

ARTIFICIAL EARTH SCULPTURE

W. N. BLAIR

with an introduction by

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Introduction

William Newsham Blair (1841-91) was born in Scotland, and trained there as an engineer and surveyor. He emigrated to Dunedin at the end of 1863 and took employment with the Otago Provincial Survey Department at the beginning of the new year. In 1871, he became District Engineer of Public Works, and in 1878, the year after election as a Member of the Institution of Civil Engineers, was appointed Engineer-in-Charge of Public Works in the South Island. In 1884, Blair moved to Wellington as Assistant Engineer-in-Chief. In 1890, he became Engineer-in-Chief and Under Secretary for Public Works (Furkert 1953:117).

During his career as engineer, Blair had many opportunities to travel throughout New Zealand. For example, in the 1870s he travelled widely throughout Otago and Canterbury (including traversing the Southern Alps five times) while on reconnaissance surveys for possible railway routes, and in the 1880s he visited the King Country to report on the proposed North Island Main Trunk. It was no doubt on these and similar journeys that Blair became very much aware of the changes which man was making to the landscape. A few earlier writers had expressed concern about the wholesale clearing of the natural vegetation, but none had noted the scale of man-induced erosion and change. Similarly Blair refused to accept a commonly held theory that rainfall increased if forests were planted, and decreased if the land was denuded. In some ways, Blair may be compared with George Perkins Marsh in the United States. Over two decades earlier Marsh had already recognised that man was a potent force in changing his environment. It is interesting to speculate if indeed Blair had found his inspiration in the writings of this American naturalist.

R. P. HARGREAVES.

Furkert, F. W., 1953; *Early New Zealand Engineers*, Wellington (Reed), 117-8.

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The colony of New Zealand is now celebrating her Jubilee, or Golden Wedding, an event commemorative of the time when the colonist, forsaking the shelter of the parental roof and the guidance of parental counsel, went forth to build up a home for himself at the uttermost ends of the earth. A few of the earliest settlers remain with us, and of them we can say figuratively that they have lived, not 50, but 500 years. Measured by their experience — the rapidity with which they have passed through cycles of changes — five centuries of old world progress has been compressed into one lifetime. The style of our habitations has advanced from the nomadic tabernacle of the Chaldean squatter, and the hut of the Saxon serf to the palatial luxuriousness of the nineteenth century. Our mode of land travelling has changed, by large increments, from the "pannier" period of the Tudors to the Stephenson era of "Flying Scotchmen"; and on the water, the Maori canoe and moki have given place to the "Mararoa" and "Rotomahana", palatial residences afloat. The sickle of the Irish peasant is superseded by the American reaper and binder, and the handmill of Scripture by the roller mills of Hungary. Some of our first settlers voyaged for a year in coming to New Zealand, living on salt junk, hard biscuits, and water of doubtful purity. Now the voyage is a pleasure trip of six weeks' duration, where the voyager is surrounded with as many comforts as can be got ashore.

And all this has come about, not by a slow process of evolution as in old countries, but by veritable "leaps and bounds", and why is it so? The answer is simply that in old countries the workman had to be reared through generations of tutelage, and his tools made and improved before a forward step could be taken. But the colonist comes into the field well trained and fully armed, like Minerva springing from the brain of Jupiter. Furthermore he has ever been on the alert to take advantage of every advance in science and art throughout the world; always ready to throw down his old tools and pick up new ones. This is the reason why the settler has so quickly made his impress on the face of the land, and, with the wand of a magician, transformed the wilderness into a fertile field.

The forces that spread settlement and create commerce are equally powerful in modifying the physical features of the country, and it is with this aspect of the question that we have to deal. In old countries the physiographical effects of human agencies go hand in hand with the development of the race, but for the reasons already given, the pace is greatly accelerated in new countries. The beds of the rivers in Italy and Japan have been raised above the level of the adjoining country by slow gradations, extending over centuries. In New Zealand the sluicing operations of the miner have raised the beds of the Arahura and Teremakau to probably the same height in 10 or 15 years.

