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Full name of author ......LYNLEE RUTH CURRIE......

Full title of dissertation ..IN THE RESTORATION PLANTINGS AT RICCARTON BUSH, ARE SOME PLANTED SPECIES, OR SPECIES COMBINATIONS, BETTER NURSES FOR REGENERATION THAN OTHER SPECIES AND WHAT ARE THE FEATURES THAT CHARACTERISE THESE SPECIES? Year of presentation ......1997......

Supervisor ......DAVID NORTON......

Signature of author ......[signature]......

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ABSTRACT

The aim of this dissertation was to find out if certain plant combinations in the canopy of restoration plantings in Riccarton Bush were more effective nurse plants than other plant combinations and what were the characteristics that these plants had. Fifty plots in Riccarton Bush were analysed and it was found that Community Two, a *Pittosporum tenuifolium-Coprosma robusta* forest had a significantly larger number of seedlings (greater than 10 centimetres in height) than three other Communities present in the restoration plantings. It was also found that the total canopy cover in the restoration plantings had little effect on the number of seedlings on the forest floor. It was decided that the primary reason for the greater nurse plant ability of Community Two was its attractiveness to birds as *Pittosporum* tenuifolium and *Coprosma robusta* have the most preferred fruit colour out of the four Communities. Other reasons include the moderate amounts of light getting through to the forest floor and the branchiness of trees favoured by birds.

AIM

The aim of this dissertation was first decided to be "to assess whether the restoration plantings in Riccarton Bush have been successful. However after collecting the plot data, and preliminary analysis had been carried out, it was decided to change the emphasis of the dissertation to try and find out what the various plant associations are in the restored areas of Riccarton Bush and if certain canopy trees determine what seedlings will become established under them. "In the restoration plantings at Riccarton Bush, are some planted species, or species combinations, better nurses for regeneration than other species and what are the features that characterise these species?"

INTRODUCTION

As far as is known, (according to Brian Molloy, (Editor of *Riccarton Bush: Putaringamotu Natural History and Management*) one previous Ranger, (Jack Wildermoth 1976-1990), the present Ranger (John Moore 1990-19-) and Minutes from meetings with the Riccarton Bush Trust) the restoration of Riccarton Bush which took place in 1978, 1981 and 1984 has not been studied. However a number of other studies have been conducted in Riccarton Bush of which I will describe below. The first mention of studies in Riccarton Bush (Molloy and Wildermoth 1995) occurred in the 1840s and 50s in which Charles Torlesse, John Deans and Charlotte Godley made comments about the impact of Maori use on

Riccarton Bush. It seems that the impact of Maori use was considered to have been minimal by these individuals.

In 1917 the Trust Board received its first plan of Riccarton Bush, compiled by W.F.Robinson, from Canterbury College. The plan showed the precise location of the Reserve in 1917, the former extent of the forest in 1849, and the initial system of walking tracks (Molloy and Wildermoth 1995).

"Several students from Canterbury College undertook research on the plants in the bush for their post graduate theses. The results of one of these studies, on climbing plants, was subsequently published, but attempts to trace the other theses have been fruitless. Other early botanical studies listed Riccarton Bush as a source of plant material or cited the bush as an illustration of particular plants and their habitats" (Molloy and Wildermoth 1995).

In 1978 it seems that a soil survey was also carried out in Riccarton Bush (Molloy and Wildermoth 1995). In 1977 pollution recorders were installed on the edge of the Bush for the mid-winter period from June to August. These instruments measured high smoke but low sulphur dioxide (Molloy and Wildermoth 1995).

In the late 1980s tree ring wood, bark and foliage from kahikatea trees in Riccarton Bush were sampled and analyzed for heavy metals and compared with similar samples taken from kahikatea in south Westland. Around the same time an information brochure was compiled by a graduate student, Clare Jackson and is an excellent introduction to the Bush and Riccarton House (Molloy and Wildermoth 1995).

There have been hundreds of papers written about restoration of environments and its related philosophies. To summarise all of these studies would take a book, however there does tend to be several similar threads of ideas which are usually present in most restoration projects. Generally, "a restoration programme has three points: (1) A restoration goal; (2) active intervention; (3) monitoring of progress" (Atkinson 1988). Another more detailed process of restoration is as follows:

Steps for restoration:

1) Identify process leading to decline.

2) Develop methods to reverse decline.

3) Determine realistic goals for reestablishing species and functional ecosystems.

4) Develop easily observable measures of success.

5) Develop practical techniques for implementing these restoration goals at a scale commensurate with the problem.

6) Document and communicate these techniques for broader inclusion in land-use planning and management strategies.

7) Monitor key system variables, assess progress of restoration relative to the agreed-apon goals, and adjust procedures if necessary (Hobbs and Norton 1996).

What is restoration? The society for Ecological Restoration defines restoration as: "The international alteration of a site to establish a defined indigenous, historical ecosystem. The goal of this process is to emulate the structure, functioning, diversity, and dynamics of the specified ecosystem" (Atkinson 1995). Norton (1990) defines ecological restoration as "the active intervention and management to restore or partially restore biotic communities, both their plants and animals, and the associated physical environment as fully functioning and sustainable systems with the predominance of indigenous species."

Goals for restoration tend to be very vague and can vary according to different situations. One goal of restoration could be the recovery of threatened species which can vary from very minor manipulation of a species' habitat to restoration of several biotic communities in order to provide habitat for the species of concern (Atkinson 1990). A more specific objective for restoration in certain circumstances is "to ensure that a good plant cover develops on the site and within which ecosystem processes are functional, and then let the system develop without further direct human input" (Norton 1990).

"If it is to be an *ecological* restoration the objective can be expressed in terms of the kind(s) of biotic community, habitat, or, more explicitly, soil-plant-animal system that it is desired to restore" (Atkinson 1995). "Reconstructing lost biotic communities and habitats, repairing damaged ones, providing habitats for threatened species, conserving genetic variation of both threatened and common species, providing specific educational, scientific and recreational opportunities, or aesthetic benefits, are all widely recognised as legitimate goals for restoration" (Atkinson 1995).

Why restore? Some reasons could be a) educational assets; b) aesthetic benefits; c) scientific opportunities; d) sources of native plants and animals; e) genetic conservation (Atkinson 1988). More importantly, why should we restore Riccarton Bush? Many would say that Riccarton Bush is too small to be viable and that it is so modified by human actions that it is not worth restoring. In response to these claims, one can say that it should be restored because it represents one of the last remaining floodplain kahikatea forest remnants in the Canterbury area. Contrary to popular belief, some areas of the bush are largely unmodified which is a remarkable acheivement for a forest surrounded on all sides by residential areas. Riccarton Bush is also a very important habitat area for numerous animals and plants which would have little likelihood of surviving if Riccarton Bush did not exist.

"Hobbs has suggested that there are three main ways in which restoration can be directly useful for conservation; provide additional habitat, provide buffer zones and establish corridors linking existing fragments" (Norton 1990). It seems that the restoration plantings in Riccarton Bush do all three to varying degrees. For example the 1978 and 1981 plantings which were studied in this dissertation replaced open grassland areas which were created by inappropriate management during the 1970s (mowing of the forest floor and burning of leaf litter) (Molloy and Wildermoth 1995). So the areas restored do add additional habitat that was not present before. These areas also provide buffer zones between the 'original' vegetation and the younger plantings, which also buffer the bush from residential areas. Before these 1978 and 1981 plantings, the bush was somewhat more fragmented, again because some of the areas were dominated by grass and exotic weeds. So the restoration plantings, in effect, did establish corridors linking isolated (perhaps moreso for small organisms) fragments with each other.

Hobbs also stresses that "restoration is an important tool for dealing with highly degraded sites such as mines within conservation areas and can assist in integrating productive and non-productive landuses" (Norton 1990). It could be said that at one time, particularly during the 1970s, Riccarton Bush was becoming degraded as a result of poor management because of a lack of knowledge about how to treat an indigenous forest system by a former Ranger. Several studies were conducted in the bush at the time and it was found by several scientists that invertebrates were virtually absent, as were several native climbing plants (Climbing fushia and Climbing rata) while regeneration was also very restricted because of the lack of suitable ground litter (Molloy and Wildermoth 1995).

Restorations are also valuable for increasing 'natural' areas and hence biodiversity in environments which have been developed to such an extent that these type of environments no longer exist in these areas. This point is especially applicable to Riccarton Bush because it is situated in the middle of a large city and very few, largely unmodified tracts of forest exist in the Christchurch area any more.

Restored areas have "...considerable potential for nature conservation" (Norton 1990). Many native animals such as the native wood pigeon use Riccarton Bush along with the Botanical Gardens and now that the restoration plantings have been so successful in increasing the overall health and sustainability of the bush, it is envisaged that sometime in the future, animals that resided in the bush in the past could be reintroduced such as the long-tailed bat and the red-crowned parakeet (Molloy and Wildermoth 1995).

For a restoration project to succeed "...a clear definition of restoration goals, an understanding of natural restorative processes, practical skills for establishing plant and animal species, and commitment by individuals and organisations to particular restoration programmes" is needed (Atkinson 1990). It does not seem that there was a clear definition of restoration goals set up prior to the restoration plantings in Riccarton Bush. This may have been because, especially during the late 1970s, the management of Riccarton Bush was largely left up to the presiding Ranger to decide on. It was during this time period that the Riccarton Bush Trust began to have much more of an involvement in how the bush was being managed. Judging from conversations with the Ranger at the time (Jack Wildermoth 1976-1990) the main aim of the plantings was simply to provide appropriate ground cover to 'kick-start' the restoration process and then let nature do the rest.

