SCIENCE AND RESEARCH INTERNAL REPORT 3

PLANTING TRIALS FOR THE REVEGETATION OF MANA ISLAND

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EXECUTIVE SUMMARY

The management plan for Mana Island includes revegetation of parts of the island. Any major attempt to restore indigenous vegetation to a degraded landscape like Mana, modified by over 150 years of farming, requires trials to determine the most effective revegetation methods. This is particularly so for Mana where the soils are very variable and the climate harsh. Trials can improve the success rate of a revegetation programme and save money and effort.

The trials on Mana should take account of several variables. Site factors that could influence the success of planting include slope, aspect, exposure to wind and wind-carried salt, soil type and moisture regime. The plant species most appropriate for each kind of site should be tested.

Planting has been initiated on the island with manuka, largely because plants of this species were available. While manuka may be satisfactory for some types of site, other species, eg akeake, kanuka, ngaio, and taupata, are likely to be more useful on some sites. A range of planting methods, site preparation techniques and after care procedures is possible at any site.

The variables described above comprise the 'treatments' to be tested. The number of plants in a trial should relate to the number required to test each variable with a certain degree of accuracy. The number of plants must be sufficient to allow natural variation in plants to be separated from that related to the treatments.

The more plants used per plot the more accurate is the trial. We recommend that 200 plants per plot is a satisfactory compromise between feasibility of establishing the trial and desirable accuracy. The plants should be used to form 3 replicates, groups planted at the same site.

All treatments to be tested at the same site should form part of the same plot. The planting density and method should be identical to that employed in the rest of the revegetation programme. Each treatment should be separated from its neighbour by a strip of untreated ground, replicates should be randomly distributed throughout the plot, and a diagram of the plots should show the layout.

Plant measurements, survival rate and growth rate, should be made: at planting time, November after planting and May the following year. They could be made by a group of students under the guidance of Department of Conservation staff.

A set of trials should be established in positions representative of likely planting site conditions to test 6 planting techniques, 4 species at 2 valley bottom sites, 5 species at 2 northerly aspect (drier) valley sides and 5 species at 2 southerly aspect valley side sites (as recommended in this report).This subset of all possible trials should produce results which help guide the Mana Island revegetation programme towards the most effective revegetation methods.

PLANTING TRIALS FOR THE REVEGETATION OF MANA ISLAND

ABSTRACT

Experimental trials are a necessary prerequisite and integral part of the programme to revegetate part of Mana Island. Such trials are needed to test the suitability of various indigenous plant species as well as to determine the best methods of establishment. Variables requiring characterization or measurement, and the design requirements of such trials are discussed. Estimates of costs of revegetation are given and a set of trials for Mana Island is recommended.

1. INTRODUCTION

Mana Island, a 217 ha island near Wellington, is being managed to maintain the island's native species and communities in perpetuity while allowing compatible education and recreation enjoyment (Department of Lands and Survey As the island has been farmed for over 150 years it is highly modified but even so it has no introduced mammals except mice. Thus the management concept includes a plan to revegetate parts of the island.

This report provides a justification for including experimental planting trials as an integral part of the revegetation programme, discusses which variables should be tested and how the trials should be designed, and concludes by recommending a set of trials to be established on Mana Island.

Any major attempt to restore indigenous vegetation to a degraded landscape requires trials to determine the most effective revegetation methods and thus save money and effort. In discussing the restoration of degraded tropical rainforest, Lovejoy (1983) lists small-scale experimental planting as an essential part of the programme and remarks: "never embark on major planting without prior experiment on a reasonable time scale". Another example, particularly relevant to Mana Island, is the restoration of woodland to the island of Rhum in the Scottish Hebrides. Here, a series of 9 experimental tree plots were established in 1958 to measure the growth of various species of trees and shrubs. These plots were located to cover a range of site factors including altitude, soil type and exposure, and they yielded considerable information on methods of re-establishing indigenous trees and shrubs (Wormell 1968).

The need for carefully designed trials on Mana Island was recognised by the Wellington Botanical Society in its report to the Department of Lands and Survey in 1984 and has been reiterated in a discussion of management problems affecting the island (Timmins et al. 1987). The soils are very variable and include significant areas of shallow sands overlying very compact subsoils, very stony soils, as well as deeper fertile soils in the valley bottoms. In addition, the island is swept both by prevailing north westerly and by southerly winds and droughts occur in most summers. The soil differences coupled with Mana's more extreme climate, mean that the success achieved with planting on Tiritiri cannot necessarily be repeated on Mana. The trials on Mana should take account of several variables: site variation, the plant species most appropriate for each kind of site, the initial size of plants to be used, site preparation and planting method, and the aftercare of the plantings.

