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**Comparing Vegetative Effects of Domestic Stock and Feral Goats as
Ungulate Herbivores in Waingaro:
Year 1 Results**

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Abstract

Fencing remnant native vegetation has become a widespread activity throughout New Zealand to increase native biodiversity. However, there have not been many studies to show if this is an effective approach when feral goats (*Capra hircus*) are present. The present study investigated the short-term effects on dominant trees and shrubs of fencing on a private property in Waingaro, New Zealand. Two permanent plots were analyzed, one in a fenced covenanted area with feral goats present and one in an unfenced area with cows, sheep, and feral goats present. Both plots were dominated by a canopy of kanuka (*Kunzea ericoides*), a midstory of silver tree fern (*Cyathea dealbata*) and an understory of divaricating coprosma's (*Coprosma rhamnoides* and *Coprosma spathulata*).

Keywords

Native bush regeneration
Fencing
Grazing exclusion
Rehabilitation

JEL Classification

Q34

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Introduction

Waingaro is a town located in the Waikato Region of the North Island of New Zealand. It is situated on the western side of the island near the Tasman Sea in the Western Uplands just north of the eastern end of Raglan Harbour. In the 1840's, prior to European settlement, the Waingaro area was a conifer-broadleaved forest (Clarkson *et al.*, 2002 from Leathwick *et al.*, 1995) consisting primarily of kahikatea (*Dacrycarpus dacrydioides*) and totara (*Podocarpus totara*), but also containing kauri (*Agathis australis*), kanuka (*Kunzea ericoides*), mamangi (*Coprosma arborea*), rimu (*Dacrydium cupressinum*), tanekaha (*Phyllocladus trichomanoides*), and rewarewa (*Knightia excelsa*) (Clarkson *et al.*, 2002; Allan, 1961; Poole and Adams, 1994; Salmon, 1994). Upon European settlement, a large proportion of the trees were harvested and the harvested land was then used as pasture for cows and sheep. Today, a large portion of Waingaro is still used as pastureland, while other parts are being subdivided into lifestyle blocks.

The creation of pastureland throughout New Zealand has resulted in a significant reduction of native forest and therefore a reduction in native biodiversity (Fahrig, 2003; Saunders *et al.*, 1991; Saunders and Norton, 2001; Wright and Cameron, 1990). The current native vegetation that remains are primarily forest fragments (Harris and Burns, 2000; Burns *et al.*, 1999; Smale *et al.*, 2005). Since a large proportion of native vegetation in New Zealand is endemic, this depletion of native forestland is of concern to the New Zealand government, especially because over 70% of the land (approximately 19 million hectares) is privately owned (QEII National Trust, 2006; Ministry for the Environment, 1997). To address this issue, the Queen Elizabeth II (QEII) National Trust was created in 1977 to aid in the conservation of private land. To help achieve their goal, the QEII Trust allows landowners to protect sections of their property by creating an open space covenant. A QEII open space covenant is a legally binding protection agreement that becomes registered on the title of the land. While having a QEII open space covenant is voluntary, once it has been established, it binds the current and all subsequent landowners (QEII National Trust, 2006).

It is commonly believed that fencing a piece of land in New Zealand to exclude stock will result in the return of a native forest (Harris and Burns, 2000; Burns *et al.*, 1999; Smale *et al.*, 2005). In addition, it is believed that if the native flora returns in bountiful quantities to an area, other native fauna that disappeared from the area when their habitat was lost, such as birds and geckos, will return. Since fencing is thought to be an effective way of restoring native flora and fauna to a property (Spooner *et al.*, 2002; Lamb, 1994; Smale *et al.*, 2005), QEII covenants many times require a fence to be erected to surround the covenanted land.

The perception of vegetation reintroducing itself to land that has been fenced, has been the topic of recent research projects in New Zealand. In one particular study, Smale et al., 2005, looked at vegetation in the Waikato Region of New Zealand, the same region this study was conducted. This study focused on kahikatea (*Dacrycarpus dacrydioides*) forest fragments that have been fenced for up to 74 years. They found that the longer the area had been fenced, the more indigenous plant species were present and, at the same time, the lower the numbers of adventive plant species. They had shown that after 20 years of fencing, herbaceous pasture plants were believed to have disappeared, as they were out-competed by indigenous plants. They concluded that if no threatening weeds are present, it is possible that fencing alone may be enough to ensure near-natural states to return after 40 or 50 years (Smale et al., 2005).

