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(16th November, 1948)

Empire Forestry Review
28(2) 137-142
1949

SUMMARY

This article is a brief account of the progress of sand dune reclamation in the North Island of New Zealand during the last two decades. An historical introduction is followed by a description of the technique developed for New Zealand conditions and this in turn by an analysis of the various sites encountered in the dunes. In conclusion the work done is summarized, costed and compared with the classical reclamation schemes of Gascony.

Historically the most salient feature of the work is that it was initiated primarily to absorb unemployed labour and only secondarily to protect public works and private farming land. This fact, coupled with the strong demand for more and more pasture, has led to the reclamation and afforestation of the dunes being confined to a very narrow coastal strip which in Gascony would serve only as protection forest but which in New Zealand meets the demand for production also. The magnitude of the problem is clearly seen when it is realized that, despite this narrow zone of reclamation and eighteen years continuous work, only one third of the dunes which required reclaiming in 1930 have been at present brought under control.

IN 1911 L. Cockayne's report on the sand dunes of New Zealand was published, covering in a comprehensive manner the extent and characteristics of the dune vegetation associations and drawing extensively on work in France and Germany as a guide to future trials in New Zealand.

Following Cockayne's report the Department of Lands and Survey commenced work on a small scale on scattered areas throughout North Auckland. This work was terminated by the First World War and afterwards taken up by the Forest Service which came into being in 1920.

Perhaps the first notable reclamation scheme undertaken after the war was that initiated by C. M. Smith at Invercargill. Here, by taking advantage of steady strong onshore winds and low tides, Smith was able to advance considerably the fore-shore and so permanently reclaim a lagoon area to the lee of his artificial foredune. This work, however, was not followed by afforestation, and for the first scheme so completed we must turn to Tangimoana at the mouth of the Rangitikei River on the west coast of the North Island. In this area the State Forest Service carried out a full dress rehearsal of the technique which was in the course of the next few years to be adopted with success throughout the North Island. This work was brought to an end in the early 30's when, because of a narrow interpretation of the scope of Forest Service activities, the responsibility for the work passed to the Public Works Department. Under the control of Public Works the reclamation work was considerably expanded as an unemployment relief measure, the main schemes being located at Hokio, North Waikato Heads, Woodhill, Helensville, Te Kopuru, Kaitata, Rakaka and Pakiri-te-Arai. (See map.)

The work first undertaken in 1932 was that of building the foredune and stabilizing the bare drits with marram grass (*Ammophila arenaria* L.) and perennial yellow lupin (*Lupinus arboreus* L.).

By 1935 the stabilization had progressed to such a degree that the ultimate use of the dune complex came up for consideration, and as a result large-scale tree planting was undertaken.

With the onset of the Second World War work on the dune areas was reduced, and since then work has been minimized by labour shortages and so confined to the maintenance and improvement of existing works rather than to their expansion. With the increasing activities of the Soil Conservation and Rivers Control Council,



PLATE 1
Light permeable screen made of Manuka branches and No. 8 wire, showing the accumulation of sand to the lee of the screen. Waitare Sand Dune Reclamation Scheme. (Courtesy Soil Conservation and Rivers Control Council, N.Z.)