VARIABLES OF INTEREST

2.1 Site Variation

Slope, aspect, exposure to wind and wind-carried salt, soil type, and moisture regime as influenced by position on the slope, are all site factors that could influence the success of a planting project on Mana Island. Slope and aspect are easily measured. Richard Sadleir (pers. comm.) has suggested that tests could be made of a simple method of comparing differences in wind-run between sites. Soil type and moisture regime require examination of soil profiles but, in view of the restricted area of the island for which managed revegetation is proposed, the expense of a soil survey of the whole island would not be justified. Thus the primary need is for a simple classification of site types based on existing information supplemented by some additional observations of soils and wind-run.

2.2 Appropriate plant species

Planting has been initiated on the island with manuka, largely because plants of this species were available. While manuka may be satisfactory for some types of site it is not likely to be the best plant for all sites. In any case, it may not be the most effective nurse plant for larger forest trees. Even on sites where its growth rate is adequate, a more rapid development of forest may be possible using other species suggested by the Wellington Botanical Society (1984) and Timmins et al. (1987), eg akeake, akiraho, kanuka, ngaio, tauhinu, taupata. In the case of tauhinu, our observations at the head of Forest Valley indicate that matures and collapses much sooner than manuka and is replaced by other broadleaved species.

2.3 Size of plants, site preparation and planting methods

NZ Forest Service experience has been that retaining tree seedlings in the nursery until they are a metre or more in height significantly increases the rate of successful establishment. This ideal will not always be practicable, especially when root trainers of limited size are used.

A range of planting methods and site preparation techniques is possible at any site, eg

(a) root trainer stock, notch planted (dropped in a slit opened by a spade);
(b) container grown stock, planted in a dug hole;

(c) slow-release fertiliser applied at planting;

(d) ripping of surface prior to planting;

(e) grubbing of site to mechanically clear it of other plants;

(f) mowing of site prior to planting;

(g) pre-planting herbicide application to release seedlings from weed competition;

(h) post-planting herbicide application to release seedlings from weed competition;

(i) no pretreatment of site, return of grass sward to upright position after planting;

(j) laying slash heavy with ripe weed on prepared surface;

(k) scattering seed.

2.4 Aftercare of plants

Trials of weeding or other methods of releasing the plantings from competition can be planned as part of the monitoring that will be needed to follow progress of the revegetation programme.

3. EXPERIMENTAL DESIGN

3.1 Plant Measurements

In this revegetation project we are interested in

(a) plant survival,

(b) plant growth rate.

Survival is the most immediate test of the success of the project/treatment/planting conditions. Growth rate is primarily of interest in so far as it affects the type and rate of succession of other woody plant species (long-term survival). Height at the end of the first year, in relation to that of the surrounding rank grass, could be predictive of long-term survival.

3.2 Treatments

Treatments are the variable one wishes to test: planting methods, site preparation techniques, after-care procedures and plant species. It would not be feasible to test all planting techniques listed under section 2.3 nor all the species mentioned under section 2.2. We recommend the following be trialed:

(i) species
manuka
kanuka
akeake
akiraho
ngaio

These early successional species are readily propagated. They are capable of forming complete cover and suppressing grass. In the case of kanuka, akiraho and ngaio, there is a possibility of returning to native forest in a single step.

(ii) <u>techniques</u>
- -no pre-or post-planting Preparation or release
- -pre-planting site preparation, non-residual herbicide
- -pre-planting site preparation, grubbing
- -pre-planting site preparation, mowing
- -no preparation but post-planting release

Ultimately all viable planting techniques and species should be tested so that the planting project can proceed with confidence using the best methods.

3.3 <u>Variation</u>

The number of plants used in a trial should relate to the number required to test each variable with a certain degree of accuracy. Ideally this is calculated on the basis of expected variation in plant survival or growth rate. Recorded variance will be a function of the state of the plants when planted, genetic variation, the planting site and the treatment applied. The number of plants must be sufficient to allow natural variation to be separated from that related to site and treatment.

For neither survival nor growth rate is the expected variation for manuka, kanuka, akeake, ngaio or akiraho known. Assuming a binomial distribution of growth response, half the plants will do better than average and half will do worse, an increase in the number of plants per plot reduces the variance as follows:

	Variability	δ^2
50 plants per plot	35-65%	30%
100 plants per plot	40-60%	20%
200 plants per plot	43-57%	14%
400 plants per plot	46-54%	8%

Clearly the more plants used per plot, the smaller the differences that can be detected. However there are decreasing returns in reliability for the increasing number of plants.

We recommend 200 plants per plot as a satisfactory compromise between feasibility of establishing the trial and desirable accuracy.