A lot of prior research was done before the restoration plantings took place. Duff from the forest floor was collected and seedlings were grown in an on-site nursery. From that time onwards it was decided that only seeds from Riccarton Bush should be used in all operations to preserve the genetic material of the forest. Apparently, during 1977, the Ranger planted out small bays of seedlings from the nursery directly behind the Ranger's house along the South-west side of the bush to see how each species would grow. After these bays had successfully started covering the area that had once been grassland, an area at the other end of the South-west side was planted in 1978. Another area along the South-west side was planted in 1981, completing the restoration plantings on the South-west side of the bush. In 1984, the North-west side of the bush was also replanted after exotics such as oaks were removed. Because this side of the bush receives less rainfall than the South side it's appearance looks very different, particularly the ground cover, which is very sparse.

An understanding of natural restorative processes was also well-known by the Ranger, Jack Wildermoth, who had vast experience particularly in managing West Coast native forests.

Commitment to the restorative programmes in Riccarton Bush has ensured that the health of the bush has increased over the years, and the restoration plantings have been successful in increasing plant cover at the very least. Efforts are still continuing today with a major emphasis on removing exotics, particularly *Hoheria sexstylosa* (North Island lacebark) and blackberry and replanting grassy areas.

Norton (1990) also has a suggestion to increase the likelihood of success; "Restorations may be cheaper and more successful by initially using fast growing native or even naturalised species, rather than attempting to use the most ecologically appropriate species." "Restoration success can be viewed as a continuum from the successful establishment of the initial planting through to the successful establishments of those attributes that ensure a self sustaining, functioning system. While the later stages of this continuum are the most likely goals for restoration projects, the initial stages must clearly be successful if the longer term restoration goals are to be met..." (Reay and Norton 1996). Problems with restoration include "Implicit in this definition is the notion that restoration seeks to reassemble, insofar as possible, some predefined species inventory" and "...since it is rarely possible to determine exactly what historic or prehistoric ecosystems looked like or how they functioned, let alone establish the full species list of indigenous communities, restoration efforts may be plagued by amibuities in both their goals and criteria for success" (Atkinson 1995). Also the thresholds of irreversibility are not easily detected or quantified in a restoration programme.

LITERATURE REVIEW

There are many papers that have been written about restoration of various environments although few directly apply to this dissertation about the restoration of a New Zealand native forest. However many of the principles from other studies of restoration can be applied to the restoration in Riccarton Bush.

Gonzalez and Fisher (1994) studied the growth of native forest species planted on abandoned pasture land in Costa Rica. They found that the growth of most native forest species did not grow successfully.

Catalan, Carranza, Gonzalez, Karlin and Ledesma (1994) did afforestation trials with *Prosopis chilensis* (Mol.) Stuntz and *Propsopis flexuosa* D.C. in the Dry Chaco, Argentina. They showed that survival of plants after transplantation was higher (60-80%) than from direct seeding (35-45%) and that the best time to plant would be the end of summer.

Boucher, Vandermeer, Mallona, Zamora and Perfecto (1994) studied a regeneration rainforest in Nicaragua after Hurricane Joan. They discovered that *Vochysia ferruginea* suffered complete mortality of adult trees in the hurricane, but rapid growth and high survivorship of its abundant seedlings. *Qualea paraensis*, however, showed 100% survival of trees during the hurricane but substantial mortality in the following years.

Thadani and Ashton (1995) studied the regeneration of banj oak in the central Himalayas. It was found that the dense canopy of these forests does not promote the satisfactory establishment of oak in the understorey. It seemed that oak regeneration was benefitted by moderate levels of disturbance, which resulted in the partial opening of the canopy.

Reay and Norton (1996) studied the restoration plantings in Kennedy's Bush, Port Hills and found that although the earlier plantings had so far failed to successfully restore a fully-functioning, sustainable forest, they decided that in time the plantings would be indistinguishable from a mature at the site.

MATERIALS AND METHODS

It was first thought that 100 circular plots should be measured in the restoration area in Riccarton Bush, but as it was soon found, each plot took between 30 and 90 minutes to do, so it was decided that the number of plots should be reduced to 30. The information that was collected is as follows. A circular plot one metre in diameter was randomly selected approximately halfway between the 'original' vegetation and the much earlier vegetation planted for maintenance of the bush. In this plot, seedling species, numbers and heights were recorded. Then canopy cover information over this plot was recorded, including the canopy species, numbers of trees and approximate percentage canopy cover. The percentage canopy cover species were grouped into these classes: 1 = <1%, 2 = 1-5%, 3 = 6-10%, 4 = 11-25%, 5 = 26-50%, 6 = 51-75%, 7 = 76+%. The percentage ground cover of seedlings, grasses, herbs and woody species was also recorded in this plot using the same classes as above and the depth and type of litter was also recorded.

A second plot four metres in diameter was also constructed which encircled the smaller plot. In this plot, all canopy tree species, abundance and their diameter at breast height was recorded. Using this information I was able to study the tree associations in the restoration area and try to see if some tree species are better nurse crops for particular seedlings than others.

As stated above, the first plot was positioned randomly approximately halfway between the 'original' forest and the younger plantings. Thereafter the plots were placed every five metres along the ground following a transect line along the South-west side of the bush. I attempted to keep the transect line as straight as possible and half way between the adjoining areas but sometimes obstacles such as stumps and thick bush prevented this from occurring. It was also quite difficult in some places to differentiate areas from each other. The area studied only encompassed the 1979 and 1981 restoration plantings as the 1984 plantings were on the North-west side of the bush.

Once preliminary analysis was carried out on 30 plots my supervisor thought that the data would be a lot stronger if more plots were included, hence I did another 20 plots to make the total plots measured equal to 50 (see Appendix One for raw data.)

The computer programme TWINSPAN was used to perform multivariate classification analysis on the data. The analysis was run to three division levels, which yielded seven groups of plots (see Appendix Two for dendrogram). However, because of the small size of some of these groups, three groups were combined to give four groups or communities for analysis. These groups were described as Community One: *Cordyline australis-Pittosporum tenuifolium* forest (Plots 5, 7, 8, 12, 13, 15, 17-20, 27), Community Two: *Pittosporum tenuifolium-Coprosma robusta* forest (Plots 2, 6, 10, 21-25, 28, 30-32, 34, 35, 43, 50), Community Three: *Plagianthus regius-Pittosporum tenuifolium* forest (Plots 9, 11, 14, 16, 26, 29, 33, 46, 49) and Community Four: *Pittosporum eugenioides-Pittosporum tenuifolium-Hoheria angustifolia* forest (Plots 1, 3, 4, 36-42, 44, 45, 47, 48) (see Appendix Three for raw data and Appendix Four for Community data). For a fuller description see **DISCUSSION.**

RESULTS

Anova analysis was performed on the data for all seedlings. It was found that there was no significant difference (at the 95% level of significance) between the total number of seedlings in each of the four different communities with a value of 2.65.

Table 1. Anova of all seedlings.

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	5402	3	1800	**2.65**	0.05	**2.72**
Within Groups	51475	76	677			
Total	56877	79				

It was also found that there was no significant difference between seedlings less than ten centimetres in height in any of the four communities with a value of 2.65.

Table 2. Anova of seedlings <10cm in height.

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	5402	3	1800	**2.65**	0.05	**2.72**
Within Groups	51475	76	677			
Total	56877	79				

However, the number of seedlings greater than ten centimetres in height was found to be significantly different in each of the four communities yielding a value of 5.28.

Table 3. Anova of seedlings >10 cm in height.

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1047	3	349	**5.28**	0.002	**2.72**
Within Groups	5024	76	66			
Total	6071	79				

The numbers of the five most common seedling species (all) was also found to be significantly different in each of the communities at the 95% level of significance with a value of 4.06 (see Appendix Five for Community data for the five most common species).

Table 4. Anova of five most common seedling species (all) (*Hoheria angustifolia (1st), Streblus heterophyllus (2nd), Melicytus ramiflorus (3rd), Dacrydium dacrydioides (4th) and Parsonia heterophylla (5th).*

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	11046	3	3682	**4.06**	0.02	**3.23**
Within Groups	14476	16	904			
Total	25522	19				

The numbers of the five most common seedling species less than ten centimetres in height was not found to be significantly in the different communities yielding an F value of 2.63.

Table 5. Anova of five most common seedling species <10cm in height (*Hoheria angustifolia (1st), Streblus heterophyllus (2nd), Melicytus ramiflorus (3rd), Parsonia heterophylla (4th) and Dacrydium dacrydioides (5th).*

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	4188	3	1396	**2.63**	0.08	**3.23**
Within Groups	8469	16	529			
Total	12657	19				

An F value of 10.98 for the anova of five most common seedling species greater than ten centimetres in height was calculated, showing that the numbers of seedling species greater than ten centimetres in height is significantly different in each of the communities.

Table 6. Anova of five most common seedling species >10 cm in height (*Hoheria angustifolia (1st), Streblus heterophyllus (2nd), Melicytus ramiflorus (3rd), Parsonia heterophylla (4th) and Dacrydium dacrydioides (5th).*

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1991	3	663	**10.98**	0.0003	**3.23**
Within Groups	966	16	60			
Total	2958	19				

Regression was carried out using total seedling abundance against total canopy cover. The analysis revealed an R square of 0.11, indicating that total canopy cover is a poor predictor of the number of seedlings. It also shows that total canopy cover has little effect on the amount of seedlings on the forest floor.

Table 7. Regression of total seedling abundance (all) against total canopy cover.

