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CONTENTS

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EDITORIAL NOTES

The Recreational Use of Forest Land	119
Directory of Workers in the Economics of Forestry	121
PRESIDENTIAL ADDRESS 1964	A. P. Thomson 122

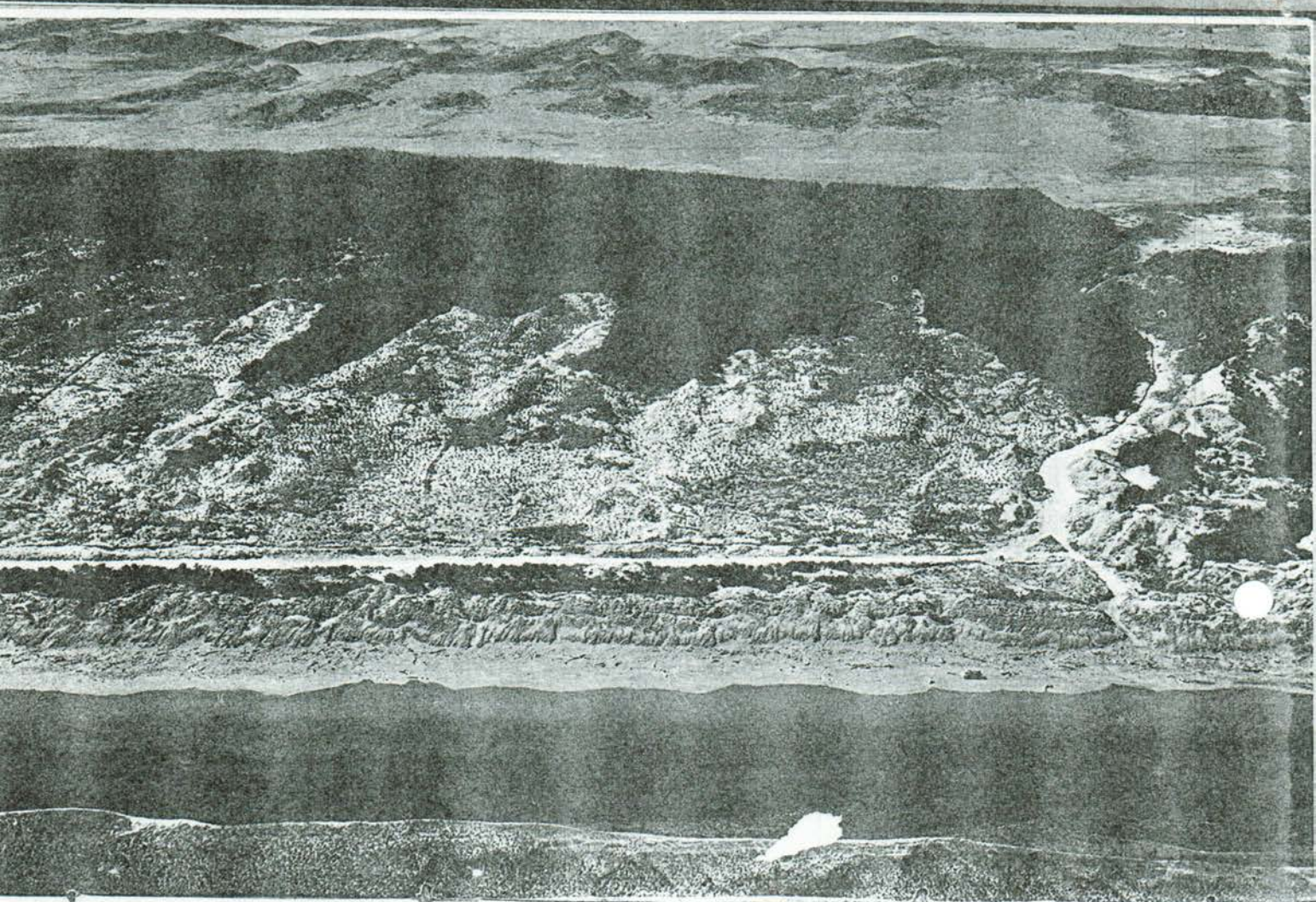
ARTICLES

Symposium on "Sand Dune Forestry", May, 1964:	
Sands and Sandhill Forests of the Auckland Conservancy	A. N. Sexton 125
Sand Country of the Wellington West Coast	G. H. Hocking 128
Coastal Sand Deposits — North Western North Island	D. Kear 139
Sand Dune Reclamation in New Zealand	P. S. Whitehead 146
Sand Dune Reclamation on Woodhill Forest	A. A. Restall 154

FRONTISPICE:

Protective afforestation on the sanddunes of Waitarere.