From these trials a more accurate picture of the true variation in survivorship and growth rate of the 5 species can be determined. More refined trials could be designed in the future based on these data.

3.4 Cost Effectiveness

An alternative basis for plot design is cost effectiveness of the different treatments. In other words, what is the cost differential between treatments? How many plants are required to detect real differences in survival under different treatments? We have calculated costs for 5 pre-preparation methods.

(a) no treatment

(b) no pre-planting treatment but post planting release spraying

(c) non residual herbicide preplanting treatment

(d) residual herbicide preplanting treatment

(e) grubbing preplanting treatment.

From these costings, the minimum number of plants required to detect differences in cost effectiveness between treatments was determined (Appendix 1).

It is important to test for relative cost effectiveness between:

(i) grubbing, which appears to be very labour intensive,

(ii) residual herbicide which demands careful planting procedure and which planters tend to be wary of, but which offers a longer period of reduced weed competition than other preplanting treatments, and

(iii) no treatment, the control in which the high fixed cost of the plants is obvious.

A trial comparing cost effectiveness of residual with non-residual herbicide would also be useful.

3.5 Replicates

Trials with no replicates would provide useful information. However, at least 3 replicates is desirable to cover microsite variation i.e. the 200 plants (recommended above) should be divided into 3 groups but be planted at the same site.

Ideally each treatment should be repeated for each variable tested (section 2). Given the number of plants required per trial and the number of plants likely to be available, it is not practicable to test all variables for all treatments.

This practical consideration has influenced the recommendations made in section 5.

3.6 Plots

All treatments to be tested at the same site should form part of the same plot. The planting density and method should be identical to that employed in the rest of the revegetation programme. This includes after-care treatment. For example, if irrigation is not seen as a possibility for large areas of planting, then the trials should not be irrigated and vice versa. Each treatment replicate should be separated from its neighbour by a strip of untreated ground. The treatment replicates should be randomly distributed throughout the plot. Diagrams of these plots should be prepared showing the layout. Labels should be assigned systematically to each plot and each treatment replicate within the plot. In addition every plant should be uniquely numbered, on the site plan if not physically.

3.7 Method and timing of measurements

Two measurements are required:

(i) is the plant alive or dead (% survival rate)

(ii) height of the plant (growth rate)

These measurements should be made:

(a) at planting time (height only!)

(b) November after planting

(c) May the following year

Data set (a) is the base data. The November data record the situation after the spring flush of growth. May is selected to record the summer growth. Only limited growth is expected in June and July.

The initial measurements (a) can be pooled data. Subsequent measurements (b and c) should record height/survival for each individual plant in the plot. This will allow analysis of the data, and sampling if required, for edge effects.

The measurements are relatively straightforward. There would be benefit in using a group of students to make them as they would provide a labour force who could make use of the data for their own purposes. The students may need supervision and instruction, particularly in the subsequent measurements. Data storage, analysis and extraction of recommendations for future revegetation could be done by Science and Research Directorate of DOC (specifically, authors of this report). To this end, 3 copies of the data set should be made after each recording session: 1 for District Office, 1 for the school/technical institute/university involved, 1 for the DOC scientists.

4. EXISTING PLOTS

Some plots have already been prepared at each of the 1987 planting sites testing 1 species, manuka, and 3 preplanting treatments: non-residual herbicide, residual herbicide, grubbing plus a 'no treatment' control. These plots marked by posts, are 20m x 20m comprising six 4 x 4m replicates, (each of 48 plants) of each of the 4 treatments, randomly located in the plot. (One treatment has 7 replicates, i.e. 336 plants; the other treatments use 288 plants.) Although the number of plants per treatment and planting location appears ample (3.2, 3.3 and 3.5) these plants are distributed between <u>many</u> replicates and the replicates of different treatments adjoin each other. A significant proportion of the plants from each replicate could be influenced by the adjoining treatment (edge effects). This would reduce the useable sample per treatment to 198 plants and bring the sample numbers close to those recommended in this report

Fertiliser was not used in the trials although it was used in the main planting. This reduces the value of the trials. Further, the plants were not measured at planting although all plants were trimmed to an average height of 200 mm prior to planting.

5. MANA ISLAND TRIALS

5.1 <u>Recommendations</u>

As stated earlier, although ideally all treatments, species and site variables should be tested against each other, this is not practicable. The following set of trials is the recommended minimum. The trials should be placed in positions <u>representative</u> of likely planting site conditions.

(a) Test the set of 6 planting techniques listed in 3.2 using one species at the four valley bottom (1987) planting sites.

(b) Test the remaining 4 species at 2 valley bottom sites using the preferred planting technique, as determined in (a).

