Monitoring condition of sand dune kanuka forest at Woodhill

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CONTENTS

Abstract

Exclosure plots established in three separate areas of kanuka forest on south Kaipara spit in 1983 to assess the impact of introduced fallow deer were remeasured in 1993. Kanuka shared canopy dominance with mapou, houpara and mahoe in forest estimated to be over 100 years old in Lookout Bush, Woodhill, and dominated exclusively in two younger stands at South Head; *Coprosma rhamnoides* dominated understories throughout. At Lookout Bush cohort senescence, already underway in 1983, continued in kanuka and mapou and began in houpara. Massive recruitment Of mahoe occurred inside the exclosure, and continued in houpara (mostly outside); seedling thickets of kanuka self-thinned, particularly inside the exclosure, where they were also smothered by faster-growing species. Mahoe and another generation of houpara are replacing the existing canopy in the absence of deer, and another generation of kanuka and houpara elsewhere in a partially stalled succession. Canopies are still intact at South Head, and there were no major changes in populations of canopy species. However, similar successional pathways are likely to occur there in future.

An influx of highly palatable shrubs, e.g., *Coprosma macrocarpa* and hangehange into collapsing forest at Woodhill in the absence of deer, and their scarcity or absence elsewhere, indicates continuing impoverishment of the understorey as well by deer. In the long term it is likely that a variety of broadleaved trees will invade these stands and that tall semi-coastal forest, similar to extant relics on the dunes, will develop. In the meantime, the high conservation value of these stands suggests that a major reduction in the deer population - sufficient to allow natural successional changes to proceed unhindered - should be a conservation priority for the region. Of the three methods suggested for achieving this (deer extermination, deer reduction, deer fencing), fencing is considered the most satisfactory.

1. Introduction

In 1983 three 20 m x 20 m exclosure plots, each with an identical adjacent control plot, were established by the Auckland Conservancy of the former New Zealand Forest Service in three separate stands of kanuka forest on south Kaipara spit. Five plots were remeasured in 1993 by Landcare Research for the Department of Conservation, including the three exclosures. The third control plot (unenclosed) had been partially destroyed by military manoeuvres in the interim.

2. Background

Fallow deer *(Dama dama)* were released at Lake Ototoa near South head in 1900 (Davidson & Nugent 1990) and now occupy some 5400 ha of sand dune, pine plantation and native forest at overall densities last estimated to be 0.11 -0.15/ha (Broome 1985). They have been hunted for some 70 years, and constitute an important, actively managed recreational hunting resource. Like many other natural plant communities on sand dunes, kanuka *(Kunzea ericoides* var. *ericoides)* forest is now extremely rare in the North Island outside of the Far North (Smale 1994). Stands of kanuka forest in Woodhill Forest support moderate densities of fallow deer, and in 1983 this study was set up to monitor the impacts of fallow deer on them. Exclosures are a standard method for assessing the impacts of introduced browsing mammals on New Zealand forests (Payton 1986). Remeasurement in 1993 has allowed these impacts to be assessed, along with natural successional changes inside protected forest and the adequacy of existing hunting pressure to maintain habitat conservation values.

The diet of fallow deer is similar to that of red deer (Davidson & Nugent 1990), which although adaptable and opportunistic also have strong food preferences (Challies 1990). Included amongst their highly preferred foods are some important or potentially important understorey and canopy species in kanuka forest on south Kaipara spit, such as large-leaved coprosmas *(Coprosma* spp.), araliads *(Pseudopanax* spp.), hangehange *(Geniostoma rupestre* var. *ligustrifolium),* mahoe *(Melicytus ramiflorus* ssp. *ramiflorus)* and kawakawa *(Macropiper excelsum),* as well as less preferred but widely eaten species such as mapou *(Myrsine australis),* small-leaved coprosmas and weeping mapou *(Myrsine divaricata)* (Jane & Pracy 1974, Allen *et al.* 1984, Wardle 1984). Conversely, some highly unpalatable species such as prickly heath *(Cyathodes juniperina)* are also locally common here. Light to moderate browse was noted in 1983 and 1993 on mapou and small-leaved coprosmas, and light browse on houpara or coastal lancewood *(Pseudopanax lessonii)* and hangehange.

