.

T.vulpecula which were trapped in the sclerophyll forest, woodland and the plantation were used in determining the population performance of this species (Chapter 6). It can be seen from Figure 6.1, however, that no individual which resided in the area for more than one capture, was trapped exclusively in the pine. Some individuals, such as F35, M83 and F111 were caught for the greater proportion of their trap record in the plantation area over periods in excess of 18 months, but most individuals that consistently occupied the pine were trapped there for significantly shorter periods.

T.caninus also failed to utilise the pine exclusively. Many individuals of the southern sclerophyll population were trapped in the plantation for the greater proportion of their trap record, but none exclusively (Table 8.6). Several individuals of the northern sclerophyll population were trapped in the pine area, but few of these were trapped there consistently and only five (M43, F74, M82, M104 and F121) for the greater proportion of their trap record.

Both species had sedentary adult populations with a male range size of about 7.5 ha. and a female range size of about 4.5 ha., but despite the small nature of these ranges relative to the 20 ha. of pine, no individual utilised the plantation exclusively.

In answer to the second question - pine plantations are low preference habitats for *Trichosurus* spp. in N.S.W.

Section 8.4.2. showed that after the cessation of the removal of *T.vulpecula* from the plantation at Clouds Creek, there was a gradual decrease in the numbers of this species occupying the plantation during the following 32 months (Table 8.13). This decrease occurred even though there was no interference with the woodland population that was the major source of *T.vulpecula* using the plantation. The reason for this decrease in population size has two possible explanations. It may be a reflection of the instability of the *T.vulpecula* population in the presence of *T.caninus*, which was shown to be the case in both the northern sclerophyll (Section 6.2.4) and the southern sclerophyll (Section 8.2.2) forests, or it may reflect a genuine low preference for pine plantations by undisturbed *T.vulpecula* populations. The second explanation appears to be the most plausible for the N.S.W. situation as a whole, as *T.vulpecula* is abundant in most areas where *Pinus* spp. plantings occur,yet very few reports of damage have been recorded in these areas (Section 3.3). The situation at Clouds Creek, however, could well be a combination of both these explanations.

The *T.caninus* population made regular use of the plantation and there was an unusually high density (1.20/ha.) of this species in the plantation after removal. There was little or no instability amongst the possums of this species that utilised the plantation regularly. The individuals of the southern sclerophyll population were frequently trapped in the *P.elliottii* and these comprised the greater proportion of the *T.caninus* frequenting the whole plantation, however, after the clearing of the southern sclerophyll area, only three individuals of this population remained and all utilised a part of the northern sclerophyll area, as well as the pine, in their home ranges. No extension of the northern sclerophyll population into the then unoccupied *P.elliottii* section of the pine occurred, except for M82 which was occasionally trapped in this area.

These findings suggest that pine is a very low preference habitat for both these species.

In answer to the third question - neither species moved through unfavourable vegetation types to feed in the 1950-51 planting, but each species had different tolerances to various vegetative types.

T.vulpecula moved quite readily over grassland to enter the plantation. This was in keeping with their natural habitat preferences of dry sclerophyll forests and woodlands, where canopy overlap is not complete and individuals move over the ground for considerable distances during feeding. Thus, *T.vulpecula* move readily through the grassland and old urban area to enter the plantation, as was illustrated by the numerous individuals that were captured in both the plantation and woodland extensively (Figure 6.1). There were also the instances of M3 and F15 moving into the pines from sclerophyll forest 400-500 m. north-west of the plantings during the removal phase. No individual of this species, however, moved freely in the 1965 plantation (Section 8.4.2.6).

T.caninus only moved into the plantation through sclerophyll forest. No *T.caninus* that moved from the northern sclerophyll area into the pines were trapped in the old village area or the grassland adjacent to the western end of the plantation; further, no *T.caninus* were trapped inside the 1965 plantation despite the close proximity of the 1950-51 planting in which numerous members of both the southern and northern sclerophyll populations occurred. During the clearing of the southern sclerophyll area there were no movements on a nightly basis over the cleared ground between the remaining natural vegetation and the pine plantation. Movements between the natural forest and the plantation only occurred when the natural vegetation remnants of an individual's home range became very small and it was forced to occupy the plantation area. These occupants seldom remained long in the trap record (Section 8.3).

