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A MONITORING PROGRAMME TO ASSESS VEGETATION CHANGES WITH WATER TABLE MANIPULATIONAT WHEWELL'S BUSH SCIENTIFIC RESERVE, HAMILTON

by

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ABSTRACT

Whewell's Bush Scientific Reserve is a small stand of kahikatea/tawa-puketea-titoki forest in the Hamilton Ecological District. Surrounded by land which has been drained, cleared and developed for farming, the reserve has suffered stock damage in the past. This, plus the low water table, has resulted in poor regeneration of kahikatea. In a bid to improve regeneration a project to raise the water table was commenced. A concommitant vegetation monitoring programme was established; the simple methods employed are outlined.

The preliminary baseline data shows that there are seasonal and annual variations in species abundance and diversity resulting from fluctuations in temperature, rainfall, water table and kahikatea seed production. Most dramatically, there are usually abundant tiny kahikatea seedlings in November but very few in April. The non native component of the vegetation of the reserve is increasing both in terms of species and areal extent.

1. INTRODUCTION

This report was prepared for Tainui District Office, Department of Conservation. It describes the background to the present reserve management regime and outlines a vegetation monitoring programme being conducted in the reserve. The methods are described in sufficient detail to allow local staff to do the regular monitoring. Some initial findings from the monitoring are discussed.

1.1 VEGETATION

Whewell's Bush Scientific Reserve is an 11.49 ha stand of kahikatea/tawa-puketea-titoki forest in the Hamilton Ecological District, near Hamilton Airport. It lies on flat land at the head of a tributary of the Mangaharakeke Stream surrounded by land that has been drained, cleared and developed for pastoral agriculture. It is a fragment of a once more widespread vegetation type.

Towards the edges of the reserve the canopy is pure kahikatea, about 30-37 m tall and with an average diameter at breast height (dbh) of 35 cm (Champion 1988). The central portion of the reserve is dominated by tawa and pukatea, with titoki and stag-head kahikateam and occasional rewarewa. These large kahikatea have been measured at over 50 m tall with diameters at breast height of up to 2 m (Champion 1988). Champion

(1985) considered they are probably the largest kahikatea in the Waikato (Champion 1985). Several botanical surveys have been carried out in Whewell's Bush: Esler (1978), Sircombe (1982), Boase (1984), Irving and Skinner (1985) and Champion (1988).

When I visited the site in December 1984 the mature kahikatea trees were healthy, but the shrub and ground layers of the forest were sparse. The paucity of kahikatea seedlings and saplings was of particular concern as this area is reserved for kahikatea protection. Where there were canopy gaps, there was no kahikatea to fill them. The lack of regeneration of kahikatea seemed to result from the combination of previous stock damage and the low water table. Stock had access to the area until 1976. The low water table, about 2 m below the surface, was the result of drainage of the surrounding landscape as well as drains in the reserve itself.

1.2 MANAGEMENT PROPOSAL

My visit was in response to a proposal, put up by the local Department of Lands and Survey district office staff, to raise the water table in the reserve in the hope that this would improve the regeneration of kahikatea. The proposal included lifting the weirs in the drains so that water no longer flowed along the drains and out of the reserve. As a second step, it was proposed to pump water into the reserve. The water would be collected from below an impervious layer ie, water not presently available to the vegetation of the reserve (L & S DO File 13/192; HO File Res 3/5/1).

The proposal received support from Ministry of Works and Development engineers who were consulted on its practicality. The concept was reminiscent of the management regime employed at Riccarton Bush, a 12 ha kahikatea reserve in Christchurch, part of which involved irrigation (see Discussion).

At the time the proposal was mooted I had two concerns. The first was just how significant was the lowered water table to the lack of regeneration of kahikatea? Regeneration and establishment of kahikatea is apparently encouraged by: moderately high light intensity, absence of a complete tree root-mat, high available soil moisture content and fertile alluvial soil (Champion 1988). It is inhibited by the allelopathic effects from adult kahikatea (Molloy 1978) and animal damage, browsing and trampling. Perhaps the low light levels in this dense stand was the limiting factor.

In December 1984, not only was there a paucity of kahikatea seedlings, but because of stock damage, there were very few individuals of any other species. What undergrowth there was had developed since the exclusion of stock from the reserve (Kevan Wilde, pers. comm.). This suggested that in the future regeneration of kahikatea, and other species, could well have improved markedly just because of removal of stock. To check this hypothesis would have taken at least 10 years. Monitoring would have been needed over a long enough period to even out annual fluctuations in seeding production and climate ie, dry, wet or warm.

The exposed roots of the kahikatea trees were evidence that the ground surface had once been much higher. It would have lowered when the water table dropped in association with drainage. Given this, it seemed reasonable to assume that raising the water table could enhance the chances of kahikatea regeneration.