The settlers of New Zealand are modifying the country in two ways: Directly, by the clearing and cultivation of the land to grow food, the cutting down of forests for timber, the washing down of mountains for gold, and the construction of roads, railways, and water channels, and the reclamation of land from the sea. Indirectly, by disturbing the natural equilibrium; letting loose certain forces that are held in check by certain other forces, which human agencies can destroy or weaken; clearing vegetation that hold flood waters in check; and checking streams of shingle that protect the coast from the inroads of the sea. In the one case the effective work is in direct proportion to the energy expended. In the other we draw on the energy that Nature has stored up, as, in cutting down a tree, the depth of the notch is the measure of the axeman's labour, but the damage done by the falling tree is its inherent "energy of position"; called into action by a greatly inferior force.

The influence of climate is an important factor in most of the physiographical changes that take place on the globe, and the popular impression in New Zealand is that the climate itself is changing. This opinion is not confined to New Zealand. It finds expression at intervals in all countries, as there happens to be a succession of exceptional seasons, either good or bad. There is a question as to whether human operations can at all affect climate in certain particulars, and as regards demonstrated effects, their extent is still questioned. The denudation of forest lands is popularly supposed to cause a diminution of rainfall, but there does not seem to be sufficient ground for this conclusion. Before it is accepted, we must assume that forests attract rain. Some authorities hold that the exhalations rising from the leaves condense the rain clouds passing over the forests, and the frequent coincidence of a wet climate and bush country is taken as a proof of this theory. The proposition might well be argued out on this basis in New Zealand, for the forest country is invariably wet, and a dry climate can only be found in treeless districts. Furthermore, the distance between places in which extremes of rainfall exist is remarkably short. In the South Island there is only 50 or 60 miles between the dry plains of Canterbury and Central Otago and the western slopes of the Southern Alps, where the annual rainfall is measured in feet. The same thing occurs, though to a less degree, in the North Island, between the Waipukurau and Manawatu Districts, a distance of 50 miles.

These facts are not, however, sufficient to prove that the forests attract rain. In reality, the forests are the consequence, not the cause, of excessive rainfall; and if there is any attraction at all, it is too small to have any practical effect. Rain is

not produced in particular localities, but distilled in a vast cosmical laboratory, embracing the solar system; the heat is supplied by the sun and the raw materials are extracted from all the waters of the earth. In these vast processes the greatest of human operations would have no sensible effect. It may therefore be assumed that the clouds of heaven will give forth their rain in due season all the same whether we fell or grow trees. The "localism" of the rainfall in New Zealand is due to the direction of the rain-carrying winds and the configuration of the country. The rain clouds from the southward are intercepted and broken by the higher ranges, and precipitate their contents on the lee side of the mountain, and as a rule, that side, although wetter, is very much warmer — witness the vegetation on both sides of the passes in the Southern Alps.

According to meteorologists, there has been no change in the rainfall of Paris for 130 years, and it is much the same in England. Even in America, where enormous areas of forest have been cut down, there is no perceptible diminution in the rainfall. In New Zealand we have complete records for 25 years. Taking Auckland, Wellington, and Dunedin, as fairly representing the north, middle and south of the colony, we find the average rainfall to be: Auckland, 41.8 in.; Wellington, 51.6 in.; and Dunedin, 36.1 in. Taking periods of seven years, at the beginning, middle, and the end of the quarter century, the averages for the three periods will be as follows: Auckland, 45.6 in., 42.2 in., and 38.4 in.; Wellington, 48.4 in., 54.5 in., and 51.3 in.; and Dunedin, 35.0 in., 38.6 in., and 39.8 in. As regards the average number of rainy days per annum, the three periods give: Auckland, 186, 195, and 183; Wellington, 149, 172, and 172; and Dunedin, 173, 158, and 174. From these figures we might infer generally that Auckland is getting drier, Wellington remaining stationary, and Dunedin getting wetter. There has been no forest cut down in the vicinity of Auckland, and large quantities have been cut down around Wellington and Dunedin. So the facts in this case, as in many others, are diametrically opposed to the theory. The reputation for wetness that some places enjoy is due entirely to the bad state of the streets in the early days — when both men and women wore top boots; when a wet day, or even a heavy shower, compelled pedestrians to cling to the fences to avoid the Slough of Despond that constituted the footpath.