3. Objectives

- To assess successional changes occurring in sand dune kanuka forest at Woodhill.
- To assess the impact of introduced mammals, especially fallow deer.
- To assess the adequacy for conservation of existing levels of animal control.
- To identify threats to the sustainability of kanuka forest.
- To formulate management recommendations.
- To advise Field Centre staff on the management of sand dune kanuka forest.

4. Methods

Three paired exclosure and control plots (Allen 1993) were established in three separate stands of kanuka forest in 1983. In each plot all trees and saplings >2.5 cm diameter at breast height (dbh) were tagged and measured. Seedlings <2.5 cm dbh and >135 cm high were tallied. Seedlings <135 cm high were tallied in four height classes (15-45 cm, 46-75 cm, 76-105 cm, 106-135 cm) in 24 circular subplots (total area = 0.002 ha). Plot remeasurement duplicated initial measurement protocols.

Because of differences in stand age and site type, plots at each locality were analysed separately. The use of statistics was precluded by lack of replication and the small number of plots.

5. Results

5.1 INITIAL COMPOSITION

Although forest composition differed markedly between the three study areas in 1983, adjacent paired exclosure and control plots at each site were reasonably comparable.

Lookout Bush (Woodhill)

mapou, houpara (coastal lancewood) and mahoe, with a locally dense understorey dominated by twiggy coprosma *(Coprosma rhamnoides).*

Coal Seam Hill (South Head)

There was a virtually continuous kanuka canopy at approx. 12 m over a light understorey dominated by twiggy coprosma and thick-leaved coprosma (*C. crassifolia).*

Waionui Inlet (South Head)

The plots here also had an intact kanuka canopy at approx. 8 m over a light understorey dominated by twiggy coprosma. Both kanuka and manuka *(Leptospermum scoparium)* were originally recorded here. Although only kanuka is present in the exclosure, manuka occurs in the adjacent wetland, and may have been present in the control plot before it was partly destroyed.

Kanuka was dominant in terms of basal area (overwhelmingly so on Coal Seam Hill and at Waionui Inlet) in all plots except the Lookout Bush control, where all four canopy species shared dominance. In terms of density, however, small-leaved coprosmas (especially *C. rhamnoides)* were everywhere by far the commonest woody species present, although contributing negligibly to basal area.