(c) Test all 5 species at 2 southerly aspect (wetter) valley side sites using the preferred planting technique.

(d) Test the 5 species at 2 northerly aspect (drier) valley side sites (i.e. opposite trials (c)) using the preferred planting technique.

5.2 <u>Explanation</u>

The trials (a) are partially accommodated by the trials established in 1987 at the planting sites using manuka. These trials meet the experimental design requirements (3.2, 3.3, 3.5). However, failure to measure the plants initially and omission of fertiliser (4.0) reduces the accuracy and value of these trials.

Future measurements of the trials should be made as described in 3.7 as it may be that the trials, while on sites of comparable topography, cover a range of soil types. If so, they would provide insight into the effect of soil type on planting success, a new set of trials to test planting techniques should be established, as described in 3.6.

Trials (b) extend trials (a) and allow comparison of a range of species which are likely to be useful in the revegetation programme. In future years, the trials with akeake should record any new akeake seedlings which have established. It is hoped that akeake will be able to establish in the rank grass as has been reported elsewhere 1978).

Valley sides are far more common on the island than valley bottoms. Trials (c) and (d) will test the assumption made in the 1987 plantings that valley bottoms are more favourable than valley sides. Valley bottoms tend to be more fertile and moist which will promote growth of tall grasses such as Yorkshire fog and cocksfoot, as well as the plantings. Valley sides are less fertile with consequent shorter grasslands of sweet vernal and cocksfoot. Does this reduced competition offset reduced fertility? A suitable site for these trials would be Weta Valley, parallel to, but upslope from the valley bottom planting.

Trials (c) and (d) will also give some information on which species should be planted on sites of contrasting aspect (ie moisture and sunshine).

No trials have been included on very exposed sites because these sites are unlikely to be revegetated by planting.

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APPENDIX 1 Costings for different planting methods

A rough estimate of the cost of some planting methods is given below.

Input Data:

Planting density of 3 plants per sq metre 10,000 plants per ha

Cost of plants

88c/root trainer plant ex Taupo Nursery
10c per plant transport Taupo-Mana Island $ 9,800 per ha

Non residual chemical

$120 for chamical per ha
5 hours labour application @ $10 per hour $ 170 per ha

Residual chemical

$240 for chemical per ha
5 hours application @ $10 per hour $ 290 per ha

Rate of planting	mins/plant	pls/person/day
Root trainer stock, notch pl	0.5	800
Root trainer stock, hole dug	3-4	100
Ground treated residual herb	6	66
Planting plus grubbing (clearing 0.5m x 0.5m area)	10	40

(Daily rates assume an 8 hour day but include travel overheads)

Cost Estimates:

(a)	No treatment	8,000
	Labour (100 person days @ $80 per day)	9,800
	Plants (10,000 per ha)	17,800
(b)	No preplanting treatment, post planting release spraying	
	Labour and plants	17,800
	Non residual herbicide (3 applications)	510
		18,310
(c)	Preplanting non-residual treatment herbicide	
	Labour and plants	17,800
	Initial preplanting spraying	170
	Release spraying	510
		18,480

(d)	Residual herbicide preplanting treatment	
	Plants	9,800
	Labour (152 person days)	1,200
	Residual chemical and application	290
	Release spraying (second year only)	170
		22,260
(e)	Grubbing preplanting treatment	
	Plants	9,800
	Labour (250 person days)	20,000
	Release spraying (3 applications)	510
		30,310

Cost differences in treatments (%):

Treatments	a	b	c	d	e
a	-	2.8	3.8	25	70
b	-	-	0.9	22	66
c	-	-	-	20	64
d	-	-	-	-	36

If we assume

(i) a desire to use cost effective methods,

(ii) a desire to detect differences in survival rate at 95 confidence level, and

(iii) an overall survival rate of 60% for all planting,

The following minimum number of plants would be required to detect differences in cost effectiveness between treatments.

Minimum number of plants for trials:

Treatments	a	b	c	d	e
a	-	c.2000	1500	100	10
b	-	-	2000	150	15
c	-	-	-	200	15
d	-	-	-	-	50

Because the additional cost of using non-residual herbicides is very low (0.9-2.8%) this treatment need only improve survivorship by this small amount to be worth the extra cost. However, if survivorship is not improved then non-residual herbidices need not be used; a potential saving of $12,000-$47,700, assuming a third of the island is to be revegetated. We suspect that it is unlikely that the improvement in survivorship will be as low as these figures and therefore it should be detectable with a much less sensitive trial. A further trial could be designed to test the cost effectiveness of non-residual herbicide if initial trials suggest it is warranted.