Regression Statistics	
Multiple R	0.34
R Square	**0.11**
Adjusted R Square	0.09
Standard Error	27.26
Observations	50

The regression of *Hoheria angustifolia* seedlings against total canopy cover yielded an R square of 0.13 meaning that total canopy cover has little effect on the number of *Hoheria angustifolia* seedlings.

Table 8. Regression of *Hoheria angustifolia* seedlings (most common) (all) against total canopy cover.

Regression Statistics	
Multiple R	0.36
R Square	**0.13**
Adjusted R Square	0.11
Standard Error	8.73
Observations	50

Regression of the number of *Streblus heterophyllus* seedlings against total canopy cover indicated that the latter was a poor indicator of the former giving an R square value of 0.0019.

Table 9. Regression of *Streblus heterophyllus* seedlings (second most common) (all) against total canopy cover.

Regression Statistics	
Multiple R	0.04
R Square	**0.0019**
Adjusted R Square	-0.018
Standard Error	9.28
Observations	50

Regression of the number of *Melicytus ramiflorus* seedlings against total canopy cover revealed that canopy cover has little effect on the number of *Melicytus ramiflorus* seedlings with an R square value of 0.05.

Table 10. Regression of *Melicytus ramiflorus* seedlings (third most common) (all) against total canopy cover.

Regression Statistics	
Multiple R	0.07
R Square	**0.005**
Adjusted R Square	-0.015
Standard Error	9.2
Observations	50

Regression of *Dacrydium dacrydioides* seedlings against total canopy cover failed to show that canopy cover was a good predictor of the number of seedlings present with a value of 0.01.

Table 11. Regression of *Dacrydium dacrydioides* seedlings (fourth most common) (all) against total canopy cover.

Regression Statistics	
Multiple R	0.1
R Square	**0.01**
Adjusted R Square	-0.009
Standard Error	9.1
Observations	50

Regression of *Parsonia heterophylla* seedlings against total canopy cover showed that the latter has little effect on the former with a value of 0.09.

Table 12. Regression of *Parsonia heterophylla* seedlings (fifth most common) (all) against total canopy cover.

Regression Statistics	
Multiple R	0.3
R Square	**0.09**
Adjusted R Square	0.07
Standard Error	4.4
Observations	50

The Chi-Square goodness of fit Test reveals that the null hypothesis must be rejected, that is, that the numbers of different dispersal types in the restoration plantings and the whole of Riccaton Bush are significantly different.

Table 13. Chi-Square Test comparing numbers of different dispersal types in restoration plantings and the whole of Riccarton Bush (see Appendix Six for woody species present in Riccarton Bush and the restoration plantings and dispersal types).

Area	Dispersal Types of seeds for woody species				
	Bird	Wind	Gravity	Wind/Gravity	Total
Riccarton Bush	49	5	3	3	60
Restoration Plantings	15	2	0	1	18
Total	64	7	3	4	78

Ho: That the numbers of different dispersal types of seeds is the same in the restoration plantings and the whole of Riccarton Bush.

Ha: That the numbers of different dispersal types of seeds is different in the restoration plantings and the whole of Riccarton Bush.

$$X^2 = \frac{(49-32)^2}{32} + \frac{(15-32)^2}{32} + \frac{(5-3.5)^2}{3.5} + \frac{(2-3.5)^2}{3.5} + \frac{(3-1.5)^2}{1.5} + \frac{(0-1.5)^2}{1.5} + \frac{(3-2)^2}{2} + \frac{(1-2)^2}{2} = 23.34$$

df = (4-1) = 3 $\quad\quad$ X^2 (0.05) = 7.81

DISCUSSION

<u>Community One:</u> ***Cordyline australis-Pittosporum tenuifolium*** forest. *Cordyline australis* grows up to 17 metres and has a branching form with leaves usually crowded at the top of the stem. Leaves are 0.5-1 m long and 4-6 cm wide. Flowers are in large terminal panicles and the berries are bluish white. *Cordyline australis* produces large amounts of leaf litter which creates a thick layer on the forest floor. The litter also takes a long time to decompose compared to other leaves, making it difficult for seedlings to become established particularly in areas where there are large numbers of these trees. However, because *Cordyline australis* leaves tend to be bunched at the top of the stem they do not block out much light from the forest floor. These trees are also attractive to birds because they are good roosting trees and have fruit. These two factors probably increase the probability of finding seedlings underneath *Cordyline australis* dominated canopies. The plots in this community have an average *Cordyline australis* canopy cover of 17%. *Pittosporum tenuifolium* grows up to 10 metres in height with solitary flowers and fruit 1 centimetre in diameter. Leaves are 2.5-6 cm long. The plots in this community have an average *Pittosporum tenuifolium* canopy cover of 9%. This species tends to let through filtered light to the forest floor because of the small leaf size and the litter layer produced is not a big impediment to seedling establishment. The fruit are also an attractant to birds (Poole and Adams 1994, Mitchell and Wilkinson 1995, Philipson 1995, Molloy 1995).

Community Two: ***Pittosporum tenuifolium-Coprosma robusta*** forest. *Coprosma robusta* grows up to 5 metres in height, with flowers in clusters and yellow-red fruit 6-8 mm long. Leaves are 5-12 cm long. This species does not block out much light because although leaves are large and thick they are relatively sparse on the tree. The characteristic branchiness of this species makes it attractive to birds as do the brightly coloured fruits. The plots in this community have an average *Coprosma robusta* canopy cover of 11%. Refer to *Pittosporum tenuifolium* description above. The plots in this community have an average *Pittosporum tenuifolium* canopy cover of 51% (Poole and Adams 1994, Mitchell and Wilkinson 1995, Philipson 1995, Molloy 1995).

Community Three: ***Plagianthus regius-Pittosporum tenuifolium*** forest. *Plagianthus regius* is a deciduous tree growing up to 17 metres in height. The juvenile form displays interlaced branches and small leaves. Leaves are 2-8 cm long. Flowers are small, in large terminal panicles. Fruit is an ovoid capsule 4 mm long. This species drops a large amount of leaves during Autumn, but because of their smallish size and thinness they tend to break down faster than, for example *Cordyline australis* leaves. They let a reasonable amount of light through to the forest floor because of the small size of leaves. The seeds of this tree are mostly distributed by gravity and wind. The plots in this community have an average *Plagianthus regius* canopy cover of 35%. For a description of *Pittosporum tenuifolium see above.* The plots in this community have an average *Pittosporum tenuifolium* canopy cover of 17% (Poole and Adams 1994, Mitchell and Wilkinson 1995, Philipson 1995, Molloy 1995).

Community Four: ***Pittosporum eugenioides-Pittosporum tenuifolium-Hoheria angustifolia*** forest.

Pittosporum eugenioides has a large open branching crown and grows up to 13 metres. Leaves are 5-10 cm long. Flowers are in large compound umbels and fruit is 2-3 valved and 6 mm long. This species tends to stop a lot of light from reaching the forest floor because of its branching crown, large leaf size and large number of leaves. *Pittosporum eugenioides* is moderately attractive to birds because of its branching habit and its fruits. The plots in this community have an average *Pittosporum eugenioides* canopy cover of 17%. *Hoheria angustifolia* grows up to 10 metres in height and the juvenile form shows interlaced branches and a narrow form. Leaves are 2-5 cm long. Flowers 8 mm in diameter and fruit in 5 carpels round a central axis. The adult form has a large spreading crown. This species produces little leaf litter and does not block out much sunlight because of the small leaf size and branching habit. It is also attractive to birds because of its form but seeds from this tree are mostly distributed by wind. The plots in this community have an average *Hoheria angustifolia* canopy cover of 9%. For a description of *Pittosporum tenuifolium* see above. The plots in this community have an average *Pittosporum tenuifolium* canopy cover of 22% (Poole and Adams 1994, Mitchell and Wilkinson 1995, Philipson 1995, Molloy 1995).

Judging from the anova results for the number of seedlings greater than ten centimetres in height, it was found that they are significantly different in each of the four Communities with an F value of 5.28. The number of seedlings in each of the Communities were: 1) *Cordyline australis-Pittosporum tenuifolium* forest – 51; 2) *Pittosporum tenuifolium- Coprosma robusta* forest – 225; 3) *Plagianthus regius-Pittosporum tenuifolium* forest – 77 ; 4) *Pittopsorum eugenioides-Pittosporum tenuifolium-Hoheria angustifolia* forest – 51. So going by these results, Community Two had the greatest number of seedlings followed by Community Three.

Regressions of total number of seedlings and numbers of the five most common seedlings (all) (*Hoheria angustifolia (1st), Streblus heterophyllus (2nd), Melicytus ramiflorus (3rd), Dacrydium dacrydioides (4th) and Parsonia heterophylla (5th))* showed that total canopy cover had little or no effect on the number of seedlings present underneath the canopy. So it seems that factors other than total canopy cover are more important for determining the abundance of seedlings in Riccarton Bush, such as the attractiveness of plants to birds and litter production.

The numbers of different dispersal types of seeds in the restoration plantings and the whole of Riccarton Bush were analysed using a Chi-Square goodness of fit Test. The test concluded that there were significant differences between the numbers of dispersal types for the restoration plantings and Riccarton Bush as a whole. This result may be explained by the relatively young age of the restoration plantings and the attractiveness of the area to birds. Other studies show that our results are similar to dispersal types for woody species on the Port Hills; "Of the 31 regenerating tree species...22 were primarily dispersed by avian dispersal agents...six are wind dispersed and three are dispersed by gravity..." (Reay and Norton 1996).