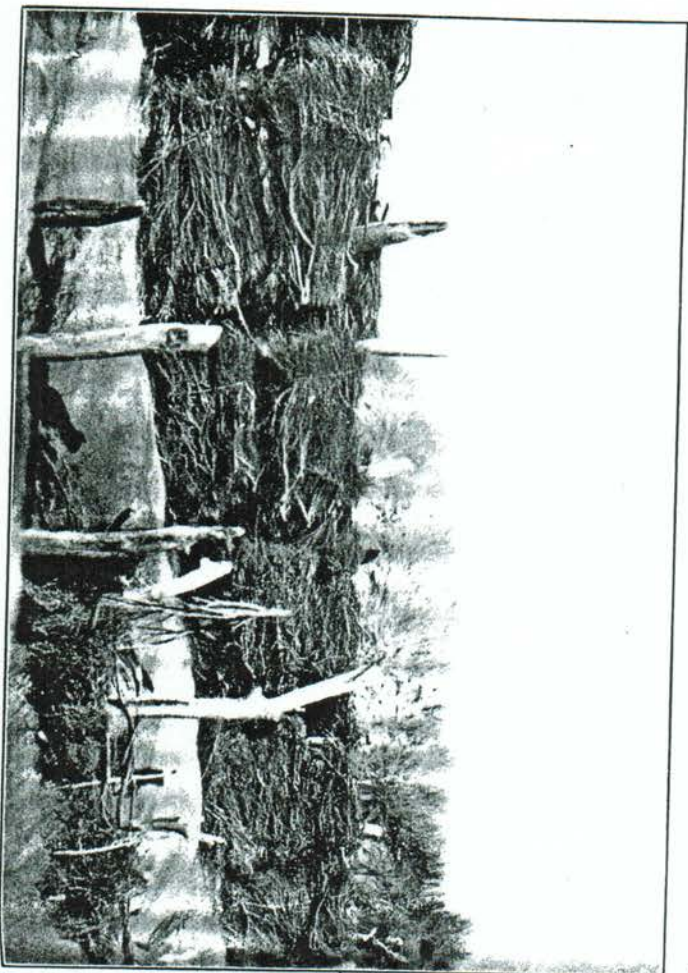
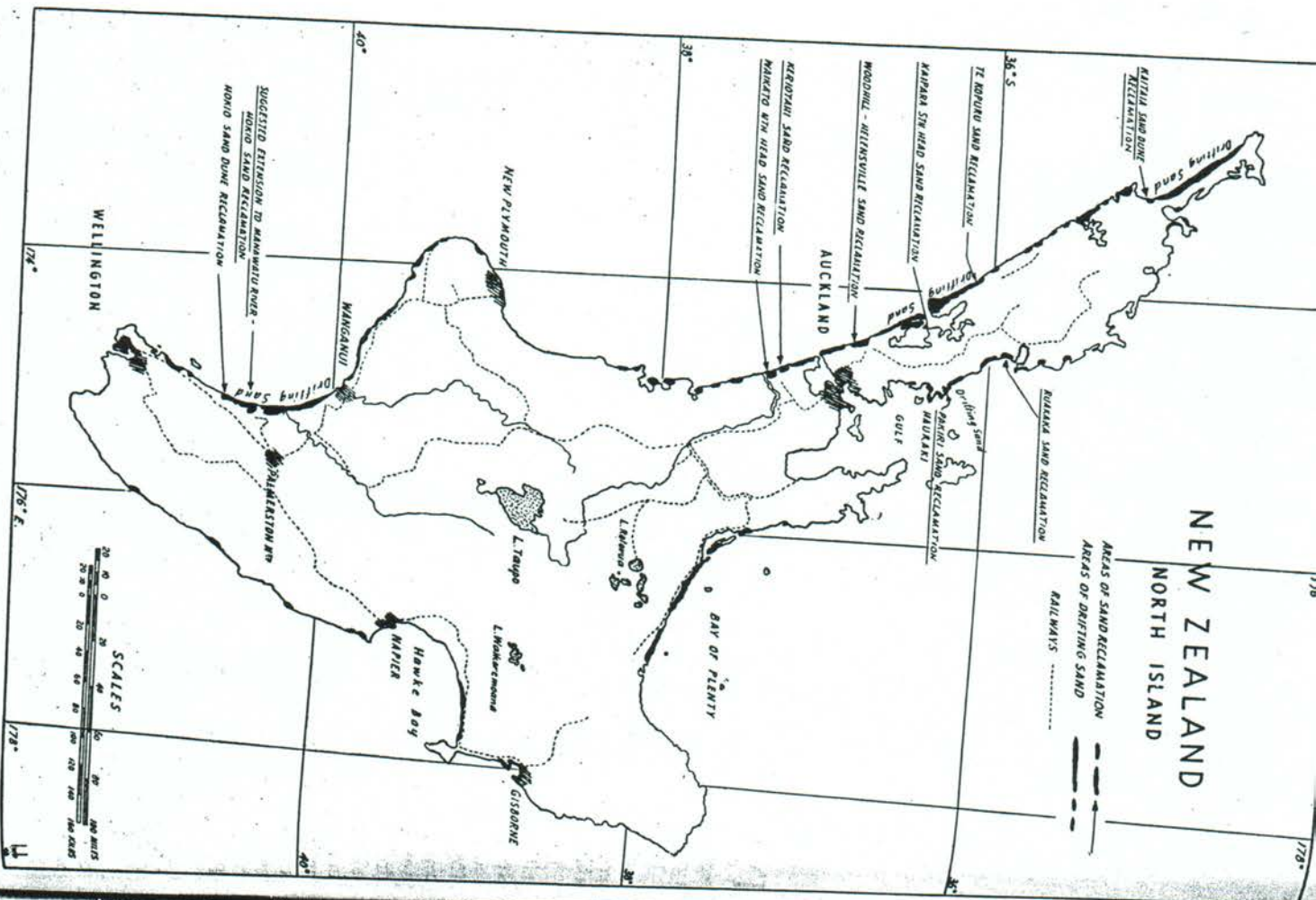


