# RESTORATION OF DEGRADED LANDS IN NEW ZEALAND*

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*SYNOPSIS*

*Land settlement in the new world has, because of lack of inhibitions in the speed and methods of settlement, sometimes led to extensive areas of degraded land—degraded for a number of reasons: alteration of the vegetation so that it is of no use to man; degeneration of soils physically and chemically, and erosion. In the hilly and mountainous parts of New Zealand where farming and pastoral settlement have stepped over safe boundaries, there are large areas of degraded lands. Agricultural methods have failed mainly because of steepness, but, except where erosion has taken place, the soils are forest soils, the climate suitable for introduced trees. These are the areas to which afforestation must now turn. On the better and more accessible sites, it is economically justifiable. These sites will grow species already accepted by the expanding forest-products industries.*

## INTRODUCTION

### *Settlement of the New World*

Land settlement in the "new world" has usually taken place rapidly and without reference to those factors which affect the stability of either soils or vegetation. Settlers were not guided by the rules of safe land use which had taken centuries to evolve in their own countries; nor were they subject to the laws which regulated this use. Visions of land possession were usually the reason that Europeans set forth for these new lands, and settlement schemes constituted one of the main preoccupations of embryo governments and of the promoters of emigration. Friction over land ownership quickly arose between settlers themselves, let alone between settlers and the indigenous peoples. In New Zealand it was largely friction over land which led to the Maori Wars (which were as colourful as the days of the Wild West, which have provided Hollywood with one of its principal and ever-popular themes). Land ownership and the ownership of the stock on it were the motives which ruled the day.

The occupation of these new lands was, in the first instance, mainly pastoral. In many places, over great tracts of country, the transplanting of Northern European agricultural methods and animals yielded unexpectedly good results, and, as methods were improved and adapted to the new conditions, yields often outstripped those of Europe. Under other conditions, however, methods failed, and degeneration of swards and then of soil structure in one form or another set in. Some classical examples come readily

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to mind — for instance, the "dust bowl" of America, and subsequent organizations and measures to set the harm to rights. Frequently this degeneration was caused by the overgrazing of natural grasslands by domestic animals, and often by the lack of recognition of the important part that vegetation, particularly forest, plays in maintaining the stability of steep lands.

*Nature of Land Deterioration*

This deterioration involves both vegetation and soils. The two are intimately related, for when crops fail or natural vegetation becomes depauperate through burning, overgrazing, or failure from other causes, soils are altered, and on sloping ground erosion can commence. Bearing in mind this correlation, it is, nevertheless, convenient to consider the degeneration of soils and of vegetation separately in analysing the present problem — the rehabilitation of degraded land by forestry. By degeneration, then, is understood changes in vegetation or soil, usually induced by some activity of man, that result in a vegetation of less use to man than the original, or in a soil that will not grow the desired crops so well.

The degeneration of vegetation must include not only its opening up, but also its invasion by weeds, shrubs, and regrowth after the burning of native vegetation, in other words, the creation of vegetation that is useless to mankind. The degeneration of soils may manifest itself in some form of erosion, though not invariably so, because repeated burning of vegetation can cause the nutritional complex of soils to deteriorate; sometimes the destruction of natural vegetation can so alter the physical properties of soils that they become almost useless for productive purposes. New Zealand has examples of degeneration, over comparatively extensive areas, of both vegetation and soil. No doubt, land affected by certain types of mining which excavate or churn up the soil should be added to these categories, but the total area so affected is limited.

It is also convenient to regard land deterioration from the point of view of land use. Broad differences in land use lead to differences in soils and vegetation; and, even within the same land use, variations of management lead to variations on the same soil or within the same type of vegetation.

*The Process of Land Settlement in New Zealand*

New Zealand is no exception to the manner in which virgin lands were settled by Europeans. Land companies and the young Government went to great lengths to get the land occupied and the forest felled, passing a variety of legislation to assist these ends. The result has been, in part, a remarkable pastoral development unequalled anywhere else in the world, a development that is still going on, leading to increased production per unit of area by the application of the results of research or through improved management techniques and the aerial topdressing and oversowing of hill pastures.

The boundaries between safe and unsafe agricultural and pastoral development are set by the mountainous terrain, with its highly shattered rocks, that occupies about a third of the country. In most places pastoralists have reached these boundaries; in many

places they have attempted to extend them into unsafe country. Because these boundaries have been ignored, there are, throughout the country, large and small areas of degraded land — degraded as the result of interference with the vegetation, changes in the soil structure and composition, and the onset of erosion.

What are the prospects for the economic utilization of this land? For it is to this degraded land that afforestation must turn.