The aim of this dissertation was to find out whether: "In the restoration plantings at Riccarton Bush, are some planted species, or species combinations, better nurses for regeneration than other species and what are the features that characterise these species?" In other words are particular plant species in the Riccarton Bush restoration plantings acting as nurse plants, helping the regeneration of seedlings more than other plant species present in the plantings? The roles of nurse plants have been well documented, for example "Some...plants can...be beneficial by encouraging natural regeneration of native plants...they may provide ideal shelter, semi-shade and litter for the germination of many native trees and shrubs" (Porteous 1993). Reay and Norton (1996) found that "*Olearia paniculata*...is an effective nurse species" for restoration plantings in the Port Hills. It has also been found that in some cases, native plants are better nurse plants than more typically used nurse crops such as *Pinus radiata* or gorse. For example "The crown spread of many other quick-growing species, such as *Coprosma* and *Pittosporum* species, is potentially greater than that of manuka" (Porteous 1993). It is these two species that dominate the canopy of Community Two which has also been found to have a significantly larger number of seedlings (measuring greater than 10 centimetres) than the other three Communities.

Numerous factors other that just the canopy cover such as the colour of fruits determine the composition of regenerating forests. In a study conducted by Stewart and Woods (1995) it was found that "In the beech 'community' *Coprosma* species and broadleaf dominate the understorey. In the broadleaved 'community' the canopy species lacebark and ribbonwood apppear to be replacing themselves, as seedlings of both are abundant. In the podocarp 'community' seedlings of lacebark and ribbonwood also dominate, and the main canopy species – kohuhu – is poorly represented in the understorey." In a study done at Kennedy's Bush in the Port Hills it was found that "...initial floristic composition is less significant in restoration plantings than has been previously suggested" and "...species choice alone is unlikely to play a major role in determining which tree species regenerate" (Reay and Norton 1996). Reay and Norton (1996) also found that "...recolonisation of indigenous biodiversity is being facilitated by the restoration" although it was conceded that "In terms of restoring fully functioning, self-sustaining natural ecosystems, the three restoration study sites have been to some extent unsuccessful." However it was decided that "...with time the canopy of the restoration plantings will change to become more similar to that present in the mature forest" and "...at the two older sites...key functional processes identifiable with natural ecosystems...have been restored."

From the initial analysis comparing woody species in Riccarton Bush with the regenerating woody species in the restoration plantings it seems that the restoration has been successful because the plantings contain approximately one-third of the species in the entire bush, although as already stated, there were significant differences between the restoration area and the bush as a whole. "Regeneration of seedlings from plants within the restoration study plots indicates that other important ecosystem processes such as pollination are occurring" (Reay and Norton 1996). We can also conclude that ecosystem processes are operating in Riccarton Bush because of the large amount of seedlings that have established over the years. Reay and Norton (1996) also say that "Historically, *Kunzea ericoides* and *Melicytus ramiflorus* were dominant in the early stages of forest succession…" which has similarities with the restoration plantings in Riccarton Bush where *Melicytus ramiflorus* is the third most common species in the restoration plantings.

So why is Community Two – the *Pittosporum tenuifolium-Coprosma robusta* forest a better nurse plant combination for seedlings than the other Communities. There are a number of reasons. Firstly, as stated above, *Coprosma* and *Pittosporum* species grow relatively fast compared to other native trees. However most of the species which dominate the canopies of the other Communities are quite fast growers as well, so this reason probably does not have much effect on the greater number of seedlings under Community Two's canopy.

Secondly, a quote from Porteous (1993) perhaps indicates the success of Community Two; "…a return to forest can be hastened by planting species that will attract birds" (Porteous 1993). The activities of native and introduced birds in Riccarton Bush have been well documented, and it has been shown that certain plant species in the bush are particularly attractive to some birds for feeding. For example "Favourite foods, which make Riccarton Bush attractive to pigeons include cabbage tree, kahikatea, Coprosma and Fuchsia fruits and the new shoots and leaves of the ribbonwood...kowhai and Meuhlenbeckia vines. Also often consumed are the fruits of mapou, kohuhu, puahou, horoeka, kaikomako, mahoe, rohutu and makomako" (O'Donnell 1995). "The New Zealand pigeon, which eats a wide variety of fruits of native plants, and the leaves, buds and flowers of many species, has a very large appetite and is among the most important bird for spreading seed, particularly seeds containing large fruits such as tawa, miro, karaka, matai, taraire and puriri" (Porteous 1993).

"Important fruit sources in Riccarton Bush are provided by the Coprosma species, makomako, mahoe, Meuhlenbeckia, mapou, rohutu, horoeka and kaikomako. Nectar is taken particularly from kowhai, ribbonwood, Fuchsia and tarata" and "Redpolls also eat kahikatea fruit, while greenfinches and chaffinches consume the developing ovules" (O'Donnell 1995).

Introduced bird species are also an important part of the fauna in Riccarton Bush, for example, "They [blackbirds] probe the soil and scatter leaf litter in search of invertebrates...However, when fruits are available, these too form a major part of the diet. Blackbirds in particular take kahikatea fruit. Coprosma, mahoe, Fuchsia, horeka and mapou fruits are also favoured" (O'Donnell 1995).

Other species of birds do not seem to prefer any particular plant in the bush, for example, "Silvereyes are omnivorous, having a staple diet of insects but consuming fruit and nectar when these are available. They are generalist feeders, using all the plant species in Riccarton Bush" and "Warblers feed from all plant species in Riccarton Bush, not appearing to prefer any particular plant" (O'Donnell 1995).

Riccarton Bush is also attractive to birds feeding on nectar and insects. For example "Only during periods when fruit is abundant are bellbirds reported as staying for a number of days. Otherwise they generally feed on invertebrates and nectar producing plants" , "Sometimes warblers are seen hovering in the air at the tips of kahikatea leaves and taking caterpillars" and "The forest plants are used as resting posts between feeding bouts or while scanning for insect swarms in clearings around the Bush [by fantails]" (O'Donnell 1995). In September "...flocks of between 10 and 20 birds are seen in every [kowhai] tree, consuming the high energy kowhai nectar..." (O'Donnell 1995).

Riccarton Bush is also a favourite place for birds to nest and roost at night. For example "Favourite nesting species within the Bush [of silvereyes] include various Coprosma species, turepo and poataniwha", "Favourite nesting plants [of blackbirds and thrushes] include mahoe, tarata and...Meuhlenbeckia and passionflower vines" and "The cabbage trees around the perimeter of Riccarton Bush are a favourite nesting site...starlings can be seen feeding on the nectar of the kowhai flowers" (O'Donnell 1995). Reay and Norton (1996) found that in the restoration plantings in the Port Hills "...the tall closed canopies at...two restoration sites appears to offer ideal perch sites for birds. Other features of the restored sites that potentially attract dispersers are the presence of invertebrates, nest sites and nectar."

It has also been found that blackbirds most often sing from low dense thickets while song thrushes prefer high perches, usually kahikatea. Starlings will only use hollow tree trunks for nests. Obviously Riccarton Bush is a very important habitat area for birds, both native and introduced, by providing fruits, foliage, nectar, insects and nesting sites (O'Donnell 1995).

So if certain plants are more attractive to birds because of their fruit, nectar, insects or branching form, they will be used more than plants that do not exhibit any of these characteristics. If birds use some plants more than others, there will be more opportunities for them to eat these fruits and then disperse them further afield and also a greater likelihood of birds depositing seeds under roosting sites; "...the passage of fruit through a bird's gut removes the inhibitory flesh" (Burrows 1994). It has also been found that "For individual seed species the greatest density of seeds falling to the ground usually occurs beneath heavily fruiting plants" (Burrows 1994).

Types of seeds in Riccarton Bush: 1) drupes – single or sometimes 2-seeded fruit with a more-or-less succulent pericarp surrounding a hard endocarp inside which is the seed. Examples in Riccarton Bush are *Elaecarpus, Myoporum* and *Pennantia* species; 2) berries – in which there are usually many seeds surrounded by, or imbedded in, more-or-less succulent soft flesh. Examples in Riccarton Bush are *Solanum, Aristotelia, Fuchsia* species and *Melicytus ramiflorus*; 3) aggregate fruit – small fruitlets, each like a drupe, grouped together, adhering more-or-less tightly; 4) false fruit – fleshy accessory tissues near the seeds or fruit proper. Examples in Riccarton Bush include *Dacrydioides, Podocarpus, Prumnopitys, Alectryon* and *Pittosporum* species (Burrows 1994).

Studies conducted on Banks Peninsula have shown that purplish-black fruits followed by red fruits were preferred by birds and were also the most common. A reason for the preference has been put forward that "Black feature in other ways as well because black seeds of *Dacrycarpus, Dacrydium, Meuhlenbeckia, Pittosporum, Alectryon* and *Cordyline*...contrast with the colours of the pericarp or accessory tissues" (Burrows 1994) thus making them easier to see. The number of species with a particular coloured fruit after purplish-black (20) and red (18), were orange (11), white (10), yellow (5), black (4), purple (4) and blue (2) on Banks Peninsula (Burrows 1994).

In Community Two the fruits of *Pittosporum tenuifolium* and *Coprosma robusta* are black and orange, respectively. In Community Three, (the *Plagianthus regius-Pittosporum tenuifolium* forest) the fruits of *Pittosporum tenuifolium* are black while *Plagianthus regius* seeds are brown and dispersed by wind and gravity. In Community One (the *Cordyline australis-Pittosporum tenuifolium* forest) the fruits are purple and black, respectively. In Community Four (the *Pittosporum eugenioides-Pittosporum tenuifolium-Hoheria angustifolia* forest) the colours of fruits are black, black and brown, respectively although *Hoheria angustifolia* seeds are dispersed by wind (Burrows 1994).