N.Z. Forest Service photo, by J. H. Johns, A.R.P.S.



SAND DUNE RECLAMATION ON WOODHILL FOREST

A. A. RESTALL*

SYNOPSIS

The methods briefly described in this paper are mainly those developed over the past twelve years on Woodhill Forest. The work described is set out in the order in which it should be carried out—i.e., foredune fixation, reclamation of the dune complex, preparation and tree planting, release-cutting, and finally a brief outline of roading methods.

FIXATION OF FOREDUNES

As the prevailing winds on Muriwai Beach, the frontage to Woodhill Forest, are west to south-west, the movement of the sand off the beach on to the foredune is continuous. The only plant which grows satisfactorily on the face of the foredune under this continual build-up is *Sphintex hirsutus*.

High tides combined with strong winds make inroads into these dunes. Maintenance is necessary to stop the complete collapse of the foredune, which in time would allow sand to pour through the breach and form a wandering dune. Owing to the labour shortage during the war years, maintenance could not be done, with the result that foredunes had broken down along most of the coastline. Some of these breaches were up to 20 chains wide, each requiring up to a mile of fencing to repair.

Work on such a backlog of repairs was carried out in January-February each year when conditions were best for working on the beach; but, now that most dunes have been repaired, maintenance is best carried out as soon as damage is noted. The programme to date has been to erect 160 chains of fence per year and establish *Sphintex* or encourage it to spread from adjoining dunes on to the repaired section.

Until 1953, a permeable type of manuka brush fence was constructed across the gaps to repair the breaches. The cost of brush cutting, loading, carting and erecting this type of fence proved to be very expensive and trials were carried out using other materials. The method favoured today has been developed from these trials, and the price has been reduced to approximately £5 per chain, although this figure naturally varies according to where the work is being carried out along the 26 mile beach frontage.

Face-cuts from a local mill are purchased pre-cut into 4 ft lengths and fence sections are prefabricated at headquarters. These sections are made up to resemble a paling fence: 12 ft lengths of 4 in. × 1 in. are used as backing boards and the face-cuts, after being ripped into 3 in. or 4 in. widths, are nailed at right-angles to these, a gap of 2 in. to 3 in. being left between uprights. The bottom backing board is placed flush with the end of the uprights so that it can be buried when erected and not cause a wind obstruction. A single row of 7 ft *Pinus radiata* posts is erected across the breach at 8 ft centres; this line should be far enough back to be clear of high tide mark.

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The prefabricated sections are nailed to these with the bottom 4 in. just buried. Ends of fences are tied to the adjoining dunes with timber shorts produced during prefabrication.

Foredune Fencing Costs per Chain

Labour for prefabrication, cutting posts, cartage and erection	£ s. d.
Stores: face-cuts, nails, etc.	4 15 4
Vehicles: cartage and transport	14 4
	16 8

All labour-costs quoted in this paper are based on a wage rate of 8s. 6d. per hour, and do not include overheads.

It has been found that it is not necessary to rebuild the foredune above about 8 ft, provided erosion is stopped at the edges of the breach. *Sphintex* established at this stage will complete the repairs. Three or four fences are required to lift the dune 8 ft high. The rate of sand build-up around the fences is very rapid during periods of high winds—a new fence can be buried in 3 to 4 days, although this normally takes one month. No attempt is made to lift the fences as the sand builds up around them. The materials used in construction are all untreated and will last up to four years, which is enough to build up the dune and establish *Sphintex* on it.

Sphintex has proved to be a difficult plant to transplant. Runners out the year and mortality has been over 95%. More success has been achieved by using young plants lifted on a spit of sand and transplanted without disturbing the sand or exposing the roots to the air.

RECLAMATION OF THE DUNES

Probably one of the most disheartening sights in forestry is to see a gang of men planting marram grass by hand on the edge of a 20,000 acre sand drift.

While it must be admitted that an excellent job was done by hand-planting in the early days, it was realized that this system could not be continued in this age of expensive labour. It was therefore decided that an attempt should be made to mechanize this operation.