PLATE 2
Relatively impermeable screen as used at Tangimoana Reclamation Scheme. (Courtesy of State Forest Service, N.Z.)



HOWEVER, the areas immediately north and south of the Rangitikei River, demands immediate and continuing work rather than reservation as a labour absorbing project for use in depression periods.

In New Zealand, due to the prevailing westerly winds, the formation of dunes is most marked on the west coast of the North Island and particularly along the edge of the Manawatu-Rangitikei flood plain and the North Auckland peninsula (see map). In the South Island dunes are absent along the west coast because of its precipitous nature and very high rainfall.

The task of reclaiming the dunes may be divided into three phases; first the establishment of a foredune of uniform height, secondly the fixation of the foredune and the unstable areas of the dune complex with sand-binding plants, and thirdly the protection of the fixed sand with a continuous vegetative cover, in the present case perennial yellow lupin.

In the more hilly sections of the dune complex within 1 mile to 1½ miles of the sea the reclaimed area is converted to forest, whilst the lower ridges and sand flats to the lee of this area are developed for grazing purposes.

The foredunes in New Zealand are established by erecting a permeable fence some distance to the windward of the desired crest of the dune. The sand accumulates behind the fence (Plate 1), and ultimately buries it. At this stage a second fence is erected to the lee of the first fence and the process repeated until the desired height is of between 20 and 30 feet has been achieved. The fences used in this work are made largely from Manuka (*Lepidospermum scoparium* Forst.) and fencing wire. Where the source of supply is remote, light screens, similar to that illustrated in Plate 1, are made by weaving Manuka branches between two pairs of wires, the resulting fence being rolled up like a mat for ease of transport.

An alternative material for such fences is New Zealand flax (*Phormium tenax*), which resembles a 6-foot version of an iris plant and occurs in dense colonies in swampy areas. Alternatively, where Manuka or fresh prunings from plantations are readily available, the fences are made by placing brushwood between pairs of stakes (Plate 2).

The foredune built, it is then stabilized with marram grass. In the North Island the marram establishes best along the upper half and top of the ridge where it is constantly supplied with sand and yet not lapped with the high tides. Along the seaward toe of the foredune the native silvery sand grass (*Spinifex hirsutus* Labill.) soon establishes itself (Plate 3). This plant, though not readily established from cuttings, and so not artificially cultivated for reclamation work, freely establishes itself from seed. The light seed-heads bouncing along the toe of the foredune like fairy balls are a frequent sight in autumn.

Once the foredune is established and the wind funnels are closed, the more open areas of the dune complex are planted up with marram (Plate 4). In the first schemes marram grass was inserted in single sets, but though this effected an initial saving in time and marram grass, the cost of replanting failures and the difficulty of getting areas established led to the following practice being adopted. To provide the sets young marram tussocks are dug up and split so that each set has two underground root-nodes. The leaves of the sets are then cut to 9 inches or 10 inches long so that transpiration and wind resistance are reduced when they are first put out. The sets are then planted in bunches of three to six, the number in the bunches and the distance between them being varied with the exposure of the site, more per bundle and close spacing being adopted on exposed sites. The most usual arrangement is three sets to a bundle with a spacing of 2 feet 6 inches between bundles. Once the marram is established a few seeds of perennial yellow lupin are dibbled in behind each bundle. Meanwhile, on the moister and more stable areas, lupin seed is sown direct with a "Planet Junior". By this means, in the course of two years or so, the bare dunes are covered with a dense shrubby mass of perennial yellow lupin and marram grass.

other south, and they effectively illustrate the contrast between the raw and the recently reclaimed dune complex. At this stage reclamation is in effect complete, but the resulting vegetation is extremely vulnerable to fire, the risk of which is considerably enhanced by the fact that the layman considers it as waste scrub.

