1874.

NEW ZEALAND.

DURABILITY OF NEW ZEALAND TIMBERS.

(REPORT BY MR. THOMAS KIRK.)

With Papers "On the best Season for Falling Timber in New Zealand; and "On the New Zealand Teredo."

Presented in compliance with a Resolution of the House, 22nd October, 1872.

No. 1.

DR. HECTOR to the Hon. the COLONIAL SECRETARY.

(No. 297.)

SIR,— Geological Survey Office, Wellington, 14th July, 1874.

I have the honor to forward a report by Mr. T. Kirk on the durability of New Zealand timbers, which has been obtained in accordance with the resolution of the Joint Committee on Colonial Industries. The second report on the comparative strength of the various timbers, as grown in different parts of the colony, will be furnished as soon as the experiments now in progress have been completed.

Resolution of Industries Committee, 1872.

"Your Committee regret to find that so little really useful information is procurable as to the strength and durability of the various descriptions of timber growing in the colony, and recommend that the experiments which have been initiated be continued. The want of accurate knowledge on this subject cannot fail to lead to very serious results in connection with the large public works now being undertaken throughout the colony; and your Committee consider that any moderate sum of money spent in this direction will be of the greatest advantage to the public interest.

I have, &c.,
JAMES HECTOR.

The Under Colonial Secretary,
&c., &c., &c.

Enclosure in No. 1.

Mr. T. KIRK to Dr. HECTOR.

SIR,— Wellington, 11th July, 1874.

I have the honor to enclose herewith a statement of the results of my inquiries into the durability of the indigenous timbers employed in constructive works, in compliance with your instructions, and have ventured to add concise notices of other timbers presenting features of interest or value.

Although strictly beyond the scope of my instructions, I have appended notes on the best season for falling timber in New Zealand, and on the New Zealand Teredo, and trust that the importance of the subjects may be considered a sufficient justification.

I have, &c.,
T. KIRK.

Dr. Hector, F.R.S., &c.,
Director of the Geological Survey Department, New Zealand.

REPORT ON THE DURABILITY OF NEW ZEALAND TIMBERS.

THE results stated in the following pages must be taken as showing only the approximate relative durability of the principal timbers indigenous to the colony, since it is found that totara, kauri, puriri, matai, and others, have not yet been tried under fair conditions for a sufficient period to exhaust their durability. It is true that kauri and totara, for instance, have, under certain circumstances, perished in a few years; but on the other hand, some of the oldest kauri weather-boarding in the colony is still perfectly sound, and some of the oldest totara piles in our wharves and piers are equally good, where not actually ravaged by the teredo. Moreover, it is obvious that until we have trees felled during the period in which the circulating sap has the least amount of activity, and properly seasoned before being worked up, we are not in a fair position for accurately estimating either the actual or relative durability of our native timbers.

The disadvantages attending winter work in the bush have led to the anomalous fact that by far the larger portion of timber used in New Zealand is felled during the spring and summer months; and this has given rise to the erroneous idea that some of our best timbers—the kauri, totara, and others—season imperfectly, contracting in length and breadth long after they are used. Except, possibly, with white pine grown in swamps, there is not the slightest valid foundation for such a statement: the shrinking has arisen solely from the use of summer-cut timber worked up while in an unseasoned condition. Exactly similar results would attend the use of the best European and American timbers under similar circumstances.

The wide differences sometimes observed in the durability of the same kind of timber in different localities, has in most cases arisen from one or other of the following causes:—

1. Trees having been felled during the growing season.
2. Timber having been used immediately after being felled.
3. Trees having been felled before the heart-wood was sufficiently matured.
4. The use of defective timber, whether sappy, shaky, laggy, worm-eaten, or soft, from having grown in unsuitable situations.
5. Defective workmanship; no care having been taken to exclude rain from imperfect joints, exposed hewn beams being left with a concave upper surface so as to retain rain, &c., &c.
6. The application of paint, tar, &c., to the surface, while the timber is in an unseasoned condition.

The importance of timber being felled only during the winter months, and of its being well seasoned before it is worked up, is so generally admitted, that no further remark is needed. In the early days of a new country or district, timber must unavoidably be used as soon as cut; but persistence in this course involves constant expenditure for repairs and renewal, and is accompanied by great public inconvenience, as is proved by the continuous complaints that are being made relative to the defective and decayed state of bridges and wharves in all parts of the colony.