*Afforestation to Replace Liquidated Native Forest*

Before this question is dealt with, a brief account will be given to show why New Zealand has arrived at the stage of having to consider using degraded land for afforestation.

The native forests, at least the mixed broadleaf-softwood ones, did not lend themselves to management. Their clearance was, in any event, so rapid that there was no time to study and introduce management into forests which were very complex in structure and totally unfamiliar to European settlers. Thoughts were therefore quite early turned to afforestation with introduced tree species, and governments have pursued a consistent policy of afforestation ever since the first provincial Act for the Encouragement of Tree Planting was passed in 1858. Afforestation by the State itself was commenced about the turn of the century, and a separate department, the State Forest Service, the forerunner of which was in the Lands Department, was founded about 1920. The rate of afforestation was then accelerated, and, though there have been marked fluctuations, this acceleration has continued to the present day and is still continuing.

With the exception of large-scale plantings by companies (which were, in fact, land-development companies) between the years 1925 and 1935, most afforestation has been undertaken by the State. It will also be accepting the main share of a recent increased programme.

Right up to the Second World War, State afforestation had ample Crown land of good growing quality and easy terrain available to it. Crown lands were being, and in fact still are being, developed on a large scale for agricultural settlement, and State afforestation obtained its share. An example is the Kaingaroa Forest of over 300,000 acres, which was established on Crown land on the pumice soils in the centre of the North Island. The afforestation companies also had easy land of good growing quality available to them at low prices. Thirty years ago such pumice land possessed a number of drawbacks for agriculture; light-textured soils, mineral deficiencies, and high altitudes were all deterrents. Such has been the advance of agriculture that some of these areas have now been converted to excellent farming land.

*Competition for Land*

Since the war, there has been a remarkable development of forest industries — timber, pulp and paper — based on the early plantings of radiata pine. This has led to the upswing, mentioned above, in the rate of afforestation, which, however, now finds itself in competition with agriculture for better-class land. Some expansion of forests will still take place on good land adjacent to large industrial units because of the proximity value of the wood it

grows. Forestry must, however, now look largely to the degraded lands for its expansion because of the very high values placed on good farming land in New Zealand. The potential is considerable, but before describing this in more detail, brief mention must be made of factors, other than the potential for growing trees, which come into play before afforestation can yield profitable results.

*Economic Factors*

In the popular mind, trees for utilization can be grown anywhere, and the lay approach generally is that any land that cannot be used for agriculture is fit for tree planting, no matter how remote or how rugged. An analysis of the cost of logging and of the transport of logs or timber soon dispels these notions. Critical analysis, in fact, often reveals the fact that the cheapest wood is grown on some of the dearest land adjacent to conversion plants or to markets. In New Zealand the cost of logging on easy country approaches the cost of growing the stand, while on difficult country it is greater. The cost of picking up and transporting the logs to the conversion plant usually amounts to several times the cost of growing.

In selecting sites for afforestation, therefore, due weight must be given to these costs. It will then be found that, if economic considerations alone are taken into account, forestry would, in many places, successfully compete with farming for the use of land. Political, social, and other factors, however, come into play on land-use matters with the result that, in general, the best land must be used for food production.

## DEGRADED LANDS

*Degraded Farmlands: Second Growth*

Most farming in New Zealand is pastoral and is dependent on high-producing pastures of European grasses and clovers. Most of these were established originally immediately following the felling and burning of forest, a procedure traditionally known as "sowing the seed on hot ash". Even if this were not strictly true, the germinating pasture seeds did find stored fertility in the forest soils and an immediate supply of nutrients in the ash.

Many charred or unburned logs remained on the ground. These gave shelter and favourable germinating sites to the seed of forest plants and to weeds, which became established around logs and rough places. From these positions they could later invade the pastures as the natural fertility of the soil dropped and the sward of grasses opened up.

Thus extensive areas of regrowth composed of native shrubs or of weeds became established as forest was cleared for farmland. By far the most common component of this type of vegetation was the native *Leptospermum* or tea-tree. Firing of this "scrub" relieved the situation temporarily by opening the way to stock and allowing the growth of pasture plants. But in the long run it usually made matters worse by allowing the "scrub" plants to germinate more prolifically than ever and by helping to destroy the fertility and structure of the soil. In other words, this was com-

pletely the wrong treatment to mete out to soils built up and constantly replenished under forest.

Where slopes were moderate, these conditions obtaining after a "bush burn" could be set to rights by clearing the remnant logs away, ploughing and resowing the pastures, and applying fertilizers. After these operations, only poor drainage or thoroughly bad management could lead again to deterioration. Even so, such land would always be regarded as potential farm land and not forest land.