The dune complex has been afforested because once the trees are established they provide, together with adequate foredune maintenance, a permanent insurance against reversion of the area to raw moving sand. This is in particular contrast to the high risk of such reversion involved in grazing the areas when stock expose the bare sand either on regular used tracks or by over-grazing, and so initiate the movement of sand on to the otherwise permanent grazing land behind the dunes. In addition to these primary considerations afforestation is justified in the area as shelter for the pastoral farms behind, as a local supply of timber, battens and firewood in a region otherwise deficient in such supplies, and as a constant reminder to the public of the work done in reclaiming the dunes. The forest thus offers a more readily appreciated object of fire protection regulations than does the rough growth of marram and lupin.

Following the example set by the successful afforestation of the dunes in Gascony with *Pinus pinaster* Sol., this species was one of the earliest planted; but it soon proved very inferior in hardness and growth to *Pinus radiata* D. Don and *Cupressus macrocarpa* Hart. This latter species and *Pinus muricata* D. Don survive even the full force of salt laden gales, and so are used on the outer protective zone of forest between the limits of twenty and forty chains inland from high tide mark.

Thus as finally established we can visualize the dunes and their adjoining pasture areas as falling into the following zones considered in order from the seaward side:

- (1) Foredune held at its seaward toe by silvery sand grass and for the rest by marram grass.
- (2) The dune complex for some twenty chains behind the foredune held in marram, lupin, toe-toe (*Arundo conspicua*, Forst.) and other low scrub.
- (3) Wind shorn protective forest commencing some twenty to thirty chains from the foredune and perhaps five to ten chains deep. This is usually formed of *Cupressus macrocarpa* and *Pinus muricata*.
- (4) Productive forest from the limits of the protective forest to the leeward edge of the dune complex at a distance of one mile to one and a half miles from the foredunes.
- (5) Agricultural area in the lee of the forest, consisting of moist sand flats used for permanent pasture and long tongues of sand suitable for shelter-belts or for winter grazing (Plate 7).

All these features can be seen in the aerial oblique of the Hokio sand dune reclamation scheme, which shows the Manawatu littoral plain and the Tararua mountains beyond (Plate 8).

In the more protected areas and where the operations can be timed conveniently the most economic way of establishing the productive forest zone is with one-year-old *Pinus radiata* seedlings (approximately 8 inches to 10 inches high) planted in the lee of the marram clumps at approximately the same time as the lupin seed is dibbled in. In this way line cutting through thick lupin scrub is avoided. Where such line cutting has to be resorted to, as is most frequently the case, two-year-old (1/1) *Pinus radiata* seedlings, usually about 2 feet tall, are used. The normal planting distance to-day is 6 feet by 6 feet, but previously it was 8 feet by 8 feet. So far as the protective zone is concerned the species most commonly planted have been *Cupressus macrocarpa* and *Pinus muricata*. Here however these species present a wind and salt chattered canopy.

20 chains =
2 1/2 400 m.
OK

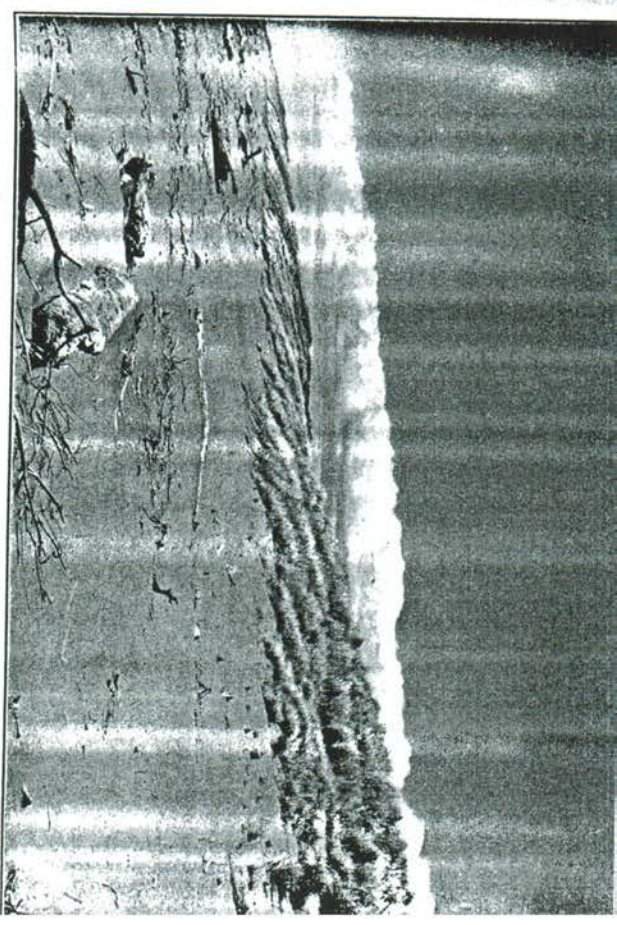


PLATE 3
Foredune Waitarere Beach showing the high growth of Marram grass towards the top of the ridge and the lower more prostrate growth of silvery sand grass towards the toe of the dune