5.2 SUCCESSIONAL CHANGES IN CANOPY AND UNDERSTOREY SPECIES

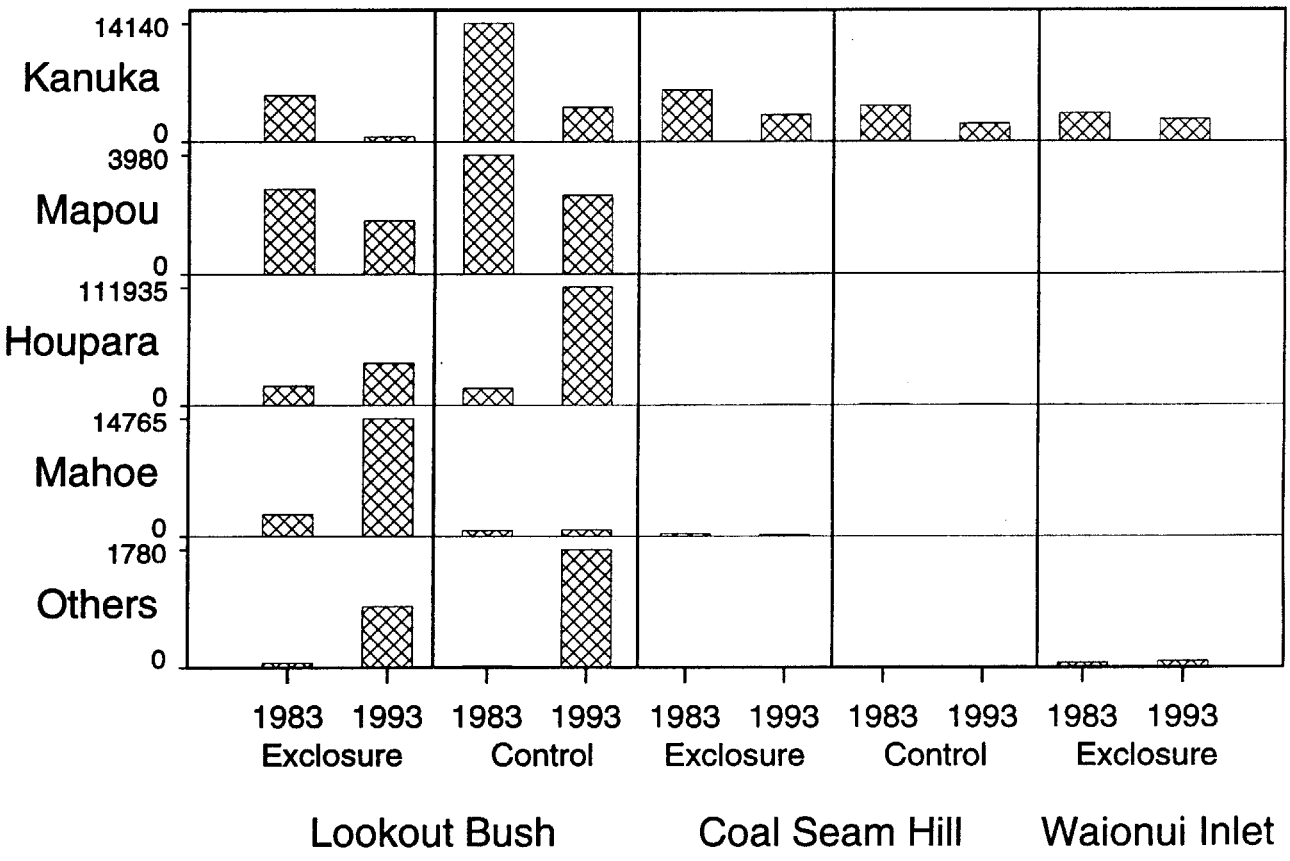
Lookout Bush

Between 1983 and 1993 the kanuka population declined dramatically in the exclosure, and much less so outside (Figure 1). Although nearly half of the larger (>3 cm dbh) stems in the exclosure and one-quarter of those in the control died, the decline was due mostly to large reductions in seedling populations through self-thinning and especially in the exclosure, through smothering by seedlings of larger-leaved species. There was a small number of additions (ingrowths) to the sapling/tree size-class from the seedling pool in the exclosure. In the control, however, over two-thirds of stems >3 cm dbh in 1993 were ingrowths from the seedling pool.

Amongst other canopy species, mapou populations declined somewhat, again due mostly to contracting seedling populations; ingrowths were insignificant. Despite one-third of larger stems in the exclosure and half of those in the control dying, houpara populations increased enormously, particularly outside the exclosure, where a sevenfold increase in the number of established seedlings occurred. The mahoe population increased dramatically inside the exclosure (a fivefold increase in seedling numbers) but only slightly outside.

Amongst understorey species, coastal karamu (*Coprosma macrocarpa*) invaded the exclosure but remained absent outside (Figure 2). Hangehange invaded

FIGURE 1. CHANGES IN THE DENSITY (STEMS/HA) OF CANOPY SPECIES IN WOODHILL FOREST BETWEEN 1983 AND 1993 (DATA IN APPENDIX 2).