While fencing does a reasonably good job of keeping grazing animals, such as cows and sheep, off a piece of land, it does not keep out feral goats, stoats, rats, mice, or possums, all of which have been found to have a significant impact on native flora and fauna (Sim and Saunders, 1997). Browsing mammals, such as feral goats (*Capra hircus*), are believed to alter the composition of the plant community. They reduce palatable species and by doing this, promote less palatable species to flourish (Wardle et al., 2001). Therefore, the presence of palatable (and preferred) and unpalatable (and avoided) species on a property may also indicate the presence of browsing animals. Unpalatable and therefore typically avoided plants are the soft mingimingi (*Leucopogon fasciculatus*), kanuka (*Kunzea ericoides*), miro (*Prumnopitys ferruginea*), and the silver tree fern (*Cyathea dealbata*). Palatable and preferred browsing species include hangehange (*Geniostoma rupestre* var. *ligustrifolium*), mahoe (*Meliccytus ramiflorus*), and lancewood (*Pseudopanax crassifolius*) (Smale et al., 1995; Husheer et al., 2003; Forsyth et al., 2002).

To investigate the issue of whether fencing alone has an effect on native vegetation regeneration with feral goats present; this study will investigate the short term effects of fencing on a property in Waingaro. Part of the property is currently grazed by sheep, cows and feral goats. The other part of the property is covenanted, has been fenced off, and therefore keeps out sheep and cows. Feral goats are still present both inside and outside of the enclosure. To address the issue of whether fencing has had a vegetative effect, and if so, what the effect is, plots in both the fenced and unfenced land were investigated.

Materials and Methods

The present study was conducted on a 27 hectare plot of land located on a hill in Waingaro (Tainui Ecological Region, Raglan District) next to the mouth of the Waingaro River where it enters the Raglan Harbour. The geographic coordinate point in the centre of the two permanently established plots is: Lat 37 44', Long 174 57'. This piece of private land was

recently acquired by new owners in 2005. Six hectares of the land were put into a Queen Elizabeth Trust (QEII) Open Space Covenant in 1998. Part of the regulations for this covenant was that a fence would be erected around the property and finished construction in 1999.

An aerial view of the property was acquired to aid with plot selection (Figure 1). The property boundary in Figure 1 is represented by the thick line. The wide barren patch to the left of the property boundary is the mouth of the Waingaro River as it enters the Raglan Harbour. The forested area between the left boundary and the river is a mangrove swamp and the covenanted area is the forested area in the left portion of the boundary. This is the only fenced area inside this location.

Figure 1: Aerial View of Waingaro Property and Plot Locations.



Note: The left dot indicates the permanent plot in the fenced covenanted area; the right dot indicates the permanent plot in the unfenced area. (Map courtesy of Kevin Collins)

To test the theory of whether a fence, to keep out cows and sheep, would result in an increase in native vegetation, two random permanent plots were selected along a transect within a kanuka (*Kunzea ericoides*) dominated forest: one within the covenanted fenced area and one in the uncovenanted area. While the results in this paper are from the first year of data, the plots are permanent and data can be collected in the future for comparison. The permanent plots are located on Figure 1: The dot in the upper left side of the diagram indicates the location of the covenanted fenced plot and the dot in the upper right side of the diagram indicates the location of the uncovenanted plot. As has been observed by the land owners, the neighbours allow cows and sheep to graze on the uncovenanted portion of the

property. In addition, feral goats have been seen both in the uncovenanted area as well as the covenanted area. Therefore, since there are no holes in the fence, it is hypothesized that the goats jump over the fence in and out of the covenanted area. Several goat skulls have been found in the fenced area (skulls were located near other skulls, but no other skeleton parts were visible). It is believed that the goats must have been hunted on this land at one point in time, but the current owners can not find any records of this. However, goats are still present, so the effectiveness of this possible hunting, or when or how it was conducted, is not known.