Under the proposed management recommendation, plantations will ultimately have to cease expanding and possum attack will eventually occur around the periphery, provided the species planted is palatable to possums. It is necessary, therefore, to consider the nature and size of a buffer zone to surround the periphery of the pine and thus prevent this attack occurring.

With *T.vulpecula*, all indications are that pine plantations are low preference habitats, and that *P.radiata* is not a palatable pine. This explains the infrequent and minor reports of damage by this species to the large *P.radiata* plantations on the southern tablelands of N.S.W. (Section 3.3.1). With *T.caninus*, damage is severe to both *P.elliottii* and *P.taeda* in the smaller plantations in the north-east of the state. Evidence from Clouds Creek shows that a large (>200m.) cleared zone adjacent to plantings of these species prevents *T.caninus* movement between the native vegetation and the plantation, while evidence from Chapmans Plain (Section 3.6.7) shows that *P.patula* is not damaged despite the severe *T.caninus* damage to the *P.elliottii* and *P.taeda* adjacent. This indicates that a cleared buffer zone, or one planted to *P.patula* would provide an effective barrier to possum attack.

The answers to the first three questions show that individuals of both species need elements of natural vegetation in their home ranges in order to survive permanently in a population. They also illustrate the low habitat preference to possums of pine plantations. This point was well illustrated by the very infrequent capture of individuals in 1971 in a large area of the 1950 *P.elliottii* planting that was not adjacent to any natural vegetation and the total lack of captures of either species within the 1965 *P.elliottii* planting. Movements of possums into the plantation were governed by the type of vegetation surrounding the planted area.

The effect of the previous management procedure, that of removal of individuals from the plantation, on populations of both species was difficult to determine during the removal phase. Two important facts emerged from the study of removal on populations in the pine plantation. Firstly, there was a relatively high rate of return of individuals released short distances away from the pine (in the short term) but over time most individuals that were repeatedly removed were lost to the population. Secondly, there was a high proportion of dispersal age, sub-adult *T.vulpecula* caught during this period, and this may also have been the case with the *T.caninus* individuals (Section 8.1.2).

The indications are, therefore, that removal is only of limited use in minimising damage to pines by possums. Removal, in the long term, will decrease population size, but the impact of this decrease is limited as many animals removed are of an age when they would disperse under normal conditions.

Removal should now be examined in the light of its influence on the social organisation and regulation of populations of both species.

With *T.vulpecula* the removal of adult resident individuals would reduce reproduction in the population, but this reduction would be small as the adults removed would be replaced almost immediately by the mature, pre-dispersal individuals which are continuously present in the population. However, the main age category represented in the removal study at Clouds Creek were shown to be dispersal age individuals. In effect then the removal of *T.vulpecula* individuals at Clouds Creek acted only to harvest from the population those individuals that would disperse or die naturally during this time. Removal, therefore, appears to have had little impact on the social structure or regulation of the *T.vulpecula* population as a whole at Clouds Creek.

Removal has a different effect on the social structure and regulation of *T.caninus* populations. If resident adults were removed, reproduction in the population would be reduced. As was the case with *T.vulpecula*, this reduction should be small due to the replacement of removed adults by the sub-adults that are continually present in the population, but reproduction could be significantly reduced if a period of time is necessary for the re-establishment of a pair bond. If, however, the product of removal is to harvest the pre-dispersal and dispersal age sub-adult individuals, for which there is some evidence (Section 8.1.2), then reproduction in the population would be increased. This increase would be the direct consequence of removing from the area sub-adult individuals, who, by their presence, inhibit the subsequent reproduction of their mothers or the survival of their mother's subsequent offspring (Section 7.2.2). A factor which supported this hypothesis was the high survival rate of dependent young in the northern sclerophyll population in 1969 (Figure 7.1) and the high sub-adult and adult female fecundity during that year (Table 4.6). Individuals had been removed from the pine plantation during the five years preceeding 1969, and several individuals which utilised the 46 ha. of northern sclerophyll forest, trapped at that time, also occupied the plantation and were presumably influenced by this removal.

Owen (1964) reported a far higher density (0.987 possums/ha.) for *T.caninus* in 24.3 ha. of forest in Victoria than was recorded for this species in 25 ha. (Table 5.2) of forest at Clouds Creek (0.680 possums/ha). Owen's density, however, was considerably lower than the 1.200 possums/ha. determined as the density for *T.caninus* in the 20 ha.

of pine, prior to clearing the southern sclerophyll forest. Both Owen's population (Section 5.1.2) and the pine population had been severely disrupted by the removal of individuals prior to their study, and in both cases the density for *T. caninus* was much higher than that in the less disturbed northern sclerophyll populations. These figures strongly support the idea that *T. caninus* population size increases subsequent to the removal of possums, and consequently removal increases reproduction in the population.