The meteorological tables for Auckland, Wellington, and Dunedin show great irregularity. There seems to be no "periodicity" in the rainfall or number of rainy days. There is a rough parallelism between the amount of rain and number of wet days. A very dry year is generally preceded or succeeded by a very wet one, and in several instances similar weather prevailed all over the colony, but in the great majority of cases there is neither order or sequence. One of the driest years at Dunedin was very wet at Wellington and Auckland. Some of the wettest years in Auckland and Dunedin occur during their driest periods, and two of the driest years on record in Dunedin and Wellington occur in their wettest periods.

Primarily, the settlers of New Zealand are modifying the face of the country by cultivating the land and clearing the forests. Settlement is practically confined to the two principal Islands, which contain 51,065 square miles of open country, 38,000 square miles of forest or bush, and 14,060 square miles of waste and water, making a total of 103,125 square miles. Of this quantity 6610 square miles have been brought under the plough, and 4770 surface sown; the area of bush-felling included being 1050 square miles. Nearly all the open country has been fired, and the natural vegetation changed or destroyed. We thus find that 50 per cent of the total area of the colony, or 60 per cent of the available area, has been operated on in the course of settlement, and a radical change effected in its leading characteristics.

Next, after the settler, comes the miner, and his operations are conducted on a scale far beyond the conception of the ordinary observer. Some 14,000 men have been cutting and carving at New Zealand for nearly 30 years. No wonder that the sign manual of the miner is clear and deep and indelible on many a hill and

glen. It is calculated that the miners of New Zealand have "shifted" 1,287,000,000 cubic yards of stuff in their search for gold. A correct idea of the magnitude of these figures is arrived at by considering that the materials removed would fill up the harbours of Lyttelton and Dunedin right to the Heads; or put 8 inches of soil on the whole of the Canterbury Plains.

Compared with those of the miner, the operations of the navy are not extensive. Although his mark is more widespread and conspicuous, he has only done about a fiftieth of the work that has been done by his *confrère* the gold-seeker.

The aggregate of the direct work of earth sculpture done by the settler, miner, and navy is enormous, but it sinks into insignificance beside the indirect result of their labours, which cannot be put into figures. Commencing again with meteorological agencies: although the total rainfall has not diminished, there is a radical change in its effects. While the original vegetation remained intact, the rain was slow in finding its way to the sea. Percolation and evaporation were both more effective, and earth and air retained more moisture. One ride through a bush track will prove this. While the open country may be dry and parched, the forest is always damp overhead as well as under foot. It has been found that evaporation is from two to five times more active in the open country than it is in the bush. On the other hand, the trees at certain seasons extract moisture from the soil and exhale it into the atmosphere. The ground is dried through the roots, but the air is moistened through the leaves. The desiccation of the soil is obvious to anyone who has a bluegum or poplar in his garden, but the extent of this desiccation, and the extent to which the air is moistened by exhalation, is little more than scientific conjecture. This being the case, it is of course quite impossible to estimate the balance as between retention of rainfall and desiccation of soil in forest lands. The amount of flood waters that are regulated by the vegetation is probably the measure of the benefit conferred. But this is a boon beyond compare, for rapid drainage means destruction and waste. The clearing of the land has a two-fold effect — the natural protection is removed and the attacking forces augmented; the scrub and flax that protected the river banks have been burned off, and the floods that encroach on them have been increased. The effect is very marked in the "shingle" rivers, where the beds are steep and the banks low; also in the "alluvial" rivers, where the banks are higher than the adjoining land. A notable instance of the latter occurs at Inch Clutha. The original section of the island was something like a dinner plate. The river has now eaten through the rim, so a much lower flood than formerly inundates the land and does greater damage.

Another well-known effect of clearing bush is the drying-up of springs, and the consequent decrease in the supply of water in dry weather. For most purposes the dry-weather flow off a watershed is of greater importance than the aggregate rainfall. In Dunedin, for a long series of years prior to 1877, the minimum flow from the Ross Creek watershed was 400 gallons per acre. It fell to 200 gallons in 1880, and on three occasions since then, viz., in 1887, 1888, and 1889, it had fallen to 280, 280, and 220 gallons. There is not the slightest doubt this extraordinary decrease in the dry-weather flow is due entirely to the clearing of the land, for, as already shown, there is no diminution in the rainfall or number of rainy days. When we destroy the bush that regulates the flow of water we must build reservoirs to store the surplus rainfall, and, for the same reason, the reservoirs must be extra strong to resist the swifter rising floods.