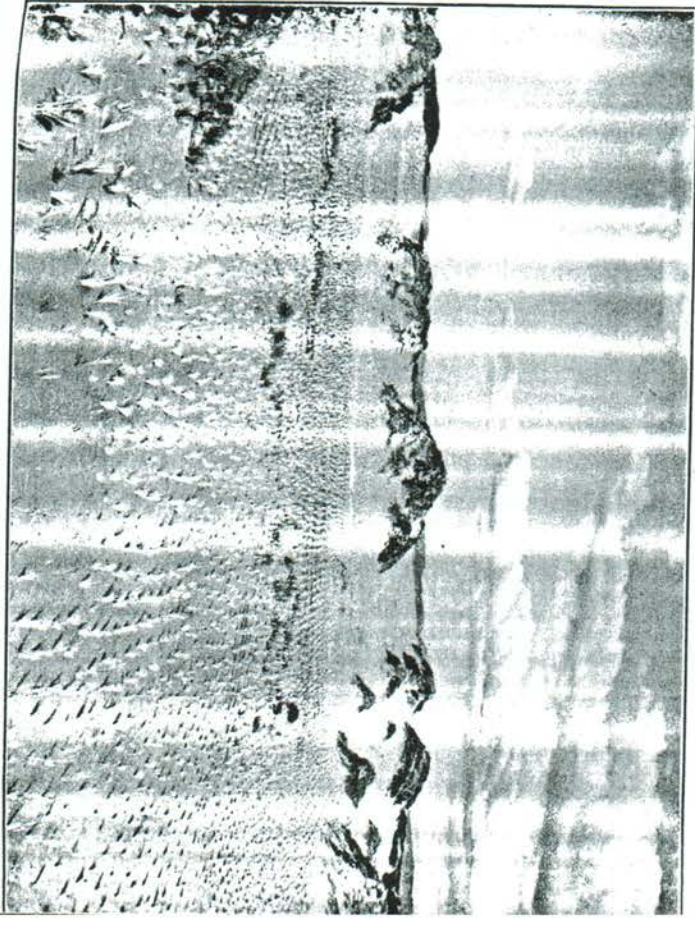


PLATE 4
Raw area of dune complex newly planted with Marram grass.
(Courtesy Soil Conservation and Rivers Control Comm.)

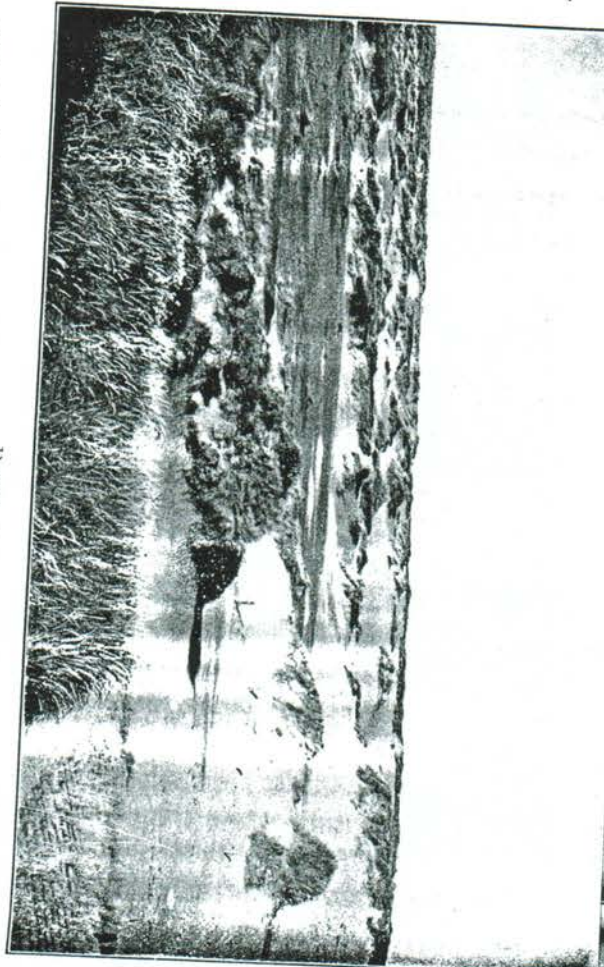


PLATE 5
Untouched dune complex at Waitarere Beach looking north. See for contrast Plate 6.
Courtesy Soil Conservation and Rivers Control Council, N.Z.