Assuming that the commonness of a fruit's colour relates to its preference by birds and that birds on Banks Peninsula prefer the same colours as those at

Riccarton Bush, Community Two seems to be the most preferred combination of species. This may explain partly why there is a significantly higher number of seedlings in Community Two. Other factors involved may relate to characteristics covered above, relating to litter production of trees and the amount of light they let through to the forest floor. For instance, the forest floor receives quite large amounts of light under the Community Two canopy while the forest floor under the canopy of Community Four does not receive as much light because of the habit of the dominant species described above.

It is probable that Community Two is the best overall site for regeneration because of the colourful fruits which attract birds, reasonable light levels and adequate leaf litter which encourages, not impedes establishment of seedlings.

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APPENDIX ONE

Seedling Density per plot (all seedlings)

Species in each plot

plot number	Age	A. serrata	(C. propinqua	C. robusta	C. australis	D. dacrydioides	H. angustifolia	L. obcordata	M. ramiflorus	M. australis	P. heterophylla	P. tetrandra	P. eugenioides	P. tenuifolium	P. regius	P. crassifolius	P. colorata	S. microphylla	S. heterophyllus
1	16	0	0	0	0	0	8	0	18	1	10	5	0	0	0	1	0	10	13
2	16	0	1	0	0	4	4	0	55	0	25	2	0	0	0	3	2	0	14
3	16	0	0	0	0	0	5	0	2	0	3	0	0	0	0	0	0	0	4
4	16	0	0	0	0	0	4	0	0	0	14	0	0	0	1	0	0	0	4
5	16	0	0	0	0	0	4	0	23	0	9	0	0	0	1	0	0	0	44
6	16	0	0	0	0	2	19	0	21	0	4	4	1	1	0	0	0	0	38
7	16	0	0	0	0	5	6	2	0	0	0	2	0	0	0	0	0	0	25
8	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	16	0	0	3	4	4	4	1	12	0	5	0	0	1	1	0	0	0	6
10	16	0	0	4	0	2	2	0	12	0	8	2	0	0	3	0	0	0	15
11	16	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	1
12	16	0	0	1	1	0	2	1	3	0	9	3	0	0	1	0	0	0	16
13	16	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0
14	19	0	0	0	0	37	14	0	6	0	1	1	0	0	5	0	0	0	8
15	19	0	0	0	3	0	3	0	3	0	5	2	0	0	0	0	0	0	2
16	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	19	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	19	0	0	0	0	5	18	1	0	0	2	2	0	5	0	0	0	0	3
22	19	0	0	0	1	54	12	21	2	0	4	3	0	2	1	0	0	0	0
23	19	0	0	0	0	0	13	2	1	0	7	2	0	1	0	0	0	0	1
24	19	0	2	0	0	5	6	26	1	0	1	1	0	2	0	0	0	0	1
25	19	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0
26	19	0	0	0	0	0	40	0	1	0	0	0	0	0	0	0	0	0	0
27	19	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	1	0
28	19	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	10	1
29	19	0	2	0	0	0	49	1	0	0	4	1	1	1	0	0	0	3	0
30	19	0	0	0	0	1	7	1	1	0	1	1	0	5	0	0	0	5	1
31	19	0	0	0	0	0	12	0	2	0	0	0	0	0	0	0	0	3	7
32	19	0	1	0	0	0	6	0	0	0	0	0	0	0	0	0	0	1	2
33	19	0	1	0	0	0	5	2	0	0	0	0	0	2	0	0	0	0	1
34	19	1	0	0	0	0	6	2	0	0	0	0	0	2	0	0	0	6	0
35	19	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	3	0
36	19	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	11	0
37	19	0	0	0	0	2	0	0	1	0	0	0	0	0	0	0	0	1	0
38	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39	19	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
40	19	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	4	1
41	19	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	4	0
42	19	0	0	0	0	2	3	0	0	0	0	0	0	0	0	0	0	0	5
43	19	1	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	2
44	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0
45	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
47	19	0	0	0	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0
48	19	0	0	0	0	0	5	0	0	0	0	1	0	0	0	0	0	0	0
49	19	0	0	0	0	1	4	0	0	0	0	0	0	0	0	0	0	0	2
50	19	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	6	0

square leave	Dagger leaves	total
0	0	66
0	0	110
0	0	14
0	0	23
2	0	83
0	0	90
0	0	40
0	0	0
0	0	41
0	0	48
0	0	4
0	2	39
0	0	4
0	0	72
0	0	18
0	0	0
0	0	2
0	0	0
0	0	0
0	0	0
0	0	36
0	2	102
0	0	27
0	0	45
0	0	5
0	1	42
0	0	5
0	0	14
0	0	62
0	0	23
0	0	24
0	0	10
0	0	11
0	0	17
0	0	6
0	0	17
0	0	4
0	0	0
0	0	1
0	0	7
0	0	7
0	0	10
0	0	6
0	0	4
0	0	0
0	0	0
0	0	4
0	0	6
0	0	7
0	0	9

Seedling Density per plot (seedlings <10cm in height)

Plot Number	Age	Species in each plot																			
		A. serrata	(C. propinqua)	C. robusta	C. australis	D. dacrydioides	H. angustifolia	L. obcordata	M. ramiflorus	M. australis	P. heterophylla	P. tetrandra	P. eugenioides	P. tenuifolium	P.regius	P. crassifolius	P. colorata	S. microphylla	S. heterophyllus	square leave	dagger leave
1	16	0	0	0	0	0	6	0	15	1	9	1	0	0	0	1	0	9	6	0	0
2	16	0	1	0	0	4	0	0	36	0	24	1	0	0	0	2	2	0	6	0	0
3	16	0	0	0	0	0	5	0	2	0	3	0	0	0	0	0	0	0	4	0	0
4	16	0	0	0	0	0	4	0	0	0	14	0	0	0	1	0	0	0	3	0	0
5	16	0	0	0	0	0	4	0	17	0	4	0	0	0	0	0	0	0	33	2	0
6	16	0	0	0	0	2	18	0	13	0	4	1	0	0	0	0	0	0	30	0	0
7	16	0	0	0	0	5	6	0	0	0	0	2	0	0	0	0	0	0	25	0	0
8	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	16	0	0	0	0	3	2	0	12	0	4	0	0	0	6	0	0	0	6	0	0
10	16	0	0	0	0	2	1	0	5	0	8	1	0	0	0	0	0	0	6	0	0
11	16	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0
12	16	0	0	1	1	0	2	0	3	0	8	0	0	0	0	0	0	0	6	0	2
13	16	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
14	19	0	0	0	0	26	3	0	0	0	1	1	0	0	0	0	0	0	2	0	0
15	19	0	0	0	0	0	3	0	2	0	5	2	0	0	0	0	0	0	2	0	0
16	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	19	0	0	0	0	2	8	0	0	0	2	0	0	0	0	0	0	0	0	0	0
22	19	0	0	0	0	37	4	6	0	0	3	0	0	0	0	0	0	0	0	0	0
23	19	0	0	0	0	0	6	2	1	0	7	1	0	1	0	0	0	0	1	0	0
24	19	0	2	0	0	4	3	20	0	0	0	1	0	2	0	0	0	0	1	0	0
25	19	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	19	0	0	0	0	0	40	0	1	0	0	0	0	0	0	0	0	0	0	0	1
27	19	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	1	0	0	0
28	19	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	5	0	0	0
29	19	0	2	0	0	0	49	1	0	0	4	0	0	0	0	0	0	1	0	0	0
30	19	0	0	0	0	0	7	1	0	0	1	0	0	0	0	0	0	2	0	0	0
31	19	0	0	0	0	0	11	0	1	0	0	0	0	0	0	0	0	0	6	0	0
32	19	0	1	0	0	0	6	0	0	0	0	0	0	0	0	0	0	1	0	0	0
33	19	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0
34	19	0	0	0	0	0	6	1	0	0	0	0	0	1	0	0	0	2	0	0	0
35	19	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36	19	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	3	0	0	0
37	19	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40	19	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	3	1	0	0
41	19	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	2	0	0	0
42	19	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	3	0	0
43	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
44	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
45	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
47	19	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48	19	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
49	19	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0
50	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0

Total
48
76
14
22
60
68
38
0
27
23
4
23
2
33
14
0
0
0
0
0
12
50
19
33
4
42
3
8
57
11
18
8
2
10
1
7
2
0
0
5
5
6
1
1
0
0
1
2
2

Seedling Density per plot (seedlings >10cm in height)