My other concern related to the wider perspective: is this the right reserve in which to put money? Whewell's Bush scientific reserve is probably the best kahikatea stand reserved in the Hamilton Ecological District. The only other stand in the district is Garrett Open Space Covenant which is 6.8 ha, has regenerating kahikatea, but it is also planted with tree species which do not belong to the reserve. Within the wider Waikato Ecological Region there is also Gordon Gow scenic reserve near Matamata, a 7.4 ha remnant with good kahikatea, rimu and totara regeneration. The nearby Waitoa Stream ensures the continued dampness of the site.

It appeared that if wished to retain a viable kahikatea stand in the Hamilton Ecological District, a representative of a once widespread vegetation type, active management of Whewell's Bush had to be considered. The alternative was to let nature take its course and accept that in the long term this representative of kahikatea forest may be lost.

It was decided to proceed with the management proposal. Because this decision was based on intuition rather than scientific evidence a monitoring programme was established in conjunction with the water table-raising project. It aimed to assess the effects on the vegetation of:

- removing of stock,
- lifting the weirs, and
- pumping water into the reserve.

2. MONITORING METHODS

This section is written as a set of instructions for easy use in the field.

2.1 PLOT ESTABLISHMENT

Four fixed 25 m x 25 m plots have been established in the reserve in sites selected to cover the range in density of kahikatea:

a) kahikatea forest; dense pole stand

b) kahikatea/pukatea-tawa forest; more open canopy, fewer individuals of kahikatea but more mature, on drier site

c) (kahikatea)/puketea-tawa forest; pukatea, tawa and titoki dominant with occasional very large stag-head kahikatea, site likely to receive most water from pumping

d) tawa forest; tawa dominant with a very few but mature kahikatea trees.

These four types of kahikatea stand were subjectively recognised and were named following the nomenclature of Atkinson (1985). A reference tree was arbitrarily selected within each stand type. It was marked with a wooden stake which was numbered (eg, Tree 1) and sprayed with a glowing paint ("dazzle").

Two of the plot boundaries are formed by 25 m lines, magnetic north and magnetic east, from the reference tree. The other two sides of the plot are formed by lines parallel to the first two reference lines (eg, see figure 2). The plot corners are sprayed with dazzle paint. This will need to be resprayed from time to time.

The plots are located by pacing the appropriate number of metres on the designated compass bearing from the last marker peg (see figures la-4a). The reference pole for plot 1 is the photo monitoring marker pole located just inside the north-west entrance to the reserve, a round pole engraved with an arrow and a roman I. Plots 2, 3 and 4 use the previous plot marker as their reference point. Note that plot 2 is near photo monitoring marker pole III

Within each of the main (tree) plots, several subplots are defined. One quarter ie, 12.5 m x 12.5 m of each main plot, is defined as the shrub plot. The quarter to be sampled was chosen originally by selecting one of four cards, one card assigned to each of the four available quarters (figures la-4a).

Three 1 m x 1 m seedling plots are established in each main plot. A seedling plot was sited by pacing 6 m along the main plot boundary from one of its corners then pacing 6 m into the plot at right angles to the paced boundary. A marker post is driven into the ground where the last foot landed. This peg usually marks the south-west corner of the seedling plot ie, the plot runs out 1 m north and 1 m east from the peg. Because of vandalism, some of these seedling plots had to be re-established on subsequent monitoring visits.

In addition to vegetation measurements, the water table was measured at 4 sites through a slotted pipe, 'mouse hole', driven into the ground. Measurements were made once a month by MWD staff as part of their monitoring programme of the water table of the surrounding farm land.

2.2 MEASUREMENTS

Measurements are recorded on standard sheets prepared beforehand. This sheet includes the location of the plot and a diagram of its layout. The monitoring focusses on the main canopy components of the Whewells Bush forest viz. kahikatea, tawa, pukatea, titoki and mahoe, and on measuring changes in these species:

- relative cover
- mortality
- recruitment.

Assessment of these parameters is applied to measuring canopy components, understorey and ground layer changes. Although changes in the canopy are ultimately of the greatest importance to the long term maintenance of the community, understorey and ground layer changes may be a more sensitive indicator of water table effects.

2.2.1 Trees

At each main plot a 100 m tape is laid out anticlockwise along compass bearings (N, E, S, W) to outline the 25 m x 25 m plot. The tape is attached to the plot marker. The glow paint marks are used to define the corner points. Another 30 m tape is laid across the plot eg, from 12.5 mark to 62.5 mark, thus dividing the plot into two halves to make counting easier.

The number of individuals of each species of tree rooted in the 25 m x 25 m plot is counted, including the corner tree. A tree is defined as a plant with an upright stem of 10 cm diameter at breast height (1.4 m). Whether the tree is canopy, subcanopy, a coppice stem, or dead standing is also noted. A canopy tree is defined as one that has 50 percent or more of its crown exposed to direct sunlight. It is essential to distinguish between canopy and subcanopy trees so that compositional changes occurring in the canopy are not confused with those occurring in the understorey. It is conceivable that such changes could be going in opposite directions. A coppice stem is an upright stem which sprouts from the base of the tree. A coppice stem is only counted if it looks likely to take over from the original leaders.