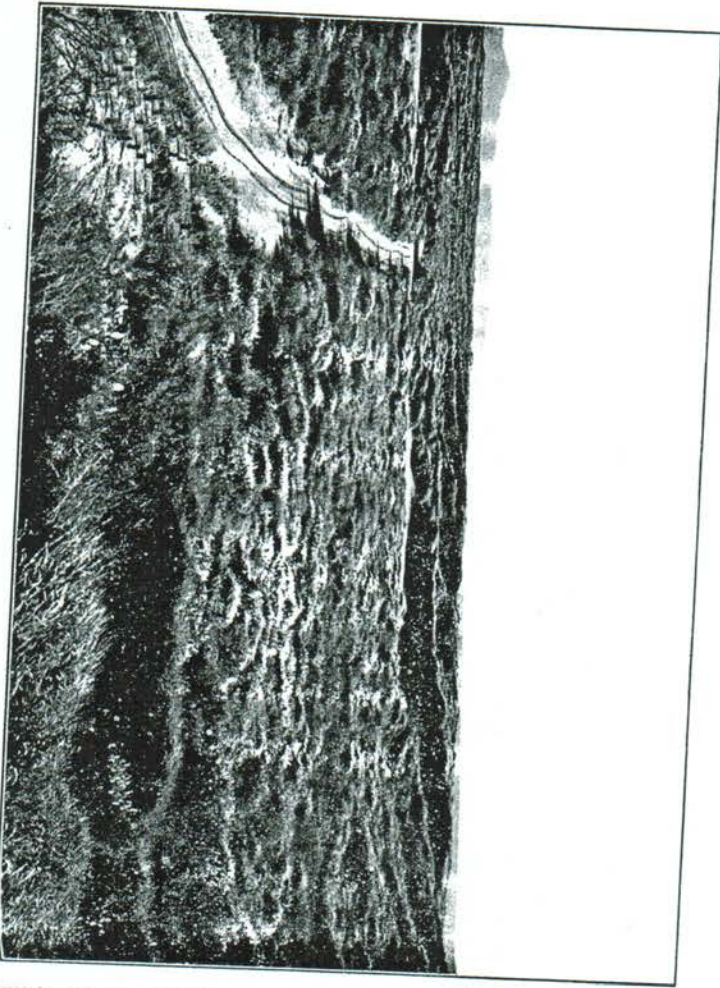


PLATE 6
Recently reclaimed dune complex of dense Marram and lupin cover, Waitarere Beach looking south.

pared with the better growth they show on the more sheltered areas. In future it is hoped to substitute such species as:

- Tasmanian Ngao (*Myoporum perforatum*)
- Taupata (*Coprosma baueri*)
- Tamarsk (*Tamarix gallica*)
- African Boxthorn (*Lycium horridum*)
- Sandstay (*Leptospermum laetvialum*)
- Chatham Island Akeake (*Olearia traversii*)

which have already proved suitable species for such sites on a small scale.

Up to the present time seven major reclamation and afforestation schemes have been undertaken on the west coast and two minor schemes on the east coast of the North Island. None of the schemes undertaken on the west coast has reached completion either so far as primary stabilization or afforestation is concerned. The work done to date with approximate costs is summarized in Table I.

The stage is now reached where fire protection and silvicultural treatment represent an insistent demand on the inadequate labour supply. Excellent roads have been formed at Woodhill-Helensville and North Walkato heads by mixing clay with the raw sand on formed tracks. At the latter station light thinnings have been made and treatment has progressed beyond the stage of low pruning and the removal of the worst malformed stems is at Tangimoana. Here, however, considerable havoc was wrought in lightly thinned *P. radiata* stands in a gale with recorded gusts of over 90 miles per hour on 23rd February, 1947; and it is interesting to note that the trees were not in general uprooted but broke off at 5 feet to 15 feet above ground level. It is possible that the irregular nature of the previous treatment and the resulting slow diameter growth contributed to the extent of the damage. On the other hand it may be argued no treatment would be sufficient to prevent extensive damage to plantations subjected to winds of 90 miles per hour and more.