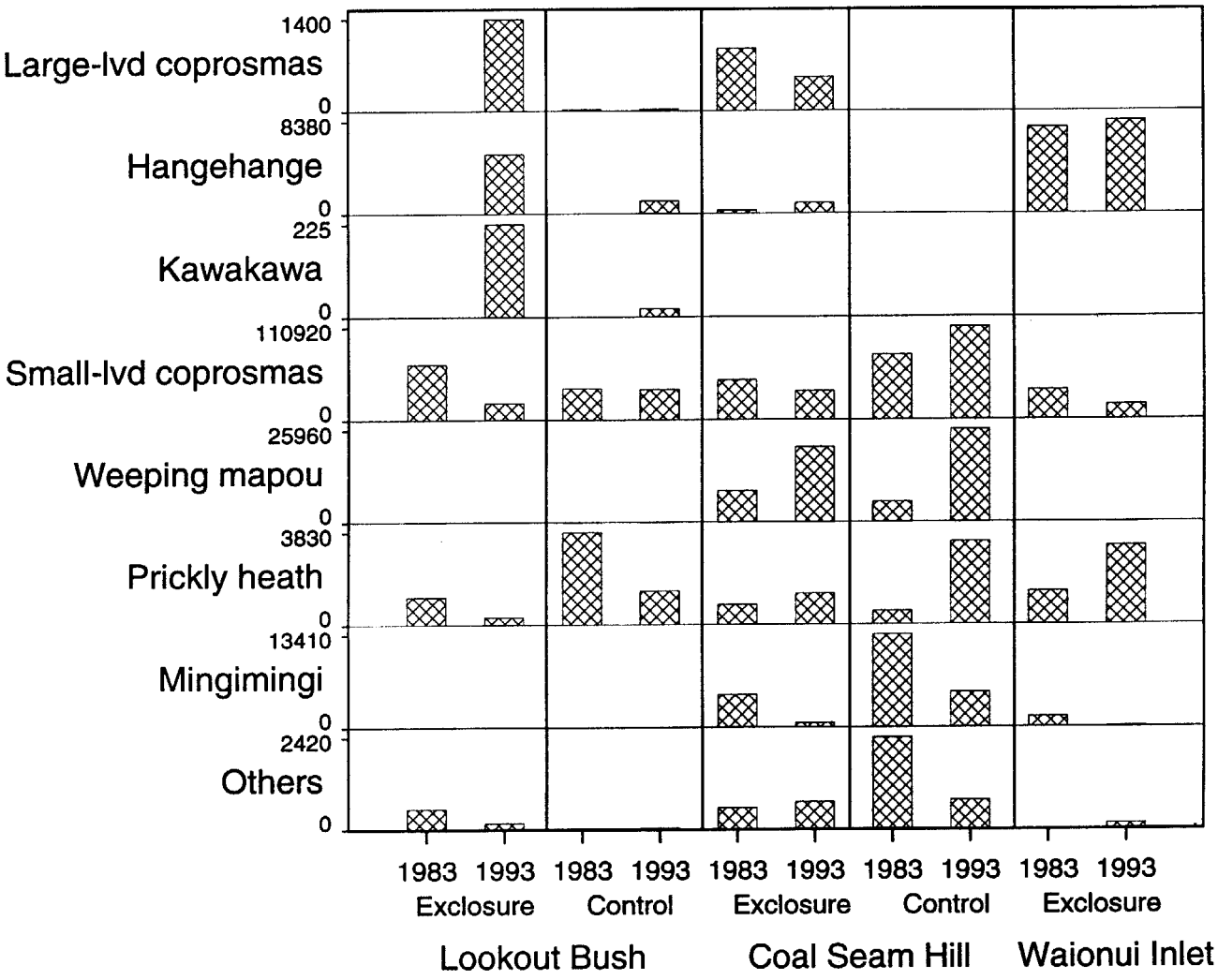
both plots, but the exclosure much more abundantly. Small-leaved coprosmas declined dramatically inside, maintaining stable populations outside, while prickly heath decline more inside than outside.

Coal Seam Hill

Kanuka populations halved between 1983 and 1993, with 15-25% of larger stems dying over the period. As in Lookout Bush, the decline was due mostly to contracting seedling populations. Mapou populations (entirely seedlings) more than doubled in the exclosure, remaining absent outside. Houpara populations, again entirely seedlings, remained more-or-less stable, while mahoe populations (mostly seedlings) halved in the exclosure and remained absent outside.