Once a year, <u>concurrent</u> with the counting, the diameter at breast height (dbh) of each tree in the plot is measured using a diameter tape. The height at which the dbh measurement should be taken (1.4 m) is checked regularly with a builder's tape. Where the tree is on a minor slope the measurement is taken on the uphill side. If the tree was on a lean, the dbh was measured at 1.4 m <u>along</u> the trunk. As above, coppice stems are recorded only if they look likely to become leaders, otherwise just their presence is noted. Coppice measurements are linked to those of the main stem on the recording sheet.

2.2.2 Shrubs and lianes

The 12.5 m x 12.5 m shrub plot is laid out, as per the plot diagram (figures la – 4a), by stretching the 'dividing' tape along the two internal boundaries of the shrub plot. The number of each species of shrub is counted. A shrub is defined as a plant with a dbh of < 10 cm and a height of > 60 cm. Shrub height and sized juveniles of tree species are referred to as saplings.

In plot 1 only, a fern transect is laid out. A tape is stretched between the 12.5 m mark and the peg near the centreline of the plot, as per the plot diagram (figure 1b). At 0.5 m intervals the presence of any species in the 30 cm -2 m tier, directly above the recording point on the tape, is recorded. This extra transect is needed because of the abundance of rhizomatous ferns in the shrub plot of plot 1; it is not feasible to count 'individual' plants of a rhizomatous species.

Also in plot 1 only, a Parsonsia subplot is laid out. A tape is stretched across the plot, parallel to the northern boundary, from the 6 m mark to the 69 m mark ie, a 6 m wide belt of trees is defined (figure 1). The presence/ absence of Parsonsia, at any height, on each of the 15 trees in the swath is recorded. This transect is necessary because a count of individuals of this multiple stemmed, scrambling liane is of limited value and Parsonsia is common in this shrub plot.

2.2.3 Seedlings

The seedling plots are located using the plot diagram. This also gives the orientation for the seedling plots with respect to the marker peg. The two 50 cm x 50 cm wooden quadrats available in District Office, DOC are used to form a 1 m x 1 m square, each quadrat being laid down twice.

In each seedling plot the species and number of seedlings is recorded in each of three height classes:

Class (i):	<5 cm
Class (ii)	>5 cm but <15 cm
Class (iii)	>15 cm but < 60 cm

A seedling is defined as a plant with a dbh of <5cm and a height of <60cm.

In addition to the seedling plots, some seedlings of species of special interest are tagged and their height remeasured regularly. The species of special interest include kahikatea, titoki, pukatea, tawa, rewarewa and milk tree ie, those which are, or are likely to become, dominant canopy components. The aim was to tag at least 10, preferably 20, seedlings of each of the species of interest in each plot and then to follow their progress over time. As a rule of thumb only seedlings which are taller than 30 cm are tagged because of the generally uncertain survival of small seedlings. In some plots this rule has been varied a little because of the paucity of any seedlings, particularly above 30 cm. Even bending the 30 cm rule it is still difficult to get 10, certainly 20, seedlings per species in some plots (Table 2).

The tagged seedlings are located by searching in the area suggested by the label. Seedling "tawa S2-3-18" is a tagged tawa seedling in plot 2, near seedling plot 3. It was the eighteenth seedling to be tagged in plot 2. If tagged seedlings 17 and 19 are also adjacent to seedling plot 3 they are likely to be near seedling 18, be they the same or another species. Seedling P2-42 is a seedling somewhere within the main plot, but not near a seedling plot. Once it is found, seedlings P2-41 and P2-43 are likely to be close by. A few of the tagged seedlings are <u>in</u> the seedling plots, most are adjacent to the seedling plots and a very few are within the main plot at large.

The height of each tagged seedling is measured using a clear plastic ruler or builders tape. The measurement is from the base of the seedling, without clearing away litter, to the tip of the growing point. If a tagged seedling can not be found after concerted searching it is recorded as "nf", not found.

2.3 SAMPLING FREQUENCY

The plots are monitored twice a year, in autumn (April) and in spring (November). Water-table effects are unlikely to cause winter mortality, unless the manipulation of the water table creates a flooding problem. Sampling in autumn and spring makes it possible to distinguish between vegetation changes resulting from water table changes and those that may have been caused by other factors. Because kahikatea is a mast-seeding species the monitoring needs to be continued in the long term. The absolute minimum life for the project should be 10 years.

Originally it was anticipated that, once set up, the monitoring would be conducted by local staff. In practice the monitoring has been undertaken by myself, assisted by a conservation officer from, first Hamilton District Office of Department of Lands and Survey, then Waikato Regional Office, and latterly Tainui District Office of Department of Conservation. Staff of Tainui District Office will take over responsibility for data collection from April 1989 onwards. On average it has taken two people two full days to collect the full data set.