TABLE I

| Name of Scheme | Location | Total Area of Scheme at 31/3/48 | Total Area of Trees at 31/3/48 | Approximate Cost to 31/3/48 | Estimated Area of Scheme at Completion | Estimated Area of Trees at Completion of Scheme |
|--|---|---------------------------------|--------------------------------|-----------------------------|--|---|
| Hokio-Manawatu. | Wellington I.D., Moutere and Waitohu S.D.'s, Topo. Sheets 148, 152 | 3,000 | 1,300 | £50,790 | 15,000 | 1,000 |
| Manawatu-Rangitikei. | Wellington I.D., Titirua, Kaitiaki, Sandy S.D.'s, Topo. Sheets 143, 148 | 3,087 | 671* | 16,150* | 12,000 | 8,000 |
| Walkato Heads (Maioiro and Kaitiaki Block) | N. Auckland I.D., Maioiro and Avihitu S.D.'s, Topo. Sheets 41246 | 5,000 | 2,500 | 157,624 | 5,000 | 4,000 approx. |
| Woodhill-Helensville. | N. Auckland I.D., Kaipara and Kumeu S.D.'s, Topo. Sheets 87241 | 14,000 | 5,000 | 246,114 | 35,000 | 25,000 |
| S. Kaipara | N. Auckland I.D., Waioneka and Okaku S.D.'s, Topo. Sheets 83 | 4,000 | Nil | 13,652 | | |
| Te Kopuru | N. Auckland I.D., Kopuru, Tokakoa, Te Kuri S.D.'s, Topo. Sheets 27232 | 3,000 | .. | 13,084 | 3,000 | Nil |
| Kaitia North | N. Auckland I.D., Ahipara S.D., Topo. Sheet 9 | 2,500 | 200† | 20,673 | 115,200 | 80,000 |
| Raukaka | N. Auckland I.D., Raukaka S.D. | 1,000 | Nil | 13,000 | 2,500 | 2,000 |
| Pahiri-Te Arai | N. Auckland I.D., Pakiri S.D. | 3,000 | Nil | 7,563 | 3,000 | Nil |
| TOTALS | | 38,787 | 9,671 | £538,650 | 180,700 | 120,000 |

* Work carried out by State Forest Service.
† Prior to 1943, when 800 acres were destroyed by fire, there were 1,000 acres.

As an example of the growth possible in the productive forest zone the scant existing data has been summarized in Table 2. It will be noted that no fir trees are

| Forest | Age at Measurement, Years | Crop Height, ft. | Per Acre | | | | Remarks | Size of Plot |
|--------------------------------|---------------------------|------------------|-----------|---------------------|-------------------------|-------------------------------|-----------|----------------|
| | | | No. Trees | Basal Area, Sq. Ft. | Total Vol. Cub. Ft. Lb. | Vol to 6 in. top ft. b.m. Lb. | | |
| 1. Waitare S. Block .. | 10-11 | 35-38 | 700 | 121 | 1,890.5 | 6,400 | Unthinned | 1/10 acre plot |
| 2. " .. | 12-13 | 55-59 | 605 | 205.5 | 4,490.0 | 29,000 | Unthinned | 1/10 acre plot |
| 3. Tangimoana .. | 16 | 75 | 560 | 257 | 5,610 | 21,000 | Unthinned | 1/10 acre plot |
| 4. Flock House .. | 16 | 65 | 360 | 231 | 4,626 | 21,000 | Thinned | 1/10 acre plot |
| 5. Tangimoana .. | 18 | 80 | 390 | 254 | 6,398 | 31,000 | Thinned | 1/10 acre plot |
| 6. " .. | 18 | 80 | 540 | 274 | 6,418 | 29,700 | Unthinned | 1/10 acre plot |
| 7. Flock House .. | 18 | 75 | 410 | 267 | 5,836 | 30,000 | Unthinned | 1/10 acre plot |
| 8. Tangimoana .. | 19 | 90 | 290 | 243 | 6,577 | 36,700 | Unthinned | 1/5 acre plot |
| 9. W. F. Alexander Waverley .. | 19 | 80 | 540 | 329 | 7,487 | 38,000 | Unthinned | 1/10 acre plot |
| 10. Flock House .. | 20 | 70 | 440 | 245 | 5,285 | 24,000 | Unthinned | 1/10 acre plot |

In conclusion we may perhaps briefly compare this recent reclamation work in New Zealand with the older and better-known works in France.