On slopes greater than 15 to 16° — the maximum for any type of ploughing — the story was different. Unless the second growth yielded to "scrub cutting" there was little a landowner could do except resort to a succession of fires. Some steep, even very steep land retained its pasture without being invaded, and, in the absence of erosion, it seems that such land might be retained in pasture indefinitely because of the development of aerial topdressing. This practice can even extend pasture into country which has been invaded with second growth.

However, vegetation of native "scrub" or weeds — useless vegetation — presents problems of land use over very extensive areas. Where there are large, continuous areas of it, State afforestation schemes find their place. A number have already been commenced on such country — some with the subsidiary aim of the suppression of weeds, particularly gorse. Such land is often good tree-growing land, provided the soil has not been destroyed by fire, because the soils are essentially forest soils. In the early days of afforesting this type of land, the second growth was dealt with initially by burning, or, when it would not carry fire, by opening lines through it. Growth following burning, and particularly that in the line-cut areas, was usually rapid.

Cleaning operations had to be carried out for at least one season and frequently for two or three, depending on the species planted. Cleaning became an expensive operation and when it could not be carried out at the right time planted stock was smothered.

Crushing of vegetation on quite steep slopes is now done by heavy crawler tractors working up and down the slopes. The crushed vegetation is then burnt, much more use being made of controlled-burning practices. Planting sites are thus cleared more efficiently than in the past. Regrowth of gorse is dealt with by aerial spraying with sprays that have differential effects and which do not harm the trees. This has been a major advance and will allow much more rapid progress in the afforestation of gorse-infested country. Investigations are also being carried out with arboricides, these being used in the same way to kill regrowth of shrubby vegetation.

On otherwise good and profitable farms, there are sometimes steep hillsides or gullies of limited extent where pastures cannot be established or maintained. Such areas are often near to good timber markets and to main roads, and possess very good soils and growing conditions. In other words, they constitute some of the most suitable growing sites in the country even though available only in small areas. It is to encourage planting of such areas that a farm forestry encouragement scheme was introduced in 1963.

*Degraded Farmlands: Eroded Tertiary Formations*

Some of the most fertile hill-country farming land has been derived from soils of Tertiary rocks. These formations range from hard sandstones and limestones to soft, crushed argillites and flowing bentonites. All these formations were relatively stable as long as they were covered with dense, native forest, which regulated the infiltration of water into the soil, and the mat of roots had a stabilizing effect.

When the forests were removed, the soils, and even the soft formations themselves, eroded easily. Slips and gullies appeared, some on a very large scale, particularly in crushed-argillite country.

Where the erosion of soils has not been severe, farmers are attempting to correct or halt the process by the planting of willows and poplars on some stream-beds or on slips. Most of this work is subsidized through the Soil Conservation and Rivers Control Council. Where erosion has been severe such planting has been ineffective, and planting with pines or other close-canopy trees has to be resorted to. Government has been compelled to undertake one large afforestation scheme to protect expensive engineering works in the lower reaches of a river — the Waipaoa River flowing into Poverty Bay. Other afforestation schemes will have to be commenced to protect country that is eroding rapidly over large areas.

*Degraded Run Land*

The tussock grasslands of the South Island that were not ploughable were steep to very steep, and from the earliest days of settlement, were leased by the Crown in extensive runs for the grazing of sheep. Pre-European fires had already destroyed much dry-climate forest, mainly beech (*Nothofagus*), throughout this country. Destruction was continued by settlers, and sheep were pushed up to the very highest altitudes at which vegetation grew. The burning and grazing on steep slopes of vegetation never before subjected to this treatment, and later the grazing and browsing by introduced deer, thar, and chamois led rapidly to serious erosion. Much of this has reached base rock, and the formation of screes arising from exposed shattered rocks under a harsh climate is common.

This country presents a great problem of rehabilitation for protection purposes alone. Tree planting will find its place in this rehabilitation, and experimental work is proceeding to determine suitable species and planting techniques to withstand the harsh climates encountered.

Many sites are suitable enough for planting for timber-production purposes to be undertaken; in fact, the greatest potential for tree growth for the distant future lies here. Species which must be planted are, however, not those which have already become established in New Zealand's forest-products economy — radiata pine and Douglas fir. Two of them, ponderosa and murrayana pines, are being used on a modest scale for timber, and both are thoroughly established in the wood economy in their native countries.

*Destroyed Forest: Cut-over Forest*

The timber trees in the indigenous broadleaf-softwood forest are usually scattered and emergent over a lower canopy of second-

ary, non-commercial trees. Logging leaves behind this lower vegetation, into which the timber trees seldom regenerate. The cut-over forest therefore falls into much the same category as weedy and second-growth land except that the vegetation is denser and taller, and the problems to be faced, if the land is to be used, are more difficult. Yet there is much of this type of land, and each year it increases as the broadleaf-coniferous native forest is cut over for timber.