Amongst understorey species, coastal karamu declined inside the exclosure, remaining absent outside. Hangehange increased markedly inside, remaining absent outside. Small-leaved coprosmas declined slightly inside but increased outside, while weeping mapou and prickly heath increased markedly in both plots. Mingimingi *(Leucopogon fasciculatus*) declined in both plots, but much more inside than outside.

FIGURE 2. CHANGES IN THE DENSITY (STEMS/HA) OF UNDERSTOREY SPECIES IN WOODHILL FOREST BETWEEN 1983 AND 1993 (DATA IN APPENDIX 3).



Waionui Inlet

Thirteen percent of the larger kanuka died in the exclosure, and there was a small number of ingrowths. Hangehange populations remained more-or-less stable in the exclosure, while small-leaved coprosmas and mingimingi declined dramatically, and prickly heath increased.

5.3 IMPACT OF FALLOW DEER

Lookout Bush

Highly palatable species populations increased dramatically inside the exclosure, but only slightly outside. Populations of moderately palatable species declined somewhat inside, but nearly trebled outside. Unpalatable species populations declined dramatically inside, and to a smaller extent outside.

Coal Seam Hill

Highly palatable species populations remained stable inside the exclosure, and absent outside. Populations of moderately palatable species remained stable inside, but increased markedly outside. Unpalatable species populations declined dramatically inside, less so outside.

Waionui Inlet

Highly palatable species populations remained stable inside the exclosure, and moderately palatable species populations decreased markedly, while unpalatable species populations remained stable.

6. Conclusions

The earliest aerial photographs show at Woodhill in 1940 kanuka forest with well developed crowns, at Coal Seam Hill in 1953 a smooth-textured closed canopy characteristic of dense young even-aged stands, and at Waionui in 1952 scattered kanuka shrubs with distinguishable individual crowns. No evidence of an earlier forest has been found at any locality, and a ground cover at Waionui of *Baumea juncea,* a common species of the adjacent saltmarsh, suggests that this stand is an early stage of a primary sere from open dune slack to closed forest.

In kanuka forest "the thinning process continues plant by plant and limb by limb for the whole life of the stand" (Esler & Astridge 1974), while basal area rises rapidly, to stabilise by the time stands are some 20 years old. At Lookout Bush stable basal area, relatively small numbers of kanuka, the moribund state of many of them, the formation of gaps too large to be filled by surviving trees

and the diameter range present all suggest that the forest is at least a century old. At South Head, however, steadily increasing basal area, relatively large numbers of bigger kanuka, and intact canopies indicate younger forest.

At Lookout Bush most of the remaining kanuka, mapou and houpara trees - species with broadly similar lifespans - are expected to die in the next few decades. Two markedly different successional pathways are evident here. Inside the exclosure (i.e., in the absence of deer) kanuka and its associated subcanopy species are being replaced by mahoe and another generation of houpara. Outside the exclosure, in the presence of deer, replacement is by another generation of both kanuka and houpara - an example of a partially "stalled succession". Successions similarly stalled by red deer (*Cervus elaphus*) have been reported in secondary kanuka forest in the northern Urewera ranges (Payton *et al.* 1984).

In the younger stands at South Head, where existing canopies are still intact, successional trends are harder to predict. Again, however, mahoe and houpara seem likely successors to kanuka inside the exclosure on Coal Seam Hill, and houpara and another generation of kanuka outside. At all sites current and ¡mmediate future canopy species are all relatively short-lived, implying frequent canopy turnover and hence susceptibility to invasion by aggressive weeds, foremost of which are the locally abundant pampas grasses (*Cortaderia selloana* and *C. jubata*).

The present scarcity or absence of mahoe, coastal karamu, hangehange and kawakawa in much of the kanuka forest here is directly attributable to the influence of a substantial fallow deer population. Thus, their effects are not only an altered current understorey but an altered future canopy as well. Apart from coastal karamu, all these species have small fleshy fruits allowing dispersal by common introduced birds, and thus widespread and rapid establishment should deer populations decline or disappear.