Species in each plot

Plot number	Age	A. serrata	(C. propinqua)	C. robusta	C. australis	D. dacrydioides	H. angustifolia	L. obcordata	M. ramiflorus	M australis	P. heterophylla	P. tetrandra	P. eugenioides	P. tenuifolium	P. regius	P. crassifolius	P. colorata	S. microphylla	S. heterophyllus	square leaves	dagger leaves
1	16	0	0	0	0	0	9	0	4	0	1	4	0	0	0	0	0	1	0	0	0
2	16	0	0	0	0	0	4	0	19	0	1	1	0	0	0	1	0	0	8	0	0
3	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
5	16	0	0	0	0	0	0	0	6	0	6	0	0	0	1	0	0	0	11	0	0
6	16	0	0	0	0	0	1	0	0	0	0	3	1	1	0	0	0	0	8	0	0
7	16	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
8	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	16	0	0	4	4	1	2	1	4	0	1	0	0	1	1	0	0	0	0	0	0
10	18	0	0	4	0	1	1	0	7	0	2	1	0	0	3	0	0	0	9	0	0
11	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	16	0	0	0	0	0	0	1	0	0	1	3	0	0	1	1	0	0	10	0	0
13	16	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
14	19	0	0	0	0	11	11	0	6	0	0	0	0	0	5	0	0	0	6	0	0
15	19	0	0	0	3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
16	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	19	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	19	0	0	0	0	3	10	1	0	0	0	2	0	5	0	0	0	0	3	0	0
22	19	0	0	0	1	17	8	15	2	0	1	3	0	2	1	0	0	0	0	0	2
23	19	0	0	0	0	0	7	0	0	0	0	1	0	0	0	0	0	0	0	0	0
24	19	0	0	0	0	1	3	6	1	0	1	0	0	0	0	0	0	0	0	0	0
25	19	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	19	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	1	0	0
29	19	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	2	0	0	0
30	19	0	0	0	0	1	0	0	1	0	0	1	0	5	0	0	0	3	1	0	0
31	19	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0
32	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
33	19	0	1	0	0	0	5	2	0	0	0	0	0	1	0	0	0	0	0	0	0
34	19	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	4	0	0	0
35	19	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	3	0	0	0
36	19	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	8	0	0	0
37	19	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0
38	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39	19	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
40	19	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0
41	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
42	19	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	2	0	0
43	19	1	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	1	0	0
44	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
45	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
47	19	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48	19	0	0	0	0	0	3	0	0	0	0	1	0	0	0	0	0	0	0	0	0
49	19	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0
50	19	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	4	0	0	0

total
19
34
0
1
24
14
2
0
19
28
0
17
2
39
4
0
2
0
0
0
24
52
8
12
1
2
0
11
5
12
3
2
9
7
5
10
2
0
1
2
2
4
5
3
0
0
3
4
3
7

Overhead tree cover per plot (in one metre diameter plot)

Plot Number	Total Cover (%)	Age (years)	Species cover (%)													
			A. serrata	C. propinqua	C. robusta	C. australis	D. dacrydioides	G. littoralis	H. angustifolia	H. sextoylosa	L. obcordata	M. ramiflorus	P. eugenioides	P. tenuifolium	P. regius	P. totara	P. crassifolius
1	63	16	0	0	0	0	0	0	0	0	0	0	63	0	0	0	0
2	63	16	0	0	18	0	0	0	0	0	0	0	0	63	0	8	0
3	63	16	0	0	0	0	0	0	0	0	0	3	18	38	0	0	0
4	88	16	0	0	0	8	0	0	0	0	0	0	63	18	0	0	0
5	63	16	38	18	0	3	0	0	0	0	0	0	0	3	0	0	0
6	63	16	0	0	8	0	0	0	0	0	0	0	0	18	18	0	0
7	38	16	0	0	8	18	8	8	0	0	0	0	0	0	0	0	3
8	3	16	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0
9	63	16	0	0	0	0	0	0	0	0	0	0	0	38	38	0	0
10	63	16	0	0	0	3	0	0	0	0	0	0	0	63	0	0	0
11	18	16	0	0	0	8	0	0	0	0	0	0	0	8	3	0	0
12	63	16	0	0	3	0	3	0	0	0	0	0	0	18	0	0	0
13	38	16	0	0	8	18	0.5	0	0	0	0	0	0	38	0	0	0
14	38	19	0	0	0	3	0	0	0	0	0	0	0	8	38	0	0
15	88	19	0	0	0	18	0	0	0	0	0	0	0	18	0	0	0
16	18	19	0	0	18	8	0	0	0	0	0	0	0	0	18	0	0
17	38	19	0	0	0	38	0	0	0	0	0	0	0	0	0	0	0
18	18	19	0	0	3	18	0	0	0	0	0	0	0	3	8	0	0
19	38	19	0	0	0.5	18	0	0	0	18	0	0	0	0	0	0	0
20	38	19	0	0	0	18	0	0	0	8	0	0	0	18	8	0	0
21	88	19	0	0	63	0	0	0	0	0	0	0	0	38	0	0	0
22	88	19	0	0	38	0	0	0	0	0	0	0	0	63	0	0	0
23	88	19	0	0	0	0	0	0	0	0	0	0	0	88	0	0	0
24	88	19	0	0	0	0	0	0	0	0	8	0	0	38	0	18	0
25	63	19	0	0	0	0	0	0	0	0	0	0	0	63	3	0	0
26	63	19	0	0	0	0	0	0	0	0	0	0	0	3	63	0	0
27	63	19	0	0	18	38	0	0	0	0	0	0	0	8	0	0	0
28	63	19	0	0	18	0	0	0	0	0	0	0	0	18	3	0	0
29	88	19	0	0	0	0	0	0	0	0	0	0	0	63	63	0	0
30	63	19	0	0	3	8	0	0	0	0	0	0	0	38	0	0	0
31	63	19	0	0	3	0	0	0	0	0	0	0	0	38	0	0	8
32	63	19	0	0	8	0	0	0	0	0	0	0	0	63	0	0	18
33	88	19	0	0	0	0	0	0	0	0	0	0	3	38	38	0	0
34	63	19	0	0	0	0	0	0	0	0	0	0	0	38	3	0	0
35	88	19	0	0	0	0	0	0	0	0	0	0	0	88	0	0	0
36	38	19	0	0	0	0	8	0	0	0	0	0	0	0	0	0	18
37	38	19	0	0	0	0	0	0	0	0	0	0	18	0	0	0	38
38	38	19	0	0	0	0	0	0	38	0	0	0	3	0	0	0	0
39	88	19	0	0	0	0	0	0	18	0	0	0	38	0	0	0	0
40	63	19	0	0	0	0	0	0	38	0	0	0	0	38	0	0	0
41	63	19	0	0	0	0	0	0	18	0	0	0	0	38	0	0	0
42	38	19	0	0	0	0	0	0	8	0	0	0	18	38	0	0	0
43	63	19	0	0	0	0	0	0	0	0	0	0	0	63	0	0	0
44	38	19	0	0	0	0	0	0	0	0	0	0	38	18	0	0	0
45	63	19	0	0	0	0	0	0	0	0	0	0	18	38	0	0	0
46	63	19	0	0	0	0	0	0	0	0	0	0	0	0	18	0	38
47	38	19	0	0	0	0	0	0	8	0	0	0	0	18	0	0	18
48	63	19	0	0	0	0	0	0	0	0	0	0	38	0	0	0	0
49	38	19	0	0	0	0	0	0	0	0	0	0	0	0	38	0	18
50	63	19	0	0	18	0	0	0	0	0	0	0	0	38	0	0	0

4-2

S. heterophyllus
0
0
0
0
0
18
0
0
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0
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0
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0
0
0

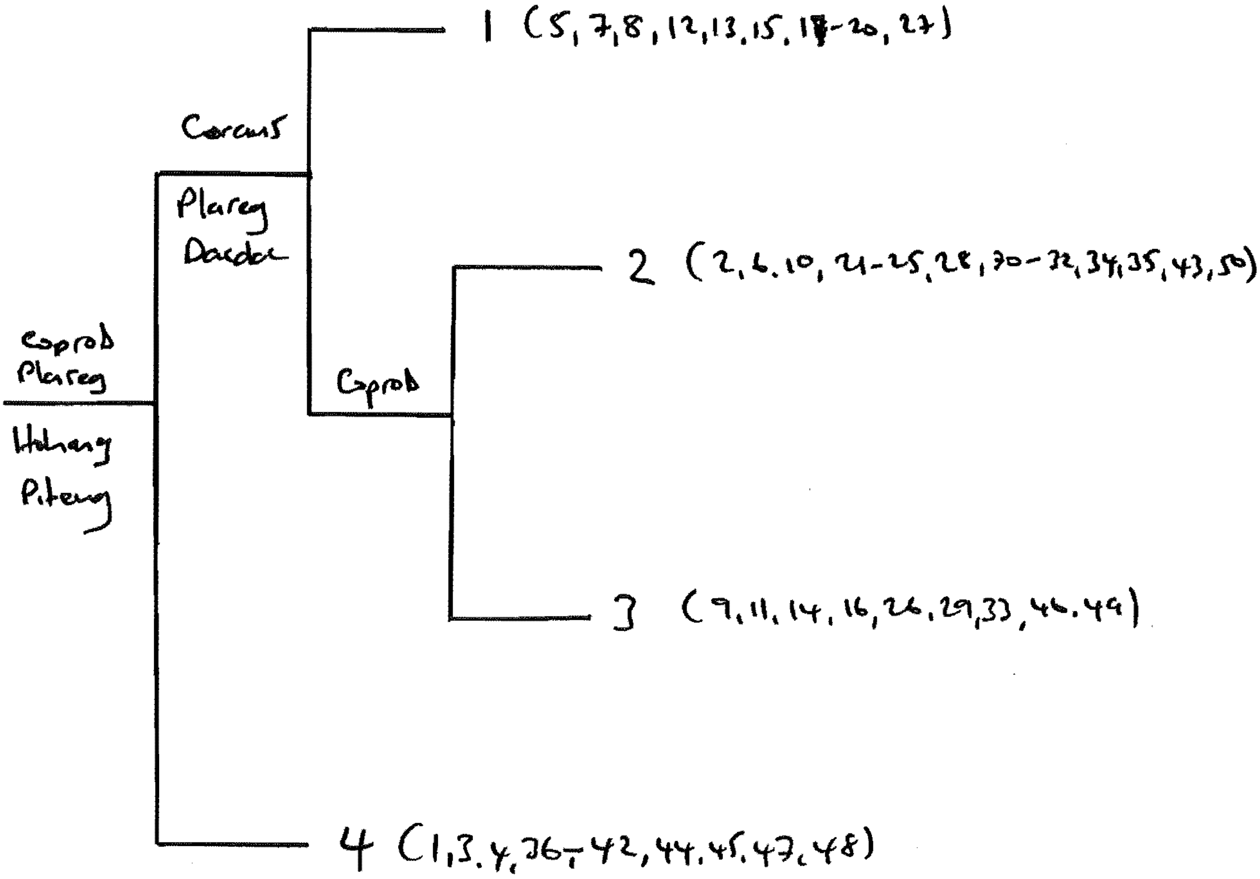
P. tenuif	australis
3	3
0	18
0	3
18	0
38	18
18	18
0	38
3	18
0	18
18	18
8	38
9.6	17.3