In 1952 a start was made with the construction of a planter mounted on the hydraulic system of a wheeled tractor. After a year of trials, such a machine had been perfected and this is still in use today. The basic unit is a "Ferguson" subsoiler, which is provided with two small wheels to firm the plants and assist to carry the weight of the two operators. Boxes on the frame carry sufficient plants to plant half an acre without stopping. Steel plates attached to the subsoiler keep the sand from falling into the furrow until after the plant has been positioned. This latter point is very important, as when planting by spade loose sand fell into the holes and difficulty was experienced in placing the sets deep enough below the surface.

Dry conditions do not interfere with the effectiveness of this planter, grass having been planted as late as October and 100% strike obtained.

As a result of the success achieved with this machine, a trailer unit was constructed, incorporating three of these subsoilers. Six men are seated in this planter which is provided with a canopy for protection and is towed by a D7 tractor. A supply of plants is kept within the machine and a further ton is carried on a trailer behind the planter. Five to six acres can be planted without stopping.

Costs of Marram Planting — six-man planting-machine.

Average over 1,460 acres established in 1963-64.

	£	s.	d.
Planting costs per acre:			
Labour — 2.7 man-hours	1	11	9
Plant and vehicles	1	4	0
	<hr/>	<hr/>	<hr/>
	2	15	9

Cost is based on 15 acre daily average for a 64 hour day after travelling 20 miles from headquarters.

The large machine is used for planting on long runs, while the small machine is used for filling in headlands, corners, and odd areas which the large machine cannot reach.

Originally, firming wheels were fitted to the larger planter but these have now been dispensed with as the sand falling back into the furrow holds the plants. Without these wheels tighter turns can be made.

Marram is spaced at 4 ft × 4 ft and an average of 600 lb per acre is planted. The small machine plants five to six acres per day and the large unit approximately twenty acres; therefore, up to seven tons of grass are required daily.

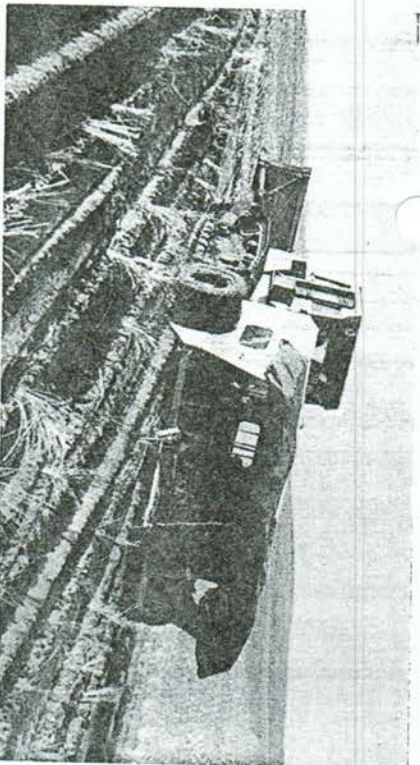
These machines altered the pattern and tempo of the whole planting operation and methods used today, to achieve an annual programme of 1,500 acres, are briefly as follows.

Planting is commenced behind the foredunes on lines running parallel to the coast, this strip being carried inland for approximately 15 chains each year. The previous year's planting slows the movement of sand being carried inland. Therefore the main sand movement is transferred to the crests of the higher inland dunes, which can be lowered by up to 15 ft in one year, or more if left unplanted for a longer period. It is possible by this method to alter the contour of the area and make for easier working by machines. Valleys between dune ridges are also planted up as early as possible so that roads can be constructed through the resultant growth to allow access to the unplanted adjoining bare areas with marram supplies.

G.M.C. 6 × 6 trucks fitted with duals on the front wheels are the only vehicles which can cope with the movement of sufficient supplies of grass to the machines. Landrovers are used for transport of gangs.

Positioning of grass supplies is all-important to save unnecessary empty running by the machines.

Topdressing of all planted areas with a nitrogenous fertilizer is now standard practice. Eighty pounds per acre is flown on in two sowings of 40 lb, one in October following planting and the other in the following March. Advantages of using fertilizer are quicker establishment, giving an even cover which is not so liable to wind



Six-man marram-planting machine on Woodhill Forest.

damage, and reduced blanking and replanting costs. Marram plants boosted in this way provide better shelter for lupin.

With a rate of hire for the topdressing aircraft at £25 per hour, and a fertilizer cost of £25 per ton, the overall cost of each topdressing is only 11s. 3d. per acre, including transport charges and supervision.

"Nitro-moncal" containing 21% nitrogen has been found the most satisfactory manure as it is in pellet form and can be spread by plane or tractor topdresser unit more evenly than other mixtures tried. Wind does not move this manure, whereas smaller grained sulphate of ammonia can be moved before it has had time to be absorbed into the sand.