Both of the analyzed plots are dominated by a canopy of kanuka (*Kunzea ericoides*), a midstory of silver tree fern (*Cyathea dealbata*) and an understory of divaricating coprosma's (*Coprosma rhamnoides* and *Coprosma spathulata*). Plots are 10 x 10 metres in size and located approximately 30 metres inside the edge of the forest (the outside of the forest was pastureland) at an elevation of 60 metres. Plots were located randomly along a transect, but were selected because of the similarity of the canopy and midstory vegetation. Data was acquired on 11 March, 2006.

Results

In general, Plot 1, the uncovenanted unfenced area, was found to have been grazed by cows, sheep and feral goats. The canopy consisted of kanuka (*Kunzea ericoides*) trees 10 - 15 m tall. The mid-story trees were silver tree fern (*Cyathea dealbata*) and were 3 to 6 m tall, while the ground covering was very bare with few small shrubs mostly under 50 cm tall. Many of these shrubs have been grazed upon several times, therefore indicating a preference for browsing. Where there was some groundcover, it seemed to be dominated by the non-native species *Selaginella kraussiana* (Figure 2).

Figure 2: Plot 1. Unfenced and Uncovenanted Area Open to Grazing



Note: General pictures of the plot including one picture of *Selaginella kraussiana* surrounding *Blechnum fluviatile*. (Pictures courtesy of Kevin Collins).

Plot 2 was located in the covenanted fenced area. This area has been fenced since 1999 (approximately 7 years from the date of data collection). While the fence excludes cows and sheep, feral goats still enter the area by jumping over the fence. This forest consists of *Kunzea ericoides* canopy trees 10 - 15 m tall and *Cyathea dealbata* & *Cyathodes fasciculata* mid-story trees 3 to 6 m tall. The ground covering was relatively bare, but there were many small shrubs <50 cm in height emerging. *Selaginella kraussiana* was present, but not as prevalent as in the unfenced plot (Figure 3).

Figure 3: Plot 2. Covenanted Fenced Area



Note: General pictures of the plot. (Pictures courtesy of Kevin Collins)

A thorough investigation of the woody vegetation yielded a more accurate representation of the vegetation in the two plots (Table 1).

From the data, it was found that both plots only had one tree over 35 cm in diameter at breast height (dbh). This one large tree was the kanuka (*Kunzea ericoides*) in the covenanted plot and the miro (*Prumnopitys ferruginea*) in the non-covenanted plot. The number of kanuka (*Kunzea ericoides*) canopy trees was very similar in the plots, 14 in the covenanted area (the one tree over 35cm in diameter and the other 13 between 10 and 15 metres in height) and 11 in the non-covenanted area. However, in addition to the kanuka (*Kunzea ericoides*), the covenanted area also has 4 totara (*Podocarpus totara*) trees 10 to 15 metres in height. Both plots had a mid-story (in these plots mid-story trees were 3 to 6 metres tall) of silver tree ferns (*Cyathea dealbata*), with the covenanted area having 9 and the non-covenanted area having 6. In addition to the silver tree ferns (*Cyathea dealbata*), the covenanted area also had 13 soft mingimingi (*Leucopogon fasciculatus*) mid-story trees which were not present in the other plot.

Table 1: Vegetation in Plot 1 (Non-Covenanted Area) and Plot 2 (Covenanted Area)