C. rob	P.ten
18	63
8	18
0	63
63	38
38	63
0	88
0	38
0	63
18	18
3	38
3	38
8	63
0	38
0	88
0	63
18	38
11.1	51.1

P. tenuif	. regius
38	38
8	3
8	38
0	18
3	63
63	63
38	38
0	18
0	38
17.6	35.2

H. angus	ugenio	nuifolium
0	63	0
0	18	38
0	63	18
0	0	0
0	18	0
38	3	0
18	38	0
38	0	38
18	0	38
8	18	38
0	38	18
0	18	38
8	0	18
0	38	0
9.1	22.5	17.4

APPENDIX TWO



See Fig 2 in Nelson & Leathwick (1990) for explanation.

APPENDIX THREE

A. serrata	C. propinqua	C. robusta	C. australis	D. dacrydioides	H. angustifolia	L. obcordata	M. ramiflorus	M. australis	P. heterophylla	P. tetrandra	P. eugenioides	P. tenuifolium	P. regius	P. crassifolius	P. colorata	S. microphylla	S. heterophyllus	square leaves	Dagger leaves	total
GROUP1	(ALL)																			
0	0	0	0	0	4	0	23	0	9	0	0	0	1	0	0	0	44	2	0	83
0	0	0	0	5	6	2	0	0	0	2	0	0	0	0	0	0	25	0	0	40
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	1	1	0	2	1	3	0	9	3	0	0	1	0	0	0	16	0	2	39
0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	4
0	0	0	3	0	3	0	3	0	5	2	0	0	0	0	0	0	2	0	0	18
0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	1	0	0	0	5
GROUP2																				
0	1	0	0	4	4	0	55	0	25	2	0	0	0	3	2	0	14	0	0	110
0	0	0	0	2	19	0	21	0	4	4	1	1	0	0	0	0	38	0	0	90
0	0	4	0	2	2	0	12	0	8	2	0	0	3	0	0	0	15	0	0	48
0	0	0	0	5	18	1	0	0	2	2	0	5	0	0	0	0	3	0	0	36
0	0	0	1	54	12	21	2	0	4	3	0	2	1	0	0	0	0	0	2	102
0	0	0	0	0	13	2	1	0	7	2	0	1	0	0	0	0	1	0	0	27
0	2	0	0	5	6	26	1	0	1	1	0	2	0	0	0	0	1	0	0	45
0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	10	1	0	0	14
0	0	0	0	1	7	1	1	0	1	1	0	5	0	0	0	5	1	0	0	23
0	0	0	0	0	12	0	2	0	0	0	0	0	0	0	0	3	7	0	0	24
0	1	0	0	0	6	0	0	0	0	0	0	0	0	0	0	1	2	0	0	10
1	0	0	0	0	6	2	0	0	0	0	0	2	0	0	0	6	0	0	0	17
0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	3	0	0	0	6
1	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	2	0	0	6
0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	6	0	0	0	9
GROUP3																				
0	0	3	4	4	4	1	12	0	5	0	0	1	1	0	0	0	6	0	0	41
0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	4
0	0	0	0	37	14	0	6	0	1	1	0	0	5	0	0	0	8	0	0	72
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	40	0	1	0	0	0	0	0	0	0	0	0	0	0	1	42
0	2	0	0	0	49	1	0	0	4	1	1	1	0	0	0	3	0	0	0	62
0	1	0	0	0	5	2	0	0	0	0	0	2	0	0	0	0	1	0	0	11
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	1	4	0	0	0	0	0	0	0	0	0	0	0	2	0	0	7
GROUP4																				
0	0	0	0	0	8	0	18	1	10	5	0	0	0	1	0	10	13	0	0	66
0	0	0	0	0	5	0	2	0	3	0	0	0	0	0	0	0	4	0	0	14
0	0	0	0	0	4	0	0	0	14	0	0	0	1	0	0	0	4	0	0	23
0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	11	0	0	0	17
0	0	0	0	2	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	4
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	4	1	0	0	7
0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	4	0	0	0	7
0	0	0	0	2	3	0	0	0	0	0	0	0	0	0	0	0	5	0	0	10
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	4
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
0	0	0	0	0	5	0	0	0	0	1	0	0	0	0	0	0	0	0	0	6

GROUP1	(<10CM)																			
0	0	0	0	0	4	0	17	0	4	0	0	0	0	0	0	0	33	2	0	60
0	0	0	0	5	6	0	0	0	0	2	0	0	0	0	0	0	25	0	0	38
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	1	1	0	2	0	3	0	8	0	0	0	0	0	0	0	6	0	2	23
0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2
0	0	0	0	0	3	0	2	0	5	2	0	0	0	0	0	0	2	0	0	14
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	3
GROUP2																				
0	1	0	0	4	0	0	36	0	24	1	0	0	0	2	2	0	6	0	0	76
0	0	0	0	2	18	0	13	0	4	1	0	0	0	0	0	0	30	0	0	68
0	0	0	0	2	1	0	5	0	8	1	0	0	0	0	0	0	6	0	0	23
0	0	0	0	2	8	0	0	0	2	0	0	0	0	0	0	0	0	0	0	12
0	0	0	0	37	4	6	0	0	3	0	0	0	0	0	0	0	0	0	0	50
0	0	0	0	0	6	2	1	0	7	1	0	1	0	0	0	0	1	0	0	19
0	2	0	0	4	3	20	0	0	0	1	0	2	0	0	0	0	1	0	0	33
0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	5	0	0	0	8
0	0	0	0	0	7	1	0	0	1	0	0	0	0	0	0	2	0	0	0	11
0	0	0	0	0	11	0	1	0	0	0	0	0	0	0	0	0	6	0	0	18
0	1	0	0	0	6	0	0	0	0	0	0	0	0	0	0	1	0	0	0	8
0	0	0	0	0	6	1	0	0	0	0	0	1	0	0	0	2	0	0	0	10
0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2
GROUP3																				
0	0	0	0	3	2	0	12	0	4	0	0	0	0	0	0	0	6	0	0	27
0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	4
0	0	0	0	26	3	0	0	0	1	1	0	0	0	0	0	0	2	0	0	33
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	40	0	1	0	0	0	0	0	0	0	0	0	0	0	1	42
0	2	0	0	0	49	1	0	0	4	0	0	0	0	0	0	1	0	0	0	57
0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	2
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	4
GROUP4																				
0	0	0	0	0	6	0	15	1	9	1	0	0	0	1	0	9	6	0	0	48
0	0	0	0	0	5	0	2	0	3	0	0	0	0	0	0	0	4	0	0	14
0	0	0	0	0	4	0	0	0	14	0	0	0	1	0	0	0	3	0	0	22
0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	3	0	0	0	7
0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	3	1	0	0	5
0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	2	0	0	0	5
0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	3	0	0	6
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2

GROUP1	(>10CM)																			
0	0	0	0	0	0	0	6	0	6	0	0	0	1	0	0	0	11	0	0	24
0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	1	0	0	1	3	0	0	1	1	0	0	10	0	0	17
0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2
0	0	0	3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	4
0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GROUP2																				
0	0	0	0	0	4	0	19	0	1	1	0	0	0	1	0	0	8	0	0	34
0	0	0	0	0	1	0	0	0	0	3	1	1	0	0	0	0	8	0	0	14
0	0	4	0	1	1	0	7	0	2	1	0	0	3	0	0	0	9	0	0	28
0	0	0	0	3	10	1	0	0	0	2	0	5	0	0	0	0	3	0	0	24
0	0	0	1	17	8	15	2	0	1	3	0	2	1	0	0	0	0	0	2	52
0	0	0	0	0	7	0	0	0	0	1	0	0	0	0	0	0	0	0	0	8
0	0	0	0	1	3	6	1	0	1	0	0	0	0	0	0	0	0	0	0	12
0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	1	0	0	11
0	0	0	0	1	0	0	1	0	0	1	0	5	0	0	0	3	1	0	0	12
0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	3
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2
1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	4	0	0	0	7
0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	3	0	0	0	5
1	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	1	0	0	5
0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	4	0	0	0	7
GROUP3																				
0	0	4	4	1	2	1	4	0	1	0	0	1	1	0	0	0	0	0	0	19
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	11	11	0	6	0	0	0	0	0	5	0	0	0	6	0	0	39
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	2	0	0	0	5
0	1	0	0	0	5	2	0	0	0	0	0	1	0	0	0	0	0	0	0	9
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	3
GROUP4																				
0	0	0	0	0	9	0	4	0	1	4	0	0	0	0	0	1	0	0	0	19
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	8	0	0	0	10
0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	2
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2
0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	2	0	0	4
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	3
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
0	0	0	0	0	3	0	0	0	0	1	0	0	0	0	0	0	0	0	0	4