Adequate supplies of grass handy to the area to be planted are essential, as about 400 tons are required each year. It has therefore been found necessary to select and treat nursery areas. Low-lying, but not wet, sheltered flats which have been planted fifteen months before are ideal. The healthiest patches of plants in these areas are marked out; these having already been topdressed with Nitro-moncal during the previous spring and autumn at 40 lb per acre. These areas are now given a further application at 2 cwt per acre in October, fifteen months after planting. The yield from these areas can be as high as 10 tons per acre, although the average is nearer 6 to 8 tons.

On new projects where older grass is not available, grass planted three months previously can be topdressed in the spring with one to two hundredweight of nitrogenous fertilizer (21% N) and this dressing repeated in the autumn. Four tons of plants per acre can be obtained from areas so treated.

Collecting of the grass is done by day workers on bonus, supplemented by workers and their families collecting at weekends. Price paid for grass dug, tied, trimmed and stacked in dumps is £4 13s 4d per ton.

Costs of Marram Supply

Marram is collected by workers on contract at weekends at 7d a 10lb bundle; or by bonus gangs in topdressed grass at approximately 5d a 10lb bundle.

	£ s. d.
Cost per ton at 7d a 10lb bundle	6 10 8
Handling and transport	1 11 9
Cost per ton delivered on planting site	8 2 5
Cost of marram per acre @ 7d (600 lb)	1 15 0
Cost of marram per acre @ 5d (600 lb)	1 5 0
Handling and transport per acre (600 lb)	8 6

The nursery is used for one year only, and after it has been worked out lupin seed sown on it at 2lb per acre ensures a complete cover in twelve months. Yellow lupin (*Lupinus arboreus*) has proved the most successful secondary stabilizer. Seed mixed with the manure used for the autumn topdressing is sown at 2 to 3lb per acre. Provided the marram is vigorous, it provides sufficient shelter for the lupin plants, which in turn provide the nitrogen necessary to promote the growth of the marram.

If blanking of lupin is necessary a rotary-type topdresser on a wheel tractor is used to distribute further seed.

Local hand-picked lupin seed is purchased at 3s 0d per lb, cleaned, or 2s 6d per lb in pod. The seed is extracted by feeding the pods through a cyclone-type blower on to a sieve where pods and seed are separated. The net cost of seed was reduced from 4s 10 3s per lb after this machine was put into service.

PREPARATION AND TREE PLANTING

For planning, 4 to 5 years is taken as the average time from initial marram planting to tree planting. This interval varies, depending on the exposure of the site. Dune crests nearer the coast can take longer to cover, whereas sheltered valleys could be planted within 2 to 3 years. On the east coast trees could be planted in 1 to 2 years after marram planting.

The ground cover at time of planting varies from marram and lupin only, to these plants mixed with toi toi (*Arundo conspiciata*) and *Muehlenbeckia complexa*. This makes a dense impenetrable cover approximately 5 ft high, through which lines must either be cut or crushed before planting. Ninety per cent. of the country can be covered by crawler tractors; D6 or bigger are preferred as they are more stable on sand country.

The rate of hand-planting seldom reaches more than 600 or 700 trees per eight-hour day in this cover. Mortality of the planted trees is generally at least 25%.

In 1954, a Lowther tree planter was tested and modified to suit local conditions. The front axle was widened to give greater stability, and additional tree boxes were fitted to increase carrying capacity and act as guards to protect the operator from sticks coming through between the front wheels. A bell set to ring on each complete rotation of the planter wheel gave the required intervals of 8ft for spacing.

As it was found necessary to crush lines before using this planter, an offset drawbar was fitted to the tractor so that the planter

followed behind one of the tractor tracks instead of between them. Vegetation is double crushed during the operation. The couler must be kept razor sharp to cut through *Muehlenbeckia* and other vegetation, and a portable power emery stone is used for this.

Using this machine towed by the D6, an average of 7 acres per day can be crushed and planted at 6 ft by 8 ft. On long runs of 10 chains or more, a figure of 10,300 trees per day has been reached. The strike is seldom below 90% and this can be attributed to the minimum planting depth of 10 in., plus very little disturbance of the humus layer. Trees so planted are not affected by dry summer conditions. Where runs of 5 chains or better cannot be obtained owing to broken terrain, lines are crushed with tractors and planting done by hand.

Tree Planting Costs

Comparative costs for hand-planting or planting with D6 and Lowther.