Genus species name	Common Name	Non-Covenanted (Unfenced) Area	Covenanted (Fenced) Area
Trees over 35 cm in diameter:			
<i>Kunzea ericoides</i>	Kanuka	-	1
<i>Prumnopitys ferruginea</i>	Miro	1	
Canopy trees 10 to 15 metres in height (<35 cm diameter)			
<i>Kunzea ericoides</i>	Kanuka	11	13
<i>Podocarpus totara</i>	Totara	-	4
Midstory trees 3 to 6 metres in height			
<i>Cyathea dealbata</i>	Silver tree ferns	6	9
<i>Leucopogon fasciculatus</i>	Soft mingimingi	-	13
Small shrubs between 50 cm and 1 meter in height			
<i>Carpodetus serratus</i>	Putaputaweta	-	12
<i>Rubus fruticosus</i> (non-native)	Blackberry	4	-
<i>Coprosma robusta</i>	Karamu	-	1
<i>Coprosma spathulata</i>	<i>Coprosma spathulata</i>	12	23
<i>Coprosma rhamnoides</i>	<i>Coprosma rhamnoides</i>	11	20
Woody plants < 50 cm in height			
<i>Cyathea dealbata</i>	Silver tree ferns	38	32
<i>Dicksonia squarrosa</i>	Wheki	3	1
<i>Podocarpus totara</i>	Totara	5	20
<i>Meliccytus ramiflorus</i>	Mahoe	20	28
<i>Geniostoma rupestre</i> var. <i>ligustrifolium</i>	Hangehange	8	48
<i>Myrsine australis</i>	Myrsine	27	46
<i>Pseudopanax crassifolius</i>	Lancewood	5	11
<i>Knightia excelsa</i>	Rewarewa	5	-
<i>Beilschmiedia tawa</i>	Tawa	1	-
Other			
<i>Adiantum cunninghamii</i>	Maidenhair fern	-	20
<i>Blechnum fluviatile</i>	Bracken fern	35	-
<i>Metrosideros perforata</i>	White rata	many	many
Unidentified true ferns, grasses*, club mosses**, lichens, and mosses	Various	many	many
*One grass was identified to be the native bamboo grass (<i>Oplismenus imbecilllis</i>)			
**One club moss was identified to be the invasive <i>Selaginella kraussiana</i> , this one was found on both plots			

There were many small shrubs between 50 cm and 1 meter in height in both plots, however the species distribution was slightly different. The covenanted area had 12 putaputaweta (*Carpodetus serratus*), 1 karamu (*Coprosma robusta*), 23 *Coprosma spathulata*, and 20 *Coprosma rhamnoides*. *Coprosma rhamnoides* and *Coprosma spathulata* always seeming to grow near each other in both of the plots. The non-covenanted area, on the other hand, did

not have any putaputaweta (*Carpodetus serratus*), but it did have 4 blackberry (*Rubus fruticosus*) (an invasive species). It also did not have any karamu (*Coprosma robusta*), but did have 12 *Coprosma spathulata* and 20 *Coprosma rhamnoides*. As can be seen, *Coprosma spathulata* and *Coprosma rhamnoides* were found in both plots; however, there were approximately half as many in the non-covenanted area. There is debate as to whether small leaved *Coprosma*'s are palatable species (Smale et al., 1995; Husheer et al., 2003; Forsyth et al., 2002). Smale et al., 1995 and Husheer et al., 2003 indicate that they are, Forsyth et al., 2002 indicate that they are typically not selected by ungulates but “ungulates can and do eat” species that they do not prefer. Perhaps in this forest, they are a palatable species, and hence the reasoning for the difference in the two plots may be a result of browsing.

There were many small woody plants emerging from the ground in both plots that were less than 50 cm in height. Four of these species were slightly more abundant in the unfenced area than in the fenced area (although these were not significant differences). In the covenanted area, there were 32 silver tree ferns (*Cyathea dealbata*), in the non-covenanted area there were 38, this is 6 more than in the covenanted area. There was 1 wheki (*Dicksonia squarrosa*) in the covenanted area but there were 3 in the non-covenanted area, 2 more than in the covenanted area. Two plants were found to be in the non-covenanted area only; 5 rewarewa (*Knightsia excelsa*) and 1 tawa (*Beilschmiedia tawa*) both shade tolerant trees.

The rest of the small woody plants < 50 cm in height were always more abundant in the covenanted area. There were totara (*Podocarpus totara*) seedlings in both plots, 20 in the covenanted area and 5 in the non-covenanted area; 28 mahoe (*Melicactus ramiflorus*) in the covenanted area and 20 in the non-covenanted area; 48 hangehange (*Geniostoma rupestre* var. *ligustrifolium*) in the covenanted area, a significant increase over the 8 found in the non-covenanted area; 47 *Myrsine australis* were in the covenanted area and only 27 in the non-covenanted; there were 11 lancewood (*Pseudopanax crassifolius*) in the covenanted area and only 5 in the non-covenanted area. One noticeable difference in these small plants is that they always seemed to be grazed upon in the unfenced area. This did not seem to be the case in the fenced area. This grazing has resulted in the stunted growth of the plants.