The drainage of the country is accelerated by the ordinary operations of settlement, as well as the cutting-down of forest and the burning of scrub and flax; even the depasturing of sheep on the ranges is an important factor. When we consider that one-half of the area of the colony has been subjected to these influences we get an idea of the magnitude of the effects. Recorded levels of pre-settlement floods are invariably misleading, and worse than useless. Instances have

occurred in recent years of floods rising 10 feet above the highest levels previously observed. Again, the clearing of the vegetation assists the denudation that is naturally taking place. The soil is laid bare to the action of water and every flood carries an extra load of sediment to the sea. An inch of rain is 86,000 cubic yards to the square mile, and ordinary flood waters contain about 1 per cent of solid matter. Multiply this by the surplus rainfall and the area operated on, and we have a result of surprising magnitude, due entirely to the labour of the colonist.

Without including the other great advantages of shelter and shade, and the beautifying of the country, we thus see that untold benefits are to be derived from conserving the natural forests, and growing artificial ones. The proverbial philanthropist who is so commended for growing one blade of grass is far behind the man who plants a tree. Viewed in this light, the labours of the Dunedin Reserves Conservation Society are to be commended, not only on aesthetic, but on utilitarian grounds.

In their indirect effects, the operations of the miner are directly a supplement to the natural denudation that is constantly taking place; and many an instructive lesson in geology can be learned from this artificial earth sculpture. High up among the Southern Alps the "mills of God" are incessantly at work lowering and flattening out the country; quarrying stone and breaking it into road metal, which is carried down a natural tail race. Some of the detritus is deposited in "fans" on flat ground among the mountains, and some carried into and down the rivers, where the harder pieces are rounded into shingle and the softer ones ground into gravel, sand, and silt, that form alluvial land on the shore and sand banks in the sea. All these natural operations find a counterpart at the various places throughout the colony where hydraulic mining is carried on. The artificial fans now in course of formation at Ross, Kumara, and the Blue Spur are, down almost to the minutest detail, exactly the same as the natural fans in the Upper Waimakariri and other valleys among the mountains. The old-world fans grown over with forest, and the new ones that have been augmented by last winter's frost, are almost identical with those that the diggers are making on the flanks of Mont d'Or. The materials composing the fans are the same; the only apparent difference is that the stones in the digger's fan are water-worn to begin with. The shape of the fans is a segment of a parabolic cone. The coarser materials are deposited at the apex, and the finer are carried down to form silt and soil at the base.

Sometimes the mining detritus is carried direct into the rivers in large tail races. The heavier materials fill up the channel and cause an overflow, and ultimately the river meanders all over the country. The finer materials are carried right to sea, to augment the supply naturally provided for the flattening out of the land. The flood of 1887 in the Clutha was 17 ft. higher at Clyde than any previously recorded, the difference being due partly to accelerated drainage through settlement, but mainly to the silting up of the river bed by tailings, and many of the rivers at all the alluvial diggings are filled up to the brim. Of the 1,287,000,000 cubic yards of material excavated by the New Zealand miners, upwards of 1,000,000,000 have been removed to a greater or less distance by water.

The ordinary engineering operations of road and railway making have had comparatively little effect on the physiography of the country. The effect is more marked in marine works when the tide is excluded from an estuary by reclamation, or a check is put on the travel of the beaches by solid jetties or breakwaters. Any reclamation hitherto made has had no material effect, but the interruption to the beach travel is giving extraordinary results.