2.4 DATA ANALYSIS

The data are held in Science and Research Directorate, Central Office and also in Tainui District Office, Department of Conservation. So far, the data have been collated only and combined into comparative tables to show up the level of 'normal' fluctuations in species abundance and diversity.

Fluctuations occur because of seasonal and annual variation in factors such as temperature, rainfall, water table, and kahikatea seeding. The tables also show up a few 'real' changes resulting from the exclusion of stock. These fluctuations and changes are described below.

These data will be used as a baseline against which to compare data collected subsequent to water table manipulation. Pumping water into the reserve began in the second week of November 1988. Analyses such as Analysis of Variance will be run to assess changes and their significance since raising the water table.

Figure 1. Plot diagrams for plot 1.

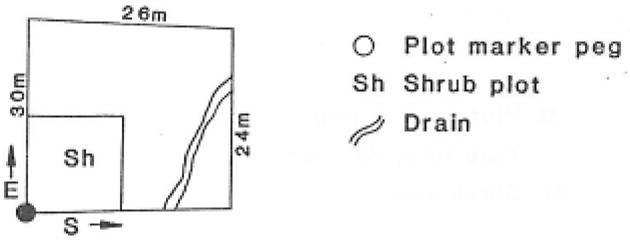


FIGURE 1a: Plot 1, located 38m on a 59° bearing from the reference pole. Plot marker at NW corner. Set up plot using dazzle marked corners, plot not square.

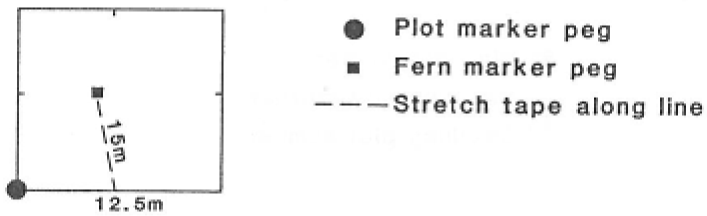


FIGURE 1b: Transect line for fern count in Plot 1.

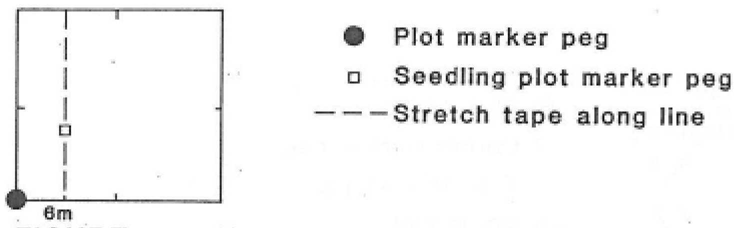


FIGURE 1c: Transect for Parsonsia count in Plot 1.

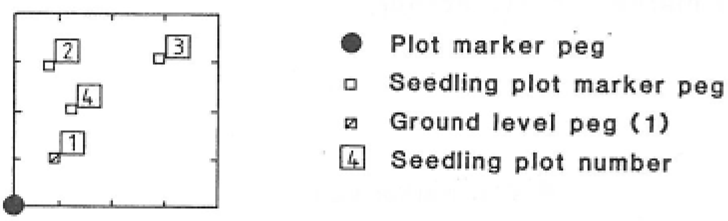


Figure 1d : Location of four seedling plots in Plot 1.

Figure 2. Plot diagram for plot 2.

Figure 3. Plot diagrams for plot 3.

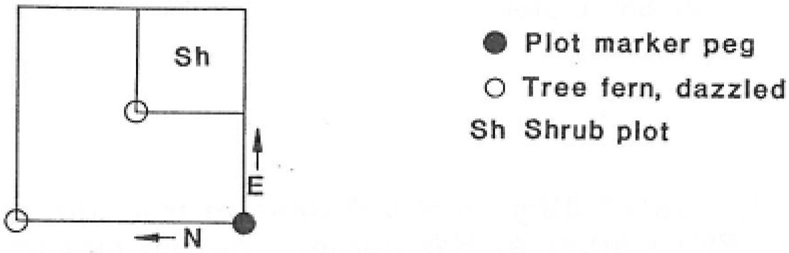


FIGURE 2a: Plot 2, located 100m on a 100° bearing from Plot 1. Plot marker at SW corner.

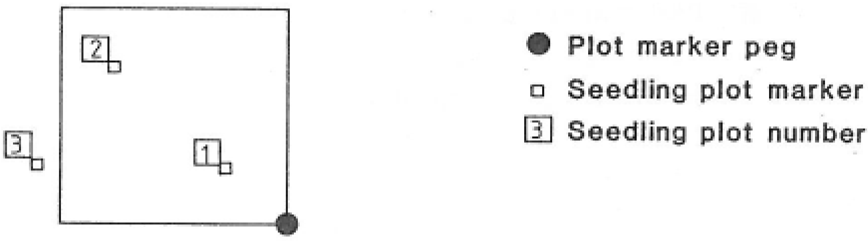


FIGURE 2b: Location of three seedling plots in Plot 2.