Both areas have a similar latitudinal range, that of New Zealand falling between 35 degrees south to 41 degrees south and that of France between 43 degrees north and 45 degrees north. The sand movement in both resulted from the exposure of low dune country, subject to strong westerly winds and indiscriminate grazing. In France cattle and horses were the animals concerned, in New Zealand cattle and sheep.

By 1787, when the work was first started in France by M. Bremonter, the coastal districts of Gironde and Landes had deteriorated seriously, and impeded drainage had added malaria to the menace of sand encroachment. Here work was first undertaken to prevent the inundation of the market town of La Teste with sand, whilst in New Zealand the threat to road and rail communication in Auckland province provided a similar motive for the early work. It soon became evident in both countries that the lasting solution of the problem lay in the reclamation and continued control of the littoral zone.

Whereas in France the swampy and malarious areas to the lee of the dunes were planted in trees as a means of reclaiming and using them, the similar areas in New Zealand, with its strong pastoral interests, have been developed into good pasture. Thus briefly comparing the utilization of the sandy coastal areas in the two countries, we find in both the State owning the reclaimed littoral dune and the protection forest on the dune complex behind. In France this seaward zone remains inviolate and the commercial forests are found extending some miles inland from it. In New Zealand the French zone of commercial forests is largely replaced by pastoral farms, and the transition zone from protective forest sites to commercial forest sites form the areas at present lightly worked and called in this article the productive forest zone. It will however be seen that the New Zealand forests with their present extension are essentially protection forests and have none of the commercial possibilities of the French forests which extend on to what in New Zealand would be farming country.

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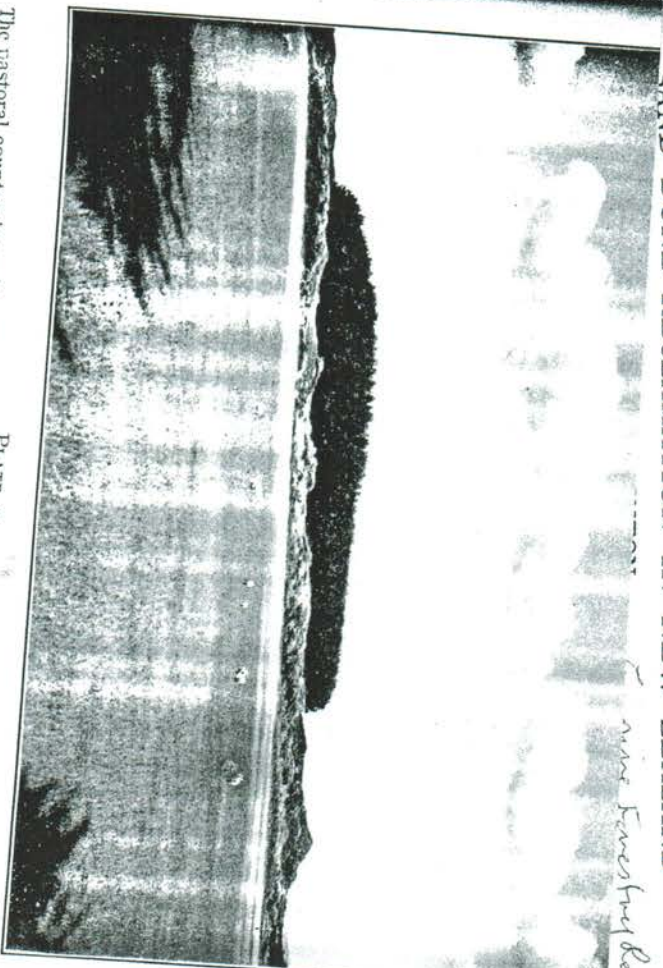


PLATE 7
The pastoral country immediately to the lee of the dune complex showing one of the long strip dunes which run out from the complex in a direction parallel to that of the prevailing wind. (Courtesy Soil Conservation and Rivers Control Council.)



PLATE 8
Aerial oblique of Waitare S. Block