Other species were also found in the plots, although not all were identified for this study. The covenanted area contained 20 maidenhair ferns (*Adiantum cunninghamii*) and the non-covenanted area had 35 bracken ferns (*Blechnum fluviatile*). *Selaginella kraussiana* was present in both plots; however, it was present in great quantities in the non-covenanted area, especially surrounding the bracken ferns (*Blechnum fluviatile*). White rata (*Metrosideros perforata*) was found in both plots growing up the sides of the canopy kanuka (*Kunzea*

ericoides) trees. Other true ferns, grasses, club mosses, lichens, and mosses were present; however, they were not part of this study, since the study focuses on larger plants.

Discussion

In this study, two permanently established plots were created; one in an unfenced area that was open to grazing and one in a fenced covenanted area; both areas were grazed by feral goats. Overall, similar species were found to be present in both plots, which include, but are not limited to, kanuka (*Kunzea ericoides*), silver tree ferns (*Cyathea dealbata*), *Coprosma spathulata* and *Coprosma rhamnoides*. Only 10 species were present in one plot and not the other. Species present in the covenanted fenced area that were not present in the non-covenanted area included totara (*Podocarpus totara*), soft mingimingi (*Leucopogon fasciculatus*), putaputaweta (*Carpodetus serratus*), karamu (*Coprosma robusta*), and maidenhair fern (*Adiantum cunninghamii*). Species that were present in the non-covenanted area but not the covenanted fenced area included miro (*Prumnopitys ferruginea*), blackberry (*Rubus fruticosus*), rewarewa (*Knightia excelsa*), tawa (*Beilschmiedia tawa*), and *Blechnum fluviatile*.

When looking at the species that were located in both areas, only 2 instances resulted in the non-covenanted area having a higher abundance, most likely due to the unpalatability of the plants. These two species were wheki (*Dicksonia squarrosa*) and silver tree ferns (*Cyathea dealbata*), both under 50 cm in height. All other species showed an increase in the abundance in the covenanted fenced area.

The kanuka (*Kunzea ericoides*) and mid-story silver tree ferns (*Cyathea dealbata*) were greater in number in the covenanted area, but not by a significant amount. These trees, however, would be over 7 years old and therefore this difference would not be a result of the fencing. All other species could very well be different because of the fencing. There was almost double the abundance in the covenanted area of *Myrsine australis* and lancewood (*Pseudopanax crassifolius*) both preferred grazing species and over quadruple the abundance of totara (*Podocarpus totara*). Hangehange (*Geniostoma rupestre* var. *ligustrifolium*) is a palatable indicator species and preferred to browsers (Figure 5a). There was a significant increase of hangehange (*Geniostoma rupestre* var. *ligustrifolium*) in the covenanted fenced area than in the non-covenanted fenced area. Other (debatably) ‘tasty’ species include mahoe (*Meliclytus ramiflorus*) (Figure 5b), karamu (*Coprosma robusta*), *Coprosma spathulata* and *Coprosma rhamnoides*. All of these species had a significantly higher number in the fenced covenanted area than in the non-covenanted area; all over double the amount than in the non-covenanted area.