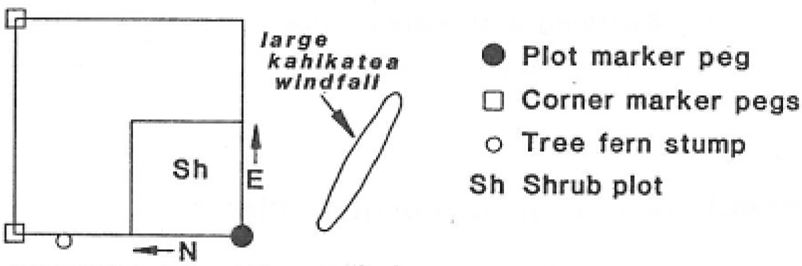


FIGURE 3a: Plot 3, locate 114m on a 102° bearing from Plot 2. Plot marker at SW corner.

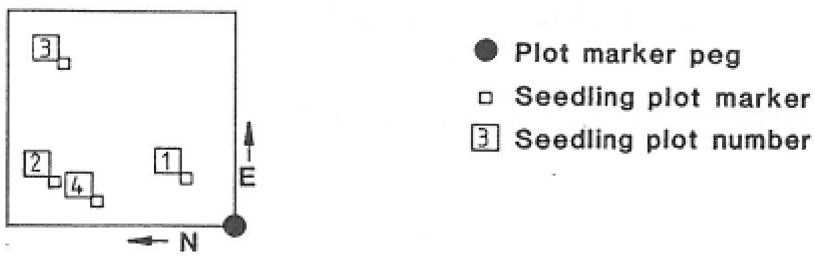


FIGURE 3b: Location of four seedling plots in Plot 3.

Figure 4. Plot diagram for plot 4.

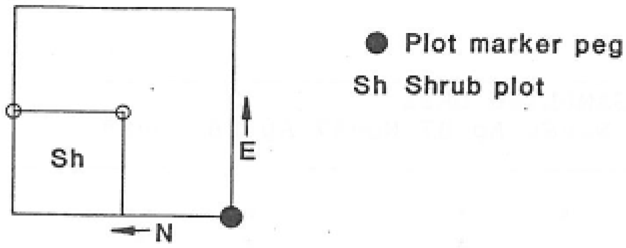


FIGURE 4a: Plot 4, located 210m on a 100° bearing from Plot 3. The plot marker is at the SW Corner.

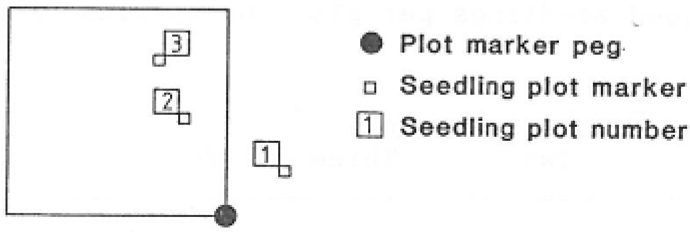


FIGURE 4b: Location of three seedling plots in Plot 4. Note seedling Plot 1 is outside the main plot. Note different orientation of seedling Plot 3.

3. RESULTS

3.1 DATA COLLECTED

Table 1. Data collected during monitoring sessions November 1985 -November 1988.

TYPE OF DATA	SAMPLING DATE						
	Nov85	Apr86	Nov86	Apr87	Nov87	Apr88	Nov88
Tree count	X	X	X	X		X	X
Basal area				X		X	X
Shrub count	X	X	X	X	X	X	X
Parsonsia				X		X	X
Fern transect				X		X	X
Seedling count	X	X	X	X	X	X	X
Tagged sdlgs				X	X	X	X

Table 2. Number of tagged seedlings per plot, by species (as at November 1988).

SPECIES	PLOT NUMBER			
	One	Two	Three	Four
Kahikatea		11	3	9
Milk tree, small leaved		1		
Puketea		10	10	9
Rewarewa			10	10
Tawa		11	5	
Titoki	5	9	10	12
Not found	2	5	1	6

3.2 TREE DATA

Despite some sampling error and a bit of initial difficulty deciding which coppice stems should be counted, a consistent set of baseline tree count data and basal area data have been established (table 3; figure 5). There has been minimal change in the tree data over the three year collection period. There has been a small amount of recruitment of tawa trees from the subcanopy into the canopy in plot 4 and one tawa tree fell over in plot 3 between April and November 1987.

Table 3. Tree count data for Plot 4, over the sampling period.

SPECIES	STAT	SAMPLING DATE						
		Nov85	Apr86	Nov86	Apr87	Nov87	Apr88	Nov88
kahikatea	c	1	1	1	1	ns	1	1
mahoe	sc	4	2	3	3	ns	3	3
mamaku	sc		2	2	2	ns	2	2
milk tree, sm-lvd	sc	3	3	3	3	ns	3	3
pukatea	c	6	6	6	6	ns	6	6
	sc						1	1
silver tree fern	sc				1	ns	1	1
tawa	c	2	2	4	4	n s	4	4
	sc	10	10	10	10	n s	14	4
	ds		1					
titoki	c	5	6	5	7	ns	7	7
wheki	sc			1	1	ns		1

Status: c = canopy, sc = sub canopy, ds = dead standing, ns = not sampled on that occasion.