No plan of seasoning timber is so effective as keeping it for the necessary time in well-ventilated sheds: in fact, simply preserving it from the rain; but this process will not meet present requirements. The plan generally pursued is to place the timber to be seasoned in close buildings, in which it is exposed to a high temperature generated by steam or hot-air pipes. The present loss to the public, both in money and labour, would speedily pay the additional cost of preparing timber in this way.

Timber of large dimensions is rendered more durable by Hyett's method, which consists in forcing a solution of acetate of lead through the pores of the wood. The solution is placed in a cistern of a size proportionate to the quantity of timber to be operated upon, and constructed at an elevation of 15 to 20 feet above the ground level. A cap is tightly fitted on the butt end of each log of timber, and connected by a tube with the cistern containing the solution. In newly-cut timber treated in this way, the sap is driven out before the solution, and may be collected at the upper end of the log. This process is most efficacious against dry-rot, and seems well adapted for a preservative of the white pine (kahikatea) against the insect ravages to which it is occasionally subject.

Saturation with creosote is extensively employed in Britain for the preservation of railway sleepers, and of timber used in constructive works. Chloride of zinc is highly recommended as a preservative.

Anything tending to increase or preserve the durability of timber, is of much greater value in New Zealand than in any part of Britain. Not only is the first cost of material usually greater, but, from the greatly enhanced value of labour in all respects, repairs and renewal are far more serious items of expenditure.

There can be no question that certain native timbers possess greater durability when grown in particular situations than in others. For example: north of the Auckland Isthmus, the hinau affords a small proportion of heart-wood, and is, therefore, considered of little value. In the Province of Wellington, the proportion of heart-wood is large, and the timber is valued for its durability. The Northern rata (*Metrosideros robusta*), when growing in moist places, produces timber of inferior quality to that grown in ordinary situations, and liable to become attacked by dry rot; in fact, the fungus is often found on this timber, grown in moist places, before it is cut down. It is notorious that kahikatea grown in dry places affords more durable timber than when grown in swamps; although at the same time inferior to the swamp timber for bearing transverse strains. Other instances might readily be given.

It seems, therefore, important that the timber required for public works of any extent, should be selected in the forest by some competent person, so that unsuitable timber, whether defective from having grown in situations not naturally adapted for the particular kind required, or from not having arrived at maturity, might be rejected at the outset.

Also, that all timber should be deprived of its sap either by simple exposure to currents of air while protected from rain, by desiccation, or by infiltration with some preservative solution.

1. Kauri.—(*Dammara australis.*)

The kauri is the finest tree in New Zealand, and produces the most valuable timber. It is restricted to the northern part of the North Island, and does not occur in any quantity south of a line drawn from Port Waikato to Tauranga, although solitary trees or small groups are found as far south as Maketu on the east coast, and Kawhia on the west. It attains the height of 120 to 160 feet, and upwards: clean symetrical trunks may be seen from 50 to 80 or even 100 feet in length, varying from 5 to 12 feet and upwards in diameter. The timber has acquired a reputation above all other New Zealand kinds from its value for masts, spars, and other purposes of naval architecture, which, about the commencement of the present century, led to its being exported for use in the British dockyards.

Except for general building purposes, its use has been chiefly confined to the North Island, where there is abundant evidence of its durability for more than thirty years in some of the old mission

buildings at the Bay of Islands, the weather-boarding of which exhibits no signs of decay. The same must be said of some of the oldest houses in the city of Auckland and in other parts of the province, although I have been unable to obtain trustworthy evidence of their existence for more than twenty-three or twenty-four years, as in all the towns most of the old buildings have been removed to make way for improvements.

Kauri has been employed, in conjunction with totara, for the upper timbers of the Auckland Wharf, the largest work of the kind in the Colony, and with most satisfactory results. Braces, stringers, and tie-beams are in good condition, after being eighteen years in use. The greater portion of the old Wynyard Pier was recently removed in the formation of the Waikato Railway, when many of the timbers were found sound, although others were much decayed, after fully twenty-three years service.

It has been extensively used for bridge timbers with the best results, but I am not aware of any instance of older date than the Auckland Wharf.

The superiority of kauri to Tasmanian blue gum, under heavy wear and tear, has been demonstrated by the use of both timbers on the Auckland Wharf, when the former was found to last twice as long as the latter, under severe tests.