At one stage an attempt was made to introduce a second timber crop into this type of cut-over forest by planting exotic trees in the gaps left by felling. Species used had to be shade bearers such as Douglas fir, Japanese cedar, Lawson cypress, etc. Time proved that, even when such planting was tended punctiliously, damage by disease and introduced animals, in particular the opossum and deer, was frequent. This method was therefore abandoned.

With the development of chain saws and crawler tractors, the scene has completely altered. It is now possible, at a reasonable cost, to clear-fell the hardwoods after timber extraction, to burn this material by controlled burning, and to plant exotic forest trees on comparatively clean country. Although this operation might be more expensive than planting on cleaner land, there are advantages in that the first crop has usually paid for roading the area, and some capital installations, for instance, housing and workshops, are established nearby. Two such areas, where planting follows immediately after felling, have now been operated by the Forest Service for some 20 years. These are proving so successful that other similar projects will be commenced in time throughout the country. Several hundred thousand acres of cut-over land are available for afforestation apart from areas to be felled in the future.

*Destruction of Forest Soils*

In some types of native forest, rimu, a softwood timber tree, grows comparatively densely. When it is felled, very little of the forest remains; in other words, the forest climate is destroyed. This forest type most commonly grows on very wet, intractable soils which are intensely podzolized. When the forest is destroyed, these soils turn to semi-bog and no means has yet been found to use them for any purpose. The real solution lies in the need to retain some of the natural forest, and, fortunately, because of its uneven-aged structure, selection forest practice holds out hopes. But much land has already been laid waste, and, on this, experimental work is indicating that murrayana pine will grow. Eventually it may be proved that this tree can be used as a nurse for more valuable forest trees.

In the North Island, podzolized yellow-brown clays are present where there have been heavy kauri forests (which cause podzolization), or where there has been repeated burning of native forest and the scrub following it. These are costly to convert to pasture, and, when they are, are not very productive. Some of them will grow radiata pine provided they are topdressed with superphosphate. Other soil types within the kauri-gum lands will not grow radiata pine but will grow an accommodating tree like maritime pine. The place of this in the timber trade is, however, unknown.

## SUMMARY

This review shows that there are ample degraded lands of promise to which afforestation can turn. Sufficient forecasts have been made which show that afforestation is needed, so that it is a matter now of working out an efficient plan of planting. Most of the lands once carried forest so that their conversion to forest again is feasible, except where they have been severely eroded.

Radiata pine has become the "bread and butter" of the new forest industries. It now provides a larger quantity of sawn timber than any other forest tree and is almost the only wood used in the manufacture of pulp and paper. Its wide use and its rapid growth make it the most desirable tree to plant on suitable sites. It can be grown throughout the length and breadth of the country from sea level to about two thousand feet altitude and on average to good soils. In this regard it is a most versatile species and also what the botanists call a plastic one.

Since a great deal of reverted farm land conforms to the site requirements of radiata pine — steepness being the basic cause of reversion — it is used for the afforestation of this land. In fact, as stated earlier, some tree-growing schemes have been commenced with radiata pine to suppress weed growth, and farmers sometimes use it for the same purpose. On very high quality sites — and there are extensive areas of them in the pumice lands of the central North Island — Douglas fir is grown. The timber of this species is also becoming well established on the market and is, in fact, the main timber imported into New Zealand — in large dimensions for structural purposes. A large proportion of the extensive reverted farm land throughout the country can thus be planted with these two proven forest trees.

The soils and sites of cut-over forest are often superior to those on reverted farmland. They can therefore also be planted in radiata pine and Douglas fir.

On more exposed sites and at higher elevations, trees which have so far proved themselves are Corsican, murrayana and ponderosa pines. All three trees are very hardy. Murrayana pine regenerates so prolifically in certain circumstances that its rapid spread from parent trees can become troublesome. For this reason, restrictions are placed on the planting of it.

Where these three trees naturally occur, the timber from them has well-established markets; but their place in New Zealand is, as yet, far from clear. The timber from none of them has yet been produced in sufficient quantities for them to be thoroughly tried out. Nevertheless, they are planted on the more difficult sites when reverted country is afforested. Their real potential, however, lies in the planting of eroded lands in the South Island. Should they eventually come to be accepted for pulp and paper and timber, there is a considerable possibility that they will be planted extensively in this country. The areas available would exceed all other degraded lands put together. However, much investigation and experimental work must be carried out before the potential for growing these trees and utilizing their wood can be assessed.