In April 1988 the effects of Cyclone Bola were noted in the reserve. The most dramatic effects were observed outside the plots and included a few kahikatea trees which were snapped off two thirds of the way up their trunks.

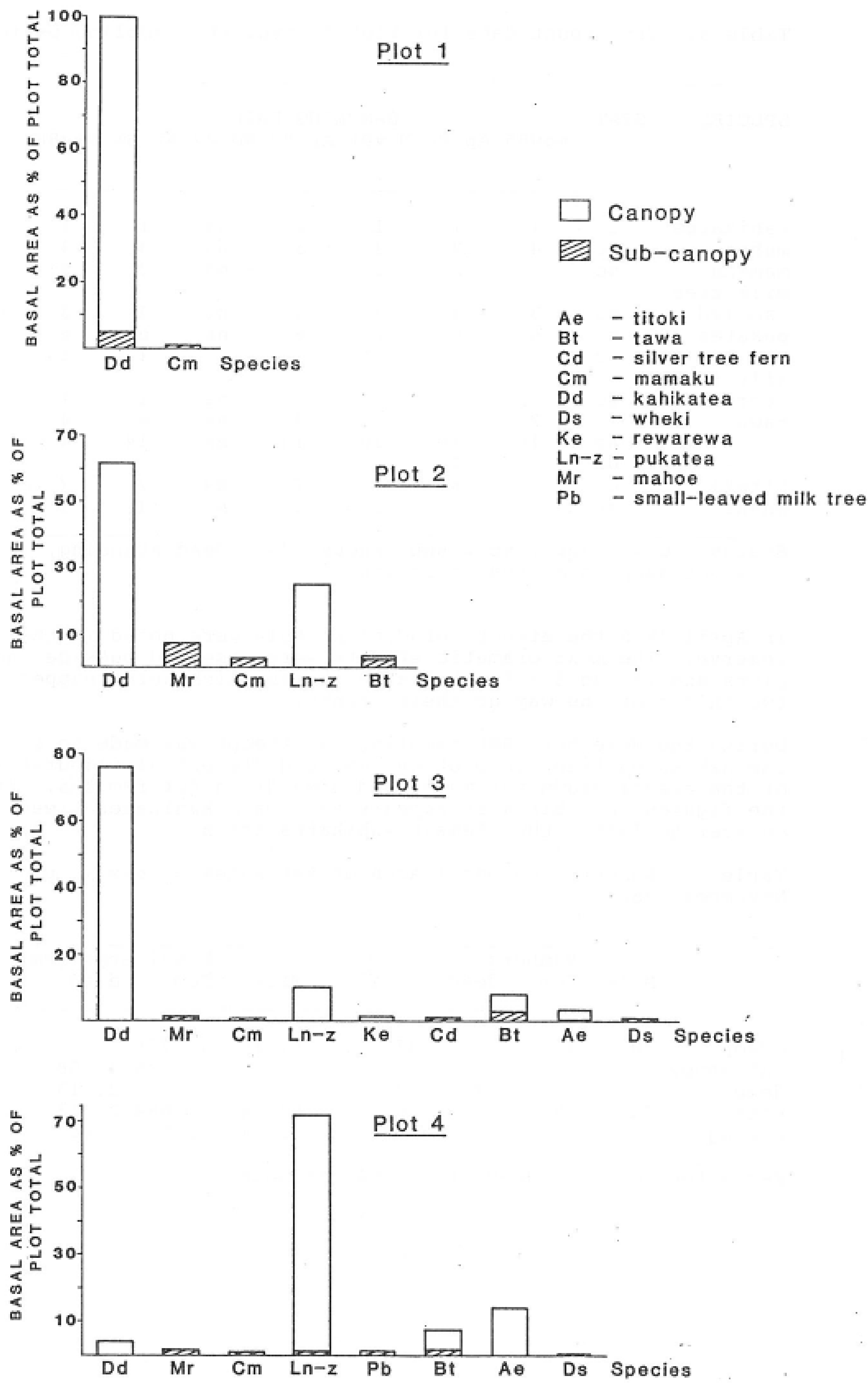
During the November 1988 sampling an attempt was made to sex the kahikatea trees in plot one using differential colouration of the trees; brown for males and grey-green for females. From the figures in table 4 it appears that male kahikatea trees are on average larger than female kahikatea trees.

Table 4. Numbers and basal area of kahikatea by sex in plot 1, November 1988.