At the Taupiri Coal Mines sleepers were in good condition after from five to nine years' use. It has been used in the tramways of the Thames Gold Field, where it is sound and good after being five years in use. Mr. A. Sheath, Inspector of Telegraph Lines for the North Island, informs me that the kauri kerbing opposite Government House, Auckland, was taken up after having been laid eighteen years, and was then perfectly sound.

It has been employed for tramway rails on the Thames Gold Field, and was nearly everywhere found in excellent condition after five years' wear and tear. At the Waikato Coal Mines it has been employed for the same purpose for nine years, and is still serviceable, which is remarkable, as the rails were cut from small-sized trees growing in the neighbourhood. Totara and rimu rails laid at the same time have perished, the former probably from having been also sawn out of young timber.

On the Thames Gold Field it is used for mine props, struts, and cap-pieces, and maintains its character for durability, although for this purpose tanekaha and black birch are often used on account of their smaller cost.

It is not adapted for piles for bridges or jetties, as it is attacked by the teredo directly the bark has decayed; and although squared timber will resist the teredo for a longer period, it is greatly inferior to totara for this purpose.

A striking instance of the uselessness of sappy timber for permanent works was afforded by the telegraph line, erected in 1863, by the Royal Engineers, between Auckland and Queen's Redoubt, in which most of the poles were round kauri saplings, from 14 to 18 inches in diameter, almost destiute of heart-wood. Hany of these were useless from decay in less than three years from the date of their erection. The whole line was taken down in about five years, and replaced by sawn heart posts, which are likely to stand for many years.

It is, however, worthy of remark, that the sap-wood of kauri and other native timbers is less speedily affected by decay when exposed to the influence of sea-water. In a small jetty at the Thames, one or two kauri poles, about 7 or 8 inches in diameter, driven nearly five years ago, are still sound and fresh, although nearly destroyed by teredines below the water-level. Within a few yards, heart of kauri scantlings, driven at the same time, are scarcely attacked.

Near Papakura, an ancient kauri forest has been buried at some remote period: in some places the logs still show above the surface. Much of the timber has been dug up in perfectly sound condition, and used for sleepers on the Auckland and Waikato Railway. A more convincing proof of its great durability could scarcely be afforded.

A steady export of kauri is carried on, chiefly with Australia, Tasmania, and Mauritius: it is, in fact, the only New Zealand timber exported to any extent. It is significant alike of its intrinsic value and of the abundance in which it occurs in the limited area to which it is confined, that the export of kauri timber from Auckland, for the seven years ending 31st December, 1873, amounted to £144,068, while the total export of all other timber from other parts of the colony amounted only to £19,739; and, as showing the growing estimation in which it is held, it may be further remarked that its export has more than doubled in the last three years.

2. Totara.—(*Podocarpus totara.*)

The totara is found throughout the colony, usually attaining its greatest dimensions on rich alluvial lands, or on dry hill sides of low elevation. Large specimens are found north of the Waitemata, but it does not occur in abundance until after passing the southern limit of the kauri. Although not equal in size to the largest specimens of the kauri, trees are occasionally found from 8 to 10 feet in diameter, 4 to 6 feet being the average size; height, 40 to 70 feet. From the extensive area which it occupies, it has been more generally used than the kauri, and is the chief timber employed for building purposes in the Province of Wellington, where it occupies a similar position to that held by the kauri in the Province of Auckland.

Although, as shown by the Sydney and Dunedin experiments on the strength of timber, totara ranks below kauri in point of strength, it is scarcely, if at all, inferior to it in durability. The general unanimity of opinion in its favour is remarkable: in one or two instances there is a disposition to consider it superior to kauri for general building and constructive purposes; but I have been unable to procure evidence in support of this conclusion. The actual durability of either timber must be considered an unsettled question for some time to come.

I have not examined any totara buildings so old as the kauri weather-boarding at the Bay of Islands, but the oldest totara houses, probably constructed above twenty-three years, are equal in condition to those of kauri of similar age: the weather-boarding in good condition, the wall-plates more or less decayed when in contact with the ground, but otherwise sound and good. Of course, these are cases in which good timber only has been used: sappy timber of either kind would perish in much less time.

Totara post and rail fences are expected to last from ten to thirteen years, and would probably stand for a longer period if split of larger dimensions. I have not seen any fence in thoroughly good condition that has been of greater age than twelve years.