(a) *Hand-planting* (average 600 trees per day)

	£ s. d.
1. Crushing and preparation at an average rate of 5 acres daily.	
Labour	13 7
D6	2 16 0
2. Planting	
Labour	3 9 7
Transport	5 2 6
	3 4
Total cost per acre	5 5 10
	8 15 5

(b) *Machine planting and crushing with D6 and Lowther, at an average daily rate of 5 acres.*

Labour	1 7 2
D6	2 16 0
Transport	2 0
Lowther	2 0
Total cost per acre	4 7 0

Ideal trees for planting on sand country are autumn sown—*i.e.*, 15 to 18 months old. These must be sturdy, at least 18 in. tall and well rooted.

The annual programme at Woodhill is 1,000 acres, rising to 1,200 acres in 1965-66.

RELEASE-CUTTING

With quick growing lupin, release-cutting is a major job, when 1,000 acres per year are being planted. This requires two releases the year after planting and probably one in the following year. The trees planted must be sturdy and able to stand a certain amount of shading.

Hand releasing, at 8 to 10 man-hours per acre, is out of the question on such a large programme. From the start of each round of releasing to its completion no more than ten weeks should elapse, otherwise trees will be smothered out by the dense regrowth or it will be impossible to find them. Even one year's planting would take twenty-five men per week for the ten weeks, or fifty men to deal with the previous year's planting as well.

Discs have been modified to release-cut the trees on the tractor country. These discs have a cutaway section in the centre so that when mounted on the three-point linkage of a wheel tractor, they can straddle the row of trees. They must be used when it is still possible to see the trees, or at least follow the lines, and this limits their use to six to eight weeks from start to finish. As only three units are available, this means that only half the area can be covered: six sets would be required to do the total programme. As these discs tend to remove most of the growth from around the trees, scorching of seedlings by salt winds is very prevalent near the coast.

Release-cutting Costs:

Comparative costs for releasing by hand or by discs on wheeled Ferguson tractor.		£	s.	d.
F				
(a) Hand cutting (average 1 acre per man day)				
Labour	.....	3	8	0
Transport	.....	2	6	
Total cost per acre	.....	3	10	6
(b) Modified discs, at an average rate of 6 acres daily.				
Labour	.....	11	4	
Ferguson	.....	5	0	
Transport	.....	1	8	
Total cost per acre	.....	18	0	

The final answer to this operation appears to be to use hormone sprays applied from the air. Trials are being carried out at present but no definite results are available as yet.

ROADING

With the mechanization of reclamation, it is essential that roads or at least tracks be provided as early as possible, to improve conditions for the movement of men and supplies.

The line of these tracks, which will be the logging roads eventually, is marked out three or four years ahead of the normal reclamation programme. Marram is planted five chains either side of this line and lupin is sown at 8 lb per acre as soon as the marram is established. Most of these routes run through sheltered valleys between the dunes and, as in this position the sand movement is negligible, a complete cover can be obtained in two to three years.

At this stage a track 12 ft wide is formed through the growth. Provided the side shelter is not damaged, this is satisfactory for traversing by 4x4 vehicles.

From four to five years after original planting, these tracks are widened out and formed up, as for roading in any type of country. To give a solid surface to carry normal traffic, a layer of sandy clay is spread on the sand, 30 cu. yd per chain being necessary for a road 16 ft wide. A light layer of sand spread on this clay with the grader gives a surface with sufficient traction for light vehicles. From this point on, improvements to the surface are made as they would be to a normal clay road.

Claying has been carried out in several ways. Until 1962, a loader was used to load G.M.C. 6x6 trucks, which transported and spread the clay. The 1964 programme consisted of a series of trials with self-propelled rubber-tyred carryalls. These machines proved capable of traversing the sand roads and laying the clay as they went, compaction was excellent, and a final run-over with a grader completed the work. Costs were reduced to approximately £5 per chain for new roads at an average distance of two miles from source of clay.

Water-tables on slopes are liable to scour out and this is overcome by planting Kikuyu grass along road edges.

CONCLUSION

Labour saving has been the keynote and the full support of staff and workmen has been solicited and obtained. Although the volume of work is at least five times that which was being done in 1952, the use of machines has allowed the labour force to be reduced by one quarter. Use of machinery has also made the work more attractive and this has led to a better and more settled type of worker being employed.

Mechanization has allowed such progress to be made that, whereas in 1952 sand reclamation was primarily an operation to protect farmlands, it provides such a successful means of afforestation that the future commercial plantings of North Auckland will be mainly on sand.