With mid-nineteenth century liberations on the Auckland isthmus (Cowan 1990), possums have probably long been present at Woodhill in low but still significant numbers. Faecal pellets were present in every plot in 1993, including the exclosures. Like deer they are opportunistic feeders, but also have strong preferences (Cowan 1990), some of which overlap with those of deer. Some of the potential future canopy species (see below) of the kanuka forests - e.g., kohekohe (*Dysoxylum spectabile*) and titoki (*Alectryon excelsus*) - are highly palatable to possums, and their future spread, along with that of deer-palatable species, may be slowed by the presence of these animals.

Relics of mature forest on the Kaipara dune systems contain a variety of broadleaved trees, the most widespread of which are karaka (*Corynocarpus laevigatus*), puriri (*Vitex lucens*), kohekohe, titoki, houpara and mahoe (P j. Bellingham & E.K. Cameron, unpublished records; Mackinder 1984; Reid 1977; unpublished New Zealand Forest Service records). Rewarewa *(Knightia excelsa*), mangeao (*Litsea calicaris*), turepo (*Streblus heterophyllus*), mapou, lancewood *(Pseudopanax crassifolius*), kohuhu and wharangi (*Melicope ternata*) are somewhat less widespread. Ngaio (*Myoporum laetum*), kowhai (*Sophora microphylla*) and narrow-leaved maire (*Nestegis montana)* are more local, and pohutukawa *(Metrosideros excelsa*), taraire (*Beilschmiedia tarairi*) and tawa (*B. tawa*) more local still. Although all these species (apart from

taraire and taws) are present in or near Lookout Bush (E.K. Cameron & P.J. Bellingham, unpublished records), most occur only occasionally or rarely, and none, apart from a single puriri seedling, in the plots themselves. Only a few of them are present on Coal Seam Hill (Cameron & Bellingham 1986) and at Waionui Inlet. Most have bird-distributed fruit, and will eventually invade the kanuka stands of the south Kaipara spit and replace them. However, several of the commonest trees of mature duneland forest have large fruit dispersed only by the New Zealand pigeon *(Hemiphaga novaezelandiae),* whose decline may restrict their future dispersal.

Conifers appear to be naturally rare, only totara (*Podocarpus totara*) being locally common, as in Tapu Bush on north Kaipara spit (Reid 1977). This probably reflects their relative flammability and the presumed long fire history of the area rather than an unsuitable habitat. Totara, rimu (*Dacrydium cupressinum*), tanekaha *(Phyllocladus trichomanoides),* and to a smaller extent matai *(Prumnopitys taxifolia),* but no kahikatea (*Dacrycarpus dacrydioides*), planted experimentally in Lookout Bush in 1961 have survived and grown well (Pardy & Steward 1987), and now constitute a significant, albeit foreign, seed source.

Like many other natural plant communities on sand dunes, kanuka forest is now extremely rare in the North Island outside of the Far North (Smale 1994). The best remaining examples on south Kaipara spit are essentially seral, and merely a stage in a primary successional pathway from open dune vegetation to tall forest. However, they currently provide habitat for some local (fierce lancewood, *Pseudopanax ferox),* vulnerable (*Pimelea tomentosa*), and rare (an unnamed *Pratia* species), and a regional endemic, *Hebe diosmifolia,* at its southern limit (Cameron & Bellingham 1986; E.K. Cameron, pers. comm.).

Increases in moderately palatable species and decreases in unpalatable species in the two remaining control plots suggest that browsing pressure may have diminished somewhat over the past decade. Nevertheless, existing levels of animal control in Woodhill Forest are still not adequate from a nature conservation standpoint; natural successional changes are being stalled by fallow deer browsing. While the present or future existence of the native forest does not appear to be in jeopardy, the stands are still being - and will continue to be - impoverished, with some potentially important canopy species like mahoe, and understorey species like coastal karamu, being virtually eliminated from the wide areas of forest.

7. Recommendations

If these impacts are considered unacceptable by DoC, three options are suggested for ameliorating them.