Totara sleepers have been in use on tramways at the Taupiri Coal Mines for nine years: some of them are still good, although of small scantling, and split from small-sized trees. On the Invercargill railways, totara has been sparingly used for sleepers. All that I saw were in capital condition, after having been down eight years, and contrasted strongly with rimu sleepers, which were worthless at the end of seven years.

For piles for marine wharves and bridges, &c., it is one of the most valuable timbers known. In addition to its great durability, it has the power of resisting the attacks of teredo for a considerable period, especially if driven with the bark intact. It is said that trees fell during the growing season will resist the attacks of teredo for a longer period than those felled during the winter. Although I have been unable to obtain direct evidence in support of this, I entertain little doubt of its truth, but fear the advantages that may be derived from the property are overrated. I have seen totara piles attacked by teredo within a year of their being driven; but usually from two to four years elapses before they are touched, and if the bark is preserved intact, a much longer period: in fact, I have never seen the bark of any timber perforated by teredines. Heart of totara will resist the teredo still longer. In the Auckland Museum is a section of a Tasmanian blue gum pile, taken from the wharf after having been driven six or seven years. The pile itself is closely perforated, but heart of totara cradle sections bolted to it have not been touched. When the sap-wood of totara has been thoroughly perforated, it sometimes happens that the teredo dies out, being unable to attack the heart-wood until it has been subjected for a longer period to the action of sea water, when the mollusc resumes possession, and the destruction of that part of the pile exposed to its ravages is a mere matter of time. The fine wharf at the Bluff Harbour, constructed scarcely ten years ago, already shows the substantial totara piles in many cases perforated to the heart. Still, no other native timber, except perhaps the puriri, has equal power to resist the teredo.

With regard to simple durability, the oldest totara piles yet driven in our wharves and piers are perfectly sound, whether below the mud level or above high water-mark—in short, where not actually exposed to the attacks of teredo. Piles driven in the Auckland Wharf have been drawn twenty years after being driven, when the portion below the mud level was fresh and sound, even the bark undecayed; and wherever used for beams, girders, or stringers, the same durability is shown, even in the oldest works, wherever good heart timber has been used.

Totara piles in inland bridges exhibit earlier signs of decay: the sap-wood decomposes more speedily, and appears to affect the heart. In situations of this kind, it is of great importance to remove the sap-wood before the pile is driven; and the same remark applies when totara is used for house blocks. The heart-wood will last longer if the sap is removed before the pile is used.

On the Otago mountains, and, I believe, on other mountains in the South Island, are still to be found large numbers of fallen totara trees, which must have occupied their present position long before the advent of settlers. Many of these logs are said to be sound and good after their protracted surface exposure, a far more trying test than would be afforded in most constructive works. I had the opportunity of examining a portion of one of these logs, which was quite sound, although evidently of great age.

It may be fairly estimated that kauri and totara afford more than two-thirds of the indigenous timber employed for buildings and constructive works in the colony. A concise summary of their comparative use and durability may, therefore, be considered of special interest.

Both are extensively used for general building purposes, and exhibit the same amount of durability; kauri, however, is easier worked, and takes a higher finish. Owing to the great abundance, in the kauri district, of puriri and manuka, which afford the most durable fence constructed in the colony, totara has been used to a far greater extent than kauri for fencing purposes, but without evincing greater durability. I am not aware that either timber has been tried on a sufficient scale to obtain average results as to their durability for sleepers; but so far as known, the results are equal. For the timbers of constructive works, kauri has the advantage of greater strength coupled with equal durability, so far as tested. For piles for marine wharves, jetties, bridges, &c., totara stands alone. Kauri has been extensively employed in shipbuilding for many years, and ranks deservedly high for this purpose. Totara has been but sparingly employed, and I have been unable to ascertain with what results. Both timbers are extensively used in the manufacture of furniture. Lastly, both are found exposed from natural causes of remote date, and exhibit great durability under the varied and severe tests thus applied.

3. Red Pine—Rimu. (*Dacrydium cupressinum.*)

A tree from 40 to 80 feet high; trunk, 3 to 5 feet in diameter. Found throughout the colony, but increasing in frequency from the Auckland Isthmus southwards.

This timber has been extensively used in the construction of public works, especially in the southern part of the colony, and has hitherto had a higher reputation for durability than it deserves.

Its chief drawback arises from its liability to decay under the influence of wet. Wherever moisture can penetrate, as at joints, sun-cracks, shakes, or even the concavities on the surface of hewn beams, decay speedily commences, although intervening spaces may remain sound for a considerable period.