Figure 4: Species Abundance of Young Plants <50 cm in Height in a Fenced (covenanted) and Unfenced (uncovenanted) area

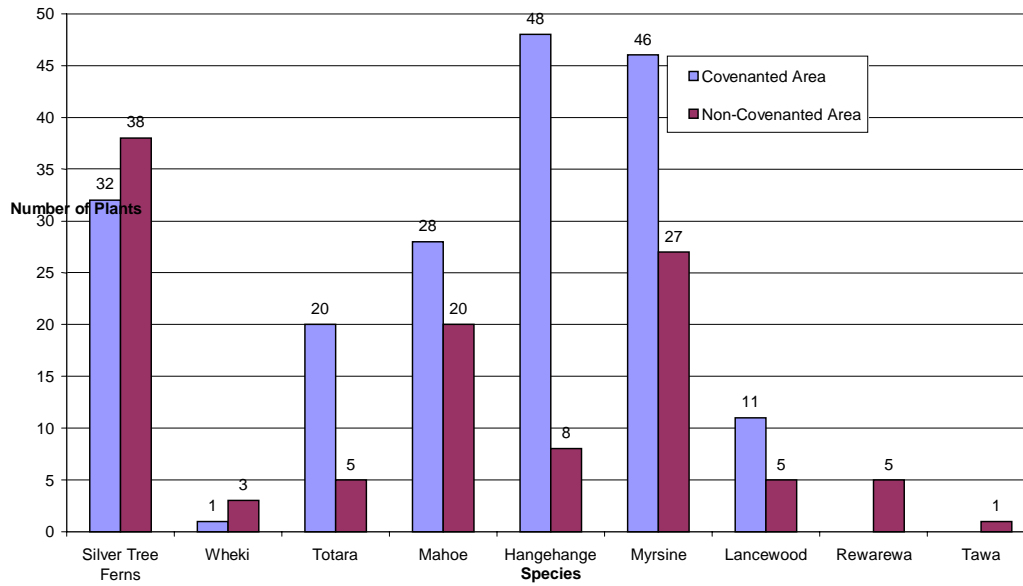


Figure: 5a (left). Hangehange (*Geniostoma rupestre* var. *ligustrifolium*) a palatable indicator species and preferred species of browsers.

5b (right). Mahoe (*Melicytus ramiflorus*) another 'tasty' species (Note that it has been browsed several times)



The results of this study provide significant information about vegetative differences between an area that has been fenced and an area that is open to grazing. Firstly, it appears that a large number of indigenous species have survived in this grazed rural landscape. Fencing appears to lead to an increase in the species abundance of native plants. Unfenced areas, that continue to be grazed, also appear to have a greater abundance of non-native invasive species like blackberry (*Rubus fruticosus*) and *Selaginella kraussiana*. Perhaps these non-natives are being transported to the area by the grazing cows and sheep. In addition, it is believed that if there were no feral goats in the area, the vegetation changes would also be different. Most likely there would be a greater abundance of native species than are currently present, especially of the palatable species such as hangehange (*Geniostoma rupestre* var. *ligustrifolium*), mahoe (*Meliccytus ramiflorus*), and lancewood (*Pseudopanax crassifolius*).

Studies show that prior to human harvesting of large native trees, vegetation in the Waingaro area consisted of kahikatea (*Dacrycarpus dacrydioides*), totara (*Podocarpus totara*), kauri (*Agathis australis*), kanuka (*Kunzea ericoides*), mamangi (*Coprosma arborea*), rimu (*Dacrydium cupressinum*), tanekaha (*Phyllocladus trichomanoides*), and rewarewa (*Knightia excelsa*) (Clarkson *et al.* 2002). Many of these species are currently present on this property. In the permanent plots, totara (*Podocarpus totara*), kanuka (*Kunzea ericoides*), and rewarewa (*Knightia excelsa*) were found. Near the unfenced plot was a giant kahikatea (*Dacrycarpus dacrydioides*) over 30 metres in height, and on the way to the plots, several large totara (*Podocarpus totara*) and tanekaha (*Phyllocladus trichomanoides*) were observed. Therefore, it is possible that if the plots are not grazed by cows, sheep, or feral goats, that the forest can once again become a conifer-broadleaved forest consisting of many of the native trees that were present prior to human harvest in the late 1800's and early 1900's.

This paper presented results from the first year of data collection in two permanent plots in Waingaro, New Zealand. It would have been ideal to establish these plots prior to fence installation and compare the results, but circumstances did not make this possible. However, since the plots are permanently marked, future comparisons can be made. Since this was an unfunded project, time and resources were limited. If funding could be established in the future, it would be recommended that a larger number of plots be considered and placed in each of the different ecosystem types across the property.

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