An analysis of the effects of removal on populations of both species of *Trichosurus* has shown that it is not a satisfactory method for the management of these species in pine plantations.

An understanding of the ecology of *Trichosurus* spp. populations and the effect of perturbations of them has verified the management recommendation put forward in 1968 as well as answering some important questions arising from this recommendation.

Possum damage can be eliminated in pine plantations that are of an age and a species composition which are susceptible to attack, by establishing younger plantings (through which possums will not move) to surround older susceptible plantings. Eventual peripheral damage can be minimised by the planting of *Pinus* species which are not susceptible to attack to surround susceptible species.

The most important aspect of this research is that it has shown that a detailed knowledge of the ecology of a mammalian pest species is a necessity if valid management procedures are to be proposed. This approach has also allowed an assessment to be made on previous control measures and determine their effectiveness as management procedures.

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APPENDIX I

THE REPRODUCTIVE HISTORY OF *T.CANINUS* FEMALES IN THE NORTHERN SCLEROPHYLL POPULATION AT CLOUDS CREEK

Female 7 was trapped only once during 1968 and she was then carrying a pouch young. The fate of this young was not known. Female 129 was born to F7 during 1969 and she survived to independence and remained in the trap record until 42/70 although her mother was not recaptured after 2/70.

Female 8 did not have a sufficient trap record during 1968 to determine her breeding history for that year. Her left teat was distended during 49/67 and the right teat very slightly distended during 47/68, indicating that she probably bred and lost the young at an early stage during 1968, but this is inconclusive. During 1969 her first young was associated with her until 43/69 but not after. This young, F153, remained in the trap record until 38/70. Female 8 produced a second young for the year on the 25th December, but this young failed to survive to 68 days during 10/70, although it was present during 4/70 aged 26 days. In 1970 a young was born that died during 38/70. The 1971 young of F8 was not trapped in association with her mother during 51/71 aged 261 days but her left teat was still being suckled.

Female 14 was trapped only three times early in the study, but her 1968 young, M137, resided in the population until the end of the study.

Female 39 was first trapped in the pines during 41/68 with two back young, one of which was adopted. The younger back young, a male aged 155 days, was suckling from the left teat when first observed, and due to his age was assumed to be her own young. This male was left behind on her release and was later taken to Armidale when it became apparent that the female would not return. The trap history of the adopted F44 is given in Section 5.2.3.2. In 1969 a male was born to F39, and this male, M117, survived in the trap record until 2/72. The young of 1970 was a pouch young during 26/70 aged 87 days, but had died prior to 44/70 aged 212 days as F39's teat was not distended and no young had been suckled for some time. Female 39 was last trapped during 36/71, and the fate of her 1971 young was not determined after this time.

Female 44 did not breed during 1970 aged two and her trap history in 1971 is too incomplete to make an assessment of her reproductive history for that year.

Female 71 lost her two young born during 1969 when she was an immigrant two year old. One young died prior to 40/79 aged 125 days, and the other prior to 8/70 aged 81 days. Her trap record is very poor during 1970 and no assessment of her reproductive history can be made for that year. In 1971 it seems unlikely that she bred, being caught during 2/71, 28/71 and 30/71. In each instance, there was no indication that either teat had been suckled but it is possible that she either lost a young at an early stage of development, bred later in the year, or both.

Female 73 produced three young which failed to survive to independence in 1969 and 1970. During 1969 two pouch young died, one prior to 36/69 aged 160 days and another prior to 2/70 aged 120 days. In 1970 a male, M163, was caught with his mother F73, during 40/70 aged 223 days, but was not trapped subsequently and apparently died sometime between this age and 238 days. Although no 1968 young is known for F73 there is strong evidence suggesting that F95 was her young of that year. This evidence was given in Section 5.4.2.2. The 1971 young of F73 was still associated with its mother during 51/71 aged 253 days.

Female 74 was first caught during 2/69 in the pines;associated with her was her 1968 young, F75. The following year F74 produced M104 and both these young survived to independence. During early 1970 most of the home range of these animals, the southern sclerophyll forest, was cleared. Female 75 was lost to the trap record after 40/70, but M104 remained associated with his mother until the end of the study. In 1970 and 1971, F74 appeared to be unproductive as indicated by the comprehensive trap record over this period. In 1971 she became a resident of the northern sclerophyll population.