All up the two coasts of New Zealand — from south to north — there is a decided, though intermittent, beach travel, varying only in its velocity. The prevailing seas from the southwards strike the coast obliquely, and drive the shingle and sand before them with a zig-zag motion, the speed of which is regulated by the force of

the seas and the angle at which they strike the shore. Occasionally, when the wind is northerly, the beach remains stationary, or goes a little backward, but these exceptions do not affect the general result — a decided movement northward. Experiments show the travel of shingle at Timaru to go up to a mile, and, at the Wairau, to five chains per day. When the material is very fine it is carried in suspension by the storm currents at a rate proportionate to the severity of the storms. As already shown, the supply of beach material — shingle and sand — is brought down by the rivers, and in the South Island the rivers north of Mount Cook are the greatest shingle carriers. This is because the mountains are composed of soft friable clay slate, easily quarried and broken, and because the rivers are swift and short, and so carry the stones to the sea without grinding them up.

Independently of the evidence to be found ashore in the mountains where the shingle is manufactured, and at Bank's Peninsula and other places, where it is trapped, an examination of the chart will tell where the shingle in the South Island comes from and where it goes to. Bank's Peninsula traps or gives shelter to most of the shingle brought down by the eastern rivers. The detritus from the West Coast rivers is carried northwards to the extremity of the South Island, and when there is no longer solid land to cling to, it turns off and forms Farewell Spit. This is a remarkable strip of sand and sandhills 13 miles long and from half a mile to a mile wide above water, and with immense shoals on its lee side. Farewell Spit is growing visibly, and in some remote geological age, with which this generation is not concerned, it will reach right across to D'Urville Island, and convert Tasman Bay into an inland sea.

The south-west seas that are forming Farewell Spit from the fragments of Mount Cook strike square on Cape Egmont, and dividing by the impact, produce two shore movements, one northwards as before, and the other eastward into Taranaki Bight. The northern travel is strong and decided at New Plymouth, and apparently continues the same up the west coast of the North Island. The eastern travel is well marked at Patea and Wanganui Rivers, but dies out at the Manawatu, where it is met by the easterly seas coming through Cook Straits. On the east of the North Island, at any rate as far as East Cape, the rule holds good. Subject to modification by the shape of the shore, the movement is always northward.

These great littoral streams of solid matter are good examples of natural forces that are easily disturbed, but difficult to control. At Timaru the construction of the breakwater has in nine years intercepted the travel of about 1,200,000 cubic yards of shingle. This shingle in its course formed a natural protection to the coast, but as soon as the flow was interrupted the sea encroached rapidly on the land north of the breakwater, and caused great damage. It has been necessary to expend about £8500 in forming an artificial beach of heavy stone to protect the railway, which skirts the shore.

At New Plymouth the breakwater has, in seven years, caused an accumulation of about 770,000 cubic yards of sand, and the shore northwards has been denuded, as at Timaru, though to a less extent. The sandbank at the end of the New Plymouth breakwater is a miniature edition of Farewell Spit. At Napier the small harbour works at the mouth of the estuary trapped 240,000 cubic yards of shingle in less than three years, notwithstanding that the mouth of the Tuki Tuki River — the source of the shingle supply — was closed for nearly half the time. As in the other cases referred to, the beach north of the Tuki Tuki was greatly denuded of shingle while the river was closed. What will be the result of the larger harbour works in course of construction at Napier is still an open question, but there is no doubt they will intercept considerable quantities of shingle.

As regards other artificial shore harbours in the colony: Oamaru has nothing to fear, because it is south of the Waitaki, the first shingle-carrying river; and the West Coast coal harbours are safe, because the large rivers on which they are situated will scour away any accumulation caused by the action of the sea.

Summing up the whole question, we find that the "heroic work of colonisation" involves the physical moulding of the country, as well as the building up of a nation, in its political and intellectual sense. Some of the earlier settlers were far-seeing men, who saw the end from the beginning; and they laid the keel straight and the ribs true, so that a goodly vessel would grow beneath the hands of the builders that came after them; but we question whether any of them dreamt of the great changes that would be effected in the physiography of the country through settlement. This paper gives an outline of what has been done in the first half-century by a mere handful of people. It is impossible to predict what the future will be, but the chances are that evil effects now existing will be neutralised or modified by the further prosecution of settlement — the disease will work its own cure. New plantations will take the place of native trees, ruthlessly destroyed, so that springs will reappear and floods decrease. Rivers will be freed from digger's *debris* and kept within bounds, and the natural forces at work on sea and shore will be better understood; so that, instead of being engines of destruction, they will become useful agents in the material advancement of the State.