APPENDIX FOUR

<u>SPECIES IN EACH COMMUNITY IN RICCARTON BUSH RESTORATION PLANTINGS</u>

	COMMUNITIES					
SPECIES (ALL)	*C.aust-P.ten* forest	*P.ten-C.rob* forest	*P.reg-P.ten* forest	*P.eug-P.ten-H.ang* forest	Total	Ranking
A. serrata	0	2	0	0	2	16th=
C. propinqua	0	5	3	0	8	13th
C. robusta	3	4	3	0	10	11th
C. australis	4	1	4	0	9	12th
D. dacrydioides	5	73	43	5	126	4th
H. angustifolia	19	117	116	33	285	1st
L. obcordata	3	53	4	0	60	7th
M. ramiflorus	33	99	20	27	179	3rd
M. australis	0	0	0	1	1	20th
P. heterophylla	23	52	10	27	112	5th
P. tetrandra	7	17	2	6	32	8th
P. eugenioides	0	1	1	0	2	16th=
P. tenuifolium	0	18	4	0	22	9th
P. regius	2	4	7	1	14	10th
P. crassifolius	0	3	0	1	4	15th
P. colorata	0	2	0	0	2	16th=
S. microphylla	0	29	9	34	72	6th
S. heterophyllus	87	85	18	27	217	2nd
square leaves	2	0	0	0	2	16th=
Dagger leaves	2	2	1	0	5	14th
Total	**191**	**572**	**239**	**163**	**1165**	

SPECIES <10CM	COMMUNITIES					
	C.aust-P.ten forest	*P.ten-C.rob* forest	*P.reg-P.ten* forest	*P.eug-P.ten-H.ang* forest	Total	Ranking
A. serrata	0	0	0	0	0	19th=
C. propinqua	0	0	3	2	5	9th
C. robusta	0	1	0	0	1	16th=
C. australis	0	1	0	0	1	16th=
D. dacrydioides	5	51	31	3	90	5th
H. angustifolia	17	77	96	24	214	1st
L. obcordata	0	0	28	2	30	7th
M. ramiflorus	24	56	14	21	115	3rd
M. australis	0	0	0	0	0	16th=
P. heterophylla	17	49	9	26	101	4th
P. tetrandra	1	4	5	1	11	8th
P. eugenioides	0	0	0	0	0	19th=
P. tenuifolium	0	0	3	1	4	10th
P. regius	0	0	0	1	1	13th=
P. crassifolius	0	0	2	0	2	11th=
P. colorata	0	0	2	0	2	13th=
S. microphylla	0	0	1	12	13	6th
S. heterophyllus	66	51	11	17	145	2nd
square leaves	0	2	0	0	2	13th=
Dagger leaves	0	2	0	1	3	11th=
total	**140**	**344**	**169**	**113**	**766**	

SPECIES >10CM	*C.aust-P.ten* forest	*P.ten-C.rob* forest	*P.reg-P.ten* forest	*P.eug-P.ten-H.ang* forest	Total	Ranking
A. serrata	0	0	0	0	0	16th=
C. propinqua	0	0	0	0	0	16th=
C. robusta	0	0	0	6	6	11th
C. australis	0	0	0	3	3	12th
D. dacrydioides	0	23	12	2	37	5th
H. angustifolia	0	40	22	16	78	1st
L. obcordata	0	0	0	2	2	6th
M. ramiflorus	9	35	10	7	61	3rd
M. australis	1	0	0	0	1	18th=
P. heterophylla	26	0	6	4	36	9th
P. tetrandra	1	0	0	10	11	7th
P. eugenioides	0	0	0	1	1	13th=
P. tenuifolium	1	0	0	6	7	8th
P. regius	1	0	1	4	6	10th
P. crassifolius	1	0	0	2	3	13th=
P. colorata	0	0	0	0	0	18th=
S. microphylla	0	24	2	16	42	4th
S. heterophyllus	21	34	7	3	65	2nd
square leaves	0	0	0	0	0	18th=
Dagger leaves	0	0	0	0	0	13th=
Total	**51**	**225**	**77**	**51**	**404**	

APPENDIX FIVE

NUMBER OF SEEDLINGS IN EACH COMMUNITY FOR FIVE MOST COMMON SPECIES

	COMMUNITIES					
SPECIES	Community One	Community Two	Community Three	Community Four	Total	Ranking
H. angustifolia (all)	19	117	116	33	285	1st
S. heterophyllus	87	85	18	27	217	2nd
M. ramiflorus	33	99	20	27	179	3rd
D. dacrydioides	5	73	43	5	126	4th
P. heterophylla	23	52	10	27	112	5th
H. angustifolia (<10cm)	17	77	96	24	214	1st
S. heterophyllus	66	51	11	17	145	2nd
M. ramiflorus	24	56	14	21	115	3rd
P. heterophylla	17	49	9	26	101	4th
D. dacrydioides	5	51	31	3	90	5th
H. angustifolia (>10cm)	0	40	22	16	78	1st
S. heterophyllus	21	34	7	3	65	2nd
M. ramiflorus	9	35	10	7	61	3rd
S. microphylla	0	24	2	16	42	4th
D. dacrydioides	0	23	12	2	37	5th

APPENDIX SIX

Woody Species In Riccarton Bush

Species	Life Form	Dispersal Form
Alectryon excelsus	tree	bird
Aristotelia serrata	shrub/tree	bird
Calystegia turguriorum	vine	gravity
Carpodetus serratus	shrub/tree	bird
Coprosma areolata	shrub	bird
Coprosma crassifolia	shrub	bird
Coprosma lucida	shrub	bird
Coprosma propinqua	shrub	bird
Coprosma propinqua x Coprosma robusta	shrub	bird
Coprosma robusta	shrub	bird
Coprosma rotundifolia	shrub	bird
Coprosma rubra	shrub	bird
Cordyline australis	tree	bird
Dacrydium cupressinum	tree	bird
Dacrydium dacrydioides	tree	bird
Elaeocarpus dentatus	tree	bird
Elaeocarpus hookerianus	tree	bird
Elaeocarpus dentatus x Elaeocarpus hookerianus	tree	bird
Fuchsia perscandens	vine	bird
Fuchsia perscandens x Fuchsia excorticata	vine	bird
Grisilinia littoralis	shrub/tree	bird
Hoheria angustifolia	tree	wind
Hoheria sexstylosa	tree	wind
Hoheria angustifolia x Hoheria sexstylosa	tree	wind
Kunzea ericoides	shrub/tree	wind
Lophomyrtus obcordata	shrub	bird
Melicope simplex	shrub	gravity
Melicytus micranthus	shrub	bird
Melicytus ramiflorus	shrub/tree	bird
Melicytus micranthus x Melicytus ramiflorus	shrub/tree	bird
Muehlenbeckia australis	vine	bird
Muehlenbeckia complexa	vine	bird
Meuhlenbeckia australis x Meuhlenbeckia complexa	vine	bird
Myoporum laetum	shrub/tree	bird
Myrsine australis	tree	bird
Nothofagus cliffortioides	tree	gravity
Nothofagus solandri	tree	gravity/wind
Parsonia heterophylla	vine	wind
Passiflora tetrandra	vine	bird
Pennantia corymbosa	tree	bird
Pittosporum eugenioides	tree	bird
Pittosporum tenuifolium	shrub/tree	bird
Plagianthus regius	tree	gravity/wind
Podocarpus totara	tree	bird
Prumnopitys ferruginea	tree	bird
Prumnopitys taxifolia	tree	bird
Pseudopanax arboreus	tree	bird
Pseudopanax crassifolius	tree	bird
Pseudowintera colorata	shrub/tree	bird
Ripogonum scandens	vine	bird
Rubus australis	vine	bird
Rubus schmidelioides	vine	bird
Rubus squarrosus	vine	bird
Rubus australis x Rubus squarrosus	vine	bird
Rubus australis x Rubus schmidelioides	vine	bird
Rubus schmidelioides x Rubus squarrosus	vine	bird
Shefflera digitata	shrub/tree	bird
Solanum laciniatum	shrub	bird
Sophora micropylla	tree	gravity/wind
Streblus heterophyllus	tree	bird
TOTAL = 60	TREE = 23 SHRUB = 12 EITHER = 10 VINE = 15	BIRD = 49 WIND = 5 GRAVITY 3 BOTH = 3

Regenerated Woody Species under Restoration Plantings	Life Form	Dispersal Form
Aristotelia serrata	shrub/tree	bird
Cordyline australis	tree	bird
Coprosma propinqua	shrub	bird
Coprosma robusta	shrub	bird
Dacrydium dacrydioides	tree	bird
Hoheria angustifolia	tree	wind
Lophomyrtus obcordata	shrub	bird
Melicytus ramiflorus	shrub/tree	bird
Myrsine australis	tree	bird
Parsonia heterophylla	vine	wind
Passiflora tetrandra	vine	bird
Pittosporum eugenioides	tree	bird
Pittosporum tenuifolium	shrub/tree	bird
Plagianthus regius	tree	bird
Pseudopanax crassifolius	tree	bird
Pseudowintera colorata	shrub/tree	bird
Sophora microphylla	tree	gravity/wind
Streblus heterophyllus	tree	bird
TOTAL = 18	TREE = 9 SHRUB = 3 EITHER = 4 VINE = 2	BIRD = 15 WIND = 2 GRAVITY = 0 BOTH = 1