Female 87 did not breed, aged two, in 1970 but her young of 1971 was still present during 51/71 aged 253 days.

Female 93 produced F115 in 1969 and this young reached independence and remained in the trap record until 36/71. In 1970, F93 produced a male which remained associated with its mother until 9/71 aged 258 days, but was not caught subsequently as an independent and seems likely to have died. Her 1971 young was still present aged 237 days during 51/71.

Female 95, very probably the 1968 young of F73, bred during 1970 aged two, but the young died before reaching 130 days. Her young as a three year old in 1971, also died prior to the age of 130 days during 34/71.

Female 99 was first trapped during 28/69 with a male pouch young, M116 . He was still associated with his mother aged 200 days during 45/69, but was not observed subsequently and had ceased suckling well before day 265. In 1970 a male, M176, was born which survived to the end of the study. In 1971 F99 apparently failed to produce a young. No distended teats were observed over this period, and although the pouch was moist and deep as in a reproductive female, it appears unlikely that a young was born.

Female 115, the 1969 young of F93, produced a young in 1971 when aged two, but this young died prior to day 135.

Female 121 bred during 1970 when aged two. This young also died during pouch life prior to day 125. Her 1971 young was still suckling though not trapped in association with her when aged 259 days.

Female 122 produced F123 in 1969 and this young remained in the trap record until 36/70. In 1970 F122 lost two pouch young, one prior to 30/70 aged 155 days, the other prior to 51/70 aged 130 days. Her 1971 young was a pouch young during 36/71 aged 152 days but was not caught during 51/71 aged 258 days. From the condition of the pouch and teats it seems likely that this young had ceased suckling prior to this date and had died.

Female 124 produced M128 during 1969 and he remained in the area until 2/72. During 1970 a female was born that was associated with her mother during 51/70 aged 246 days, but was not observed or trapped subsequently. The fate of this female, F185, is uncertain but it appears most likely that she died. The 1971 young of F124 was still present at her last capture on 30/71 aged 100 days.

Female 136 was first trapped during 47/69 with a very small pouch young. This young, M110, remained in the area for the remainder of the study. In 1970, F136 still had M110 as a dependent young and failed to reproduce. Her 1971 young died prior to age 90 days during 26/71.

Female 154 produced during 1971 and this young, was present aged 80 days during 26/71; he had ceased suckling well before 254 days on 51/71 when F154 was retrapped without distended teats. This young probably died.

Female 190 lost her 1970 young prior to 30/71, aged less than 90 days.

Females 196 and 197 had young in 1971 with the young of F197 still associated during 2/72 aged 260 days.

Females 198 and 202 were not trapped frequently over an extended period, but indications are that neither bred in 1971.

These final six females had trap records which covered less than two years and nothing is known of their previous reproductive histories.

To summarise the above reproductive histories; there were 21 deaths amongst the dependent young of females in the northern sclerophyll population. Three of these deaths occurred in the young of females whose reproductive history was not adequately known; F99 in 1969, F154 in 1971 and F90 in 1971. Five deaths occurred in the pouch young of the two year olds which were breeding for the first time, *viz* F71 twice in 1969, F95 in 1970, F121 in 1970 and F115 in 1971. The maximum age at death of these pouch young was 125, 81, 130, 125 and 135 days respectively. The remaining thirteen deaths occurred in adult (3+) females.

Of these 13 deaths, 11 occurred when the young of a previous season was known to be present. These were; F8 one in 1969 (< 68 days old) and one in 1970 (< 170 d) when F153 was present; F39 one in 1970 (< 212 d) when M117 was present; F73 two in 1969 (< 169d, < 120d) and one in 1970 (> 224d and < 238d) when F95 was present; F93 one in 1970 (> 258d) when F115 was present; F95 one in 1971 (< 130d) aged 3 and still associated with her mother F73; F122 one in 1970 (< 155d) when F123 was present;

F124 one in 1970 (>246d) when M128 was present and F136 one in 1971 (<95d) when M110 was present.

The two deaths amongst dependent young that occurred when no young of a previous season was apparently present, occurred in F122, one in 1970 (<130d) and one in 1971 (<258d).

These data are depicted in Figure 7.1.