	Numbers				Basal Area (cm^2)			
	Male	Fem	Dead	Total	Male	Fem	Dead	Total
Canopy	20	17		37	51,405	37,776		89,181
Subcanopy		2		2		1,308		1,308
Dead stg			7	7			2,813	2,813
Total	20	19	7	46	51,045	39,084	2,813	92,942
Average					2,570	2,222	402	

Fem=female, dead/deadstg = dead standing tree

Figure 5: Tree plot data : basal area expressed as a percentage of total basal area for plot, Apr 1988



3.3 SHRUB DATA

Parts of the forest are densely shaded. *Diplazium australe*, a robust fern of shady forests, is quite common in the shrub layer. The forest floor is very dry in summer; the effects of moisture stress were seen in plot 4 on April 1986 when rewarewa shrubs were wilted. These factors, shading and lack of moisture, have limited shrub development.

Nevertheless there are flushes of small saplings of broad-leaved tree species eg pukatea in plots 2 and 4, tawa in plots 2, 3 and 4 and, also in plot 4, mahoe, rewarewa and titoki. In agreement with the lack of regeneration of kahikatea mentioned in the introduction, kahikatea saplings are absent from plots 1, 2 and 3 and, in plot 4, only about three are present (table 5).

Juveniles of silver tree fern are common in all plots. Smaller ferns, eg *Phymatosorus scandens* and shining spleenwort, are quite common although not as lush as they would have been before draining (table 5). *Histiopteris incisa* has apparently increased since the trampling effects of stock were removed, although its abundance varies with moisture availability. It should be a sensitive indicator of water table changes.

Table 5. Number of shrub-sized individuals in each plot at November 1988 (some species have been combined).

SPECIES	PLOT NUMBER			
	One	Two	Three	Four
hangehange		1		1
kahikatea				3
Mahoe	3	5	12	62
Mapou	1	2		1
milk tree, small-lvd				1
pukatea		18	4	30
rewarewa			1	21
tawa		3	8	5
titoki		4		12
ferns	28	17	10	11
other natives	3	2	5	3
adventives	21	2	0	2

As Boase pointed out in 1984, the non-native component of shrubs is increasing, both in number of species and in areal extent, mostly in canopy gaps and particularly near the forest margins. This is most noticeable near the entrance to the reserve (plot 1) where inkweed is abundant (table 5). It would have spread even more dramatically had the district office staff not controlled it by hand pulling and spraying.

Jerusalem cherry and Chinese privet have been present in the reserve for some time and are spreading. They too have been controlled near the entrance to the reserve. Small-flowered nightshade, black nightshade, tree privet and blackberry are also present.

Reflecting the agricultural landscape surrounding the reserve, one specimen each of kiwifruit, tamarillo, and pampas grass have been found in plot 1.

3.4 SEEDLINGS

As mentioned earlier, the very dry forest floor limits seedling establishment. Each year there is a flush of tiny (<5 cm) kahikatea seedlings in November but few survive over the summer to be recorded in April (table 6). A dry forest floor has been observed in both November and April of some seasons.

Table 6. Average number of kahikatea seedlings per m^2 in the < 5 cm class (class i) of plot 1 over time.

SAMPLING DATE						
Nov85	Apr86	Nov86	Apr87	Nov87	Apr88	Nov88
53	11	174	13	72	3	36

Seedlings of any species are rare in class ii (>5cm but <15cm) and almost absent in class iii (> 15cm but <60 cm) in plots 1, 2 and 3. The situation is different in plot 4 where numbers of seedlings in class (ii) exceeds those in classes (i) and (iii) (Table 7).

Table 7. Average number of all seedlings per m^2, by class* and plot over time.

	SAMPLING DATE						
	Nov85	Apr86	Nov86	Apr87	Nov87	Apr88	Nov88
PLOT 1							
class	53	11	174	13	72	3	44
class	0	5	4	2	0.5	0.5	0.6
class	0	0	0.3	0	0	0	
PLOT 2							
class	34	4	165	2	2 1	2	15
class	2	4	2	0.3	22	1	1.6
class	0.3	1	1	0.6	0.3	0.3	0.3
PLOT 3							
class	2 0	8	21	6	29	4	101
class	4	3 7		5	3	6	4
class	0	0	1	0	1	2	0.8
PLOT 4							
class	17	0	3 6	0.5	15	1	
class	3 7	42	13	33	18	16	
class	3 6	9	6	6	6	5	

Class (i): < 5cm; class (ii): > 5 cm but < 1515cm; class (iii): > 15 cm but < 60 cm.

The lack of all seedlings in class (i) in plot 4 can be attributed to the abundance of *Blechnum filiforme*. It is smothering the ground layer here, and in other parts of the reserve. This is a feature of recovery after animal damage. If the seedlings can get established in plot 4 their chance of survival is better than in the other plots because the site is a little damper. From the tagged seedling data it appears that once seedlings get beyond about 30 cm the chances of survival increase; very few of this height are lost. Most of the tagged seedlings which could not be found during sampling were probably obscured by *Blechnum filiforme* or litter.