1. Ideally, the deer herd should be eliminated entirely. This is easily accomplished with an isolated population living in a highly accessible habitat, but is unlikely to be acceptable to the plantation manager (Carter Holt Harvey Ltd.) in view of the commercial value of hunting licences.
2. Less ideally, the deer population should be substantially reduced, with preferential hunting in covenanted areas of native forest. The immediate consequences of deer browsing are more serious in older, collapsing stands of kanuka such as Lookout Bush, where natural successional processes are being stalled, than in younger stands (e.g., those at South Head) where replacement of kanuka by other species has barely begun. Thus, animal control should be given priority in older stands. The level of reduction needed to allow natural successional changes to proceed more-or-less unhindered is unknown, and can be determined experimentally only by testing vegetation response to different levels of animal control. However, accumulating evidence from other regions (e.g., Stewart *et al.* 1987) suggests that major reductions in the deer population are probably required for such an outcome to occur, to a level unlikely to be acceptable to the plantation manager.
3. More realistically, covenanted areas should be fenced to exclude deer (the cost perhaps being shared by the forest managers and DoC). Such fencing would require regular inspection but relatively little maintenance in short-stature forest, and would resolve management conflicts permanently.

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10. Appendices

10.1 PALATABILITY RATINGS OF WOODY SPECIES KANUKA FOREST ON SOUTH KAIPARA SPIT USED IN THIS ANALYSIS, BASED ON LOCAL OBSERVATIONS AND OTHER STUDIES (JANE & PRACY 1974, ALLEN *ET AL.* 1984, WARDLE 1984, STEWART *ET AL.* 1987).

Highly palatable

large-leaved coprosmas	*Coprosma* spp.
houpara	*Pseudopanax lessonii*
hangehange	*Geniostoma rupestre* var. *ligustrifolium*
mahoe	*Mclicytus ramiflorus* ssp. *ramiflorus*
kawakawa	*Macropiper excelsum* var. *excelsum*

Moderately palatable

twiggy coprosma	*Coprosma rhamnoides*
thick-leaved coprosma	*C. crassifolia*
mapou	*Myrsine austrafs*
weeping mapou	*M. divaricata*

Unpalatable

prickly heath	*Cyathodes juniperina*
mingimingi	*Leucopogon fasciculatus*

10.2 CHANGES IN THE DENSITY (STEMS/HA) OF CANOPY SPECIES IN WOODHILL FOREST BETWEEN 1983 AND 1993.

	LOOKOUT BUSH		COAL SEAM HILL		WAIONUI INLET[1]
SPECIES	EXCLOSURE	CONTROL	EXCLOSURE	CONTROL	EXCLOSURE
Kanuka	5515→600	14140→4050	6160→3150	4260→2075	3325→2600
Mapou	2855→1780	3980→2635	275→600	0→0	0→0
Houpara	18495→3985 0	15820→1193 5	275→350	550→550	0→0
Mahoe	2760→14765	725→820	325→165	0→0	0→0
Others	75→925	25→1780	0→0	0→0	75→95

[1] Control plot now partly destroyed

10.3 CHANGES IN THE DENSITY (STEMS/HA) OF UNDERSTOREY SPECIES IN WOODHILL FOREST BETWEEN 1983 AND 1993.

	LOOKOUT BUSH		COAL SEAM HILL		WAIONUI INLET[1]
SPECIES	EXCLOSURE	CONTROL	EXCLOSURE	CONTROL	EXCLOSURE
Large-leaved coprosmas	0→1400	25→25	950→515	0→0	0→0
Hangehange	0→5390	0→1120	275→930	0→0	7800→8380
Kawakawa	0→225	0→20	0→0	0→0	0→0
Small-leaved coprosmas	66580→20230	37450→36450	47330→34065	77365→110920	35300→17570
Weeping mapou	0→0	0→0	8840→21055	5645→25960	0→0
Prickly heath	1140→320	3830→1400	830→1295	550→3440	1375→3260
Mingimingi	0→0	0→0	4695→640	13410→5040	1495→95
Others	550→170	25→45	575→730	2420→775	20→150

Control plot now partly destroyed