Separation of the ligneous tissue frequently takes place during growth, leaving small cavities, which become filled with a resinous deposit. This becomes shaken when the tree is felled, affording fatal facilities for the access of moisture.

In the North Island, red pine was extensively used in the Waikato district, soon after the war of 1865–66, in the construction of bridges; but in all cases where it was employed, the bridges have had to be partially or entirely rebuilt at considerable expense. Many of the principal timbers were entirely decayed, and in nearly every case the joints were in the same state.

At Invercargill, hewn stringers, 16 inches square, were used in the construction of a railway bridge, erected about twelve yeas ago. Although used in this instance under most favourable circumstances, without road planking or cross-beams, it has been found necessary to replace a portion of the beams, owing to their decayed condition, and I was informed the others would be removed in a short time. In this case the decay appears to have chiefly arisen from the concavities of the upper hewn surface allowing the retention of rain.

At the Bluff Harbour, a double row of round piles, erected to protect the railway embankment, is connected by red pine scantlings, which are let into the piles and secured by spikes. In nearly every instance the scantlings are completely rotten where in contact with the piles, although often sound in the middle.

It has been much used for bridges in the South Island, but with general results similar to those observed in the Waikato.

It has been used for sleepers on the Invercargill lines, and is said to last in good condition for six years, which is probably its limit of durability for this purpose, as a large number that had been laid seven years, were found greatly decayed on being taken up.

In the South Island it has been used for house-building purposes, for which it seems better adapted than for constructive works, as the joints are more or less protected from the influence of wet. In one or two small houses in Dunedin, rimu weather-boarding twenty years old was in fair condition, but by no means equal to kauri, totara, and black pine of similar age.

Although it cannot be considered a suitable timber for outside work, its great strength, and the facility with which straight logs of large dimensions can be obtained, enable it to be used with advantage for heavy beams, girders, &c., under cover.

It is largely used in the manufacture of furniture.

4. Kahikatea—White Pine. (*Podocarpus dacrydioides*).

A fine tree, 50 to 100 feet high, and upwards, with trunk 2 to 4 or even 5 feet in diameter. Found throughout the colony, frequently forming extensive forests in swampy districts.

When grown on hill sides, the timber is more compact and durable than when grown in swamps, which has led to the idea of two species being confused under the systematic name, but there is no direct evidence in favour of the supposition.

The timber is white and tough, and is well adapted for indoor work, but will not bear exposure. In Wellington and other places it is said to be subject to the attacks of a minute coleopterous insect; it is, however, possible that this is only the case when the timber is felled in the summer time and used in a green condition. There can, however, be no doubt that the timber is not in any way adapted for exposure, although it is occasionally used for general building purposes where kauri and totara cannot be readily procured.

In the Waikato it was used in the construction of some of the bridges hastily erected during the war. When in contact with the ground it speedily decayed, not lasting three years. Scarcely a beam was in sound condition at the end of five years, and in many instances, large timbers were mere masses of decay.

Used for house timbers, wall-plates become hopelessly decayed in three or four years if in contact with the ground. As weather-boarding, painted on the outside, it is more durable, although not to be recommended for the purpose.

On the western side of the Kaipara district it is sometimes used for fencing-rails. When split of large dimensions and perfectly free from sap it will last from seven to eight years, but I have seen rails become worthless within two years of their being used.

In Dunedin I had the opportunity of comparing its durability as weather-boarding with the Baltic white deal (*Abies communis*), and found it decidedly inferior; but as the Baltic deal had been felled in the winter, and was doubtless in a seasoned condition when used, while the white pine was in all probability felled in the summer and used in a green state, the comparison was not made under fair conditions as regards the latter. The white pine may be said to hold a similar position in regard to kauri and totara, to that held by the Baltic white deal in respect to the red or yellow deal (*Pinus sylvestris*) of Europe. It is specially adapted for flooring-boards, and for that purpose might be used with advantage in houses constructed mainly of kauri and totara.

Although of lighter specific gravity, its strength is about equal to rimu; it might therefore, within certain limits, be used for inside beams, &c., but its apparent liability to the ravages of insects will always prevent architects from recommending it to any extent. I have never seen exposed specimens of the timber attacked by insects. Contrary to what might have been expected, it appears to possess considerable power to resist the attacks of teredo. Mr. George, manager of the Wellington Gas Works, informed me that he has had seasoned kahikatea in use for landing-stages in Wellington Harbour for two years before being attacked.

5. Matai—Black Pine.—(*Podocarpus spicata.*)

Found throughout the colony, but not in great abundance north of the Upper Waikato. It usually attains a height of from 50 to 70 feet, with the trunk from 2 to 4 feet in diameter, and affords a timber of great durability, used for a variety of purposes—piles for bridges, wharves, and jetties; bed-plates for machinery, millwrights' work, house blocks, railway sleepers, houses, &c., &c.

Great confusion has arisen from the crossing and misapplication of the common names of this and the next species, the miro (*Podocarpus ferruginea*), so that it has been often difficult to ascertain what timber was intended by either name, and obtain correct information, more especially as the two kinds bear a close resemblance after the timber has been in use for a time, and it is not easy for ordinary bushmen to distinguish the foliage. In the account of the Otago experiments on the strength of New Zealand timbers, matai is erroneously called *P. ferruginea* instead of *P. spicata*, although the latter is clearly the tree intended, as is evident from the description of the cross section

of the heart-wood. I am indebted to Mr. W. N. Blair, of Dunedin, for having cleared up any doubts I entertained of this, by showing me the fruit of what he considered the true black pine, which is clearly *Podocarpus spicata:* the tree with solitary fruit being the miro (*P. ferruginea*).

In Dunedin I saw large house blocks taken up which were perfectly sound after having been down upwards of fifteen years: weather-boards and flooring were good after having been in use twenty-five years—the weatherboards fully equal to totara and kauri. Several piles in the old jetty at Dunedin are sound after having been in use nineteen years. At Invercargill, two or three piles of a bridge near the railway station were drawn after being down nearly twelve years, and found perfectly sound throughout. In a situation in which the piles are exposed to teredines, at Port Chalmers, one or two specimens were much perforated, but sound above, after being in use thirteen years. Bridges in various parts of the colony afford similar proof of its durability, alike as regards piles, stringers, and braces; but it has been far more extensively used in the South than in the North, partly on account of its greater abundance in the former and the comparative rarity of totara.

Used for tramway sleepers at the Taupiri Coal Mines, good results were obtained. Sleepers in use for nine years were perfectly sound, with the exception of the sap.

Although it has been somewhat brought into disrepute by the substitution of miro for it in several localities, there can be no doubt that it is one of the most durable timbers in the colony. For sleepers, piles, &c., it will probably rank next in value to Puriri, the most durable of all New Zealand timbers. I was much struck with the remarkably durable appearance of a large quantity of new black pine sleepers laid near the Chain-Hill Tunnel, Dunedin, and have no doubt they will be found superior to totara, kauri, and black birch, all of which are in use on the same line of railway.

6. Miro, also called Black Pine in Otago.—(*Podocarpus ferruginea.*)

Of similar distribution to the last, which it closely resembles. It is easily distinguished when in fruit, as the fruit is solitary instead of spicate. The cross section of the timber shows the heart-wood star-shaped and irregular. Much disappointment has arisen from the common names matai and black pine having been erroneously applied to the miro, which, under ordinary circumstances, is not a durable timber.

It appears, however, to be specially adapted for use in situations where it is partially exposed to the influence of sea water, and under these circumstances exhibits greater durability. A most instructive lesson on the durability of timber under different circumstances, is afforded by an examination of the piling constructed for the protection of the railway embankment at the Bluff Harbour. This protective work extends, with short intervals, for several miles, and is composed of two rows of piling, the outer row being driven strictly within high water-mark and about 8 or 9 feet above the ground level; the inner row is driven into the embankment about 8 or 10 feet behind the outer row, and about 3 feet above the ground level. The two rows are connected by rimu scantlings, which are roughly let into the piles and secured by spikes, the front row being covered, to the height of 5 or 6 feet, with rimu boarding, and the space between the two rows of piles for the most part left open.

Many of the piles in both rows are miro, but a most remarkable difference is shown in the durability of those in the front row, which are exposed to the influence of sea water, and those in the back row, which are not. Not a single miro pile in the back row is in a sound condition—many of them can be easily kicked to pieces. In the front row, not a single pile is unsound, and the bark and sap-wood, in many instances, appear as fresh as when the trees were cut. Mr. Hawkins, Inspector of Permanent Way