Just as in the shrub layer, seedling plots 1 and 2 have more adventives than plots 3 and 4; species such as blackberry, barberry, hawthorn and a new arrival, *Clerodendrum trichotomum*. The reason is that plots 1 and 2 are drier, more open and nearer to the entrance to the reserve. It must be noted that not all alien species present in the reserve are being recorded in the plots. Some have just arrived and/or have a localised distribution in the reserve. This means that in addition to measurements, general observations should be recorded during sampling visits.

4. DISCUSSION

Whewell's Bush vegetation and management regime have some similarities with Riccarton Bush, a 12 ha, predominately kahikatea, reserve in Christchurch urban area. Riccarton Bush also has a lowered water table because of development of the surrounding landscape. Like Whewell's Bush, the mature trees are quite healthy; their roots penetrate through a tight subsoil and tap into an aquifer ± 1 m below ground surface (Molloy pers. comm.). This water supply obviously is not available to seedlings and saplings. The lowered water table, plus past practices such as mowing, scratching up and burning the litter, and a myriad of tracks through the reserve, resulted in scanty ground and shrub layers.

Since 1975 a new management regime has been adopted at Riccarton Bush including closing off some tracks, encouraging deep litter accumulation, and irrigating particularly dry parts of the reserve at certain times of the year. Now 13 years later, a good litter has built up and as a result species such as hinau, pokaka and coprosmas are becoming increasingly abundant. The kahikatea seedlings which established en masse after the last mast seed year (10 years ago) are now reaching sapling size (Molloy pers. comm., see Molloy in prep.).

From the above it is clear that native vegetation takes a long time to recover from disturbance. As intimated in the Introduction, it is very likely that Whewell's Bush is still recovering from stock damage and we have yet to see the full flush of seedling establishment possible under even the present, lowered water table regime. For kahikatea this is all the more so because there probably has not been a mast seed year since stock were removed. A mast seed year is predicted for this coming autumn.

When I visited the reserve on 16-17 November the male trees were brown with pollen and the female trees had abundant cones. The colour distinction was sufficiently obvious to estimate the proportions of male and female kahikatea in plot 1.

The monitoring in Spring 1989, and subsequently, will be particularly important for checking for regeneration of kahikatea in light gaps. During the November 1988 monitoring session I checked several of the large light gaps near large kahikatea trees for regeneration of kahikatea. I found no seedlings. *Blechnum filiforme, Phymatosorus scandens*, and selaginella were abundant and the litter was bone dry; neither factor conducive to regeneration. It is very likely that raising the water table is only part of the management answer to ensuring long term survival of kahikatea at Whewell's Bush. It may be necessary to consider further intervention eg selective weeding of seedlings. Tawa and titoki are favoured at least by the present dry conditions. Other management proposals for similar sites in the Waikato are discussed by Champion including providing shelter at the edges of the reserve, eradicating problem weeds and restocking.

CONCLUSIONS

A simple monitoring programme has been established to collect vegetation data from Whewell's Bush scientific reserve. These data have shown vegetation changes as a result of stock removal and in particular an increase in importance of adventive species. Much of the variation in species abundance and diversity, however, can be attributable to annual and seasonal fluctuation in factors such as temperature, rainfall, water table and kahikatea seeding. These variations demonstrate the need to establish baseline data over several years so that such variations may be averaged out. The data can then be usefully compared with that collected after management has been instituted, in this case water table manipulation.

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GLOSSARY OF PLANT NAMES

Common Name	
barberry	Berberis glaucocarpa
black nightshade	Solanum nigrum
Chinese privet	Ligustrum sinense
cleavers	Galium aparine
coprosma	Coprosma spp
hangehange	Geniostoma rupestre ssp. ligustifolium
hinau	Elaeocarpus dentatus
hook sedge	Uncinia uncinata
hound's tongue fern	Phymatosous diversifolius
inkweed	Phvtolacca octandra
Jerusalem cherry	Solanum pseudocausicum
kahikatea	Dacrycarpus dacrydioides
kiekie	Freycinetia baueriana ssp. banksii
kiwifruit	Actinidia deliciosa
mahoe	Melicytus ramiflorus
mamaku	Cyathea medullaris
milk tree, small-leaved	Myrsine australis
pampas grass	Streblus hetrophyllus
pigeonwood	Cortaderia selloana
pohuehue	Hedycarya arborea
pokaka	Muehlenbeckia australis
poroporo	Elaeocarpus hookerianus
pukatea	Solanum aviculare
putaputaweta	Laurelia novae-zelandiae
ragwort	Carpodetus serratus
rewarewa	Senecio jacobaea
selaginella	Knightia excelsa
shield fern	Selaginella kraussiana
shining spleenwort	Polystichum richardii
silver tree fern	Asplenium oblongifolium
small-flowered nightshade	Cyathea dealbata
supplejack	Solanum americanum
tamarillo	Ripogonum scandens
tawa	Cyphomandra betacea
titoki	Beilschmiedia tawa
tree privet	Alectryon excelsus
wall privet	Ligustrum lucidum
wall lettuce	Mycelis muralis
wheki	Dicksonia squarrosa
white climbing rata	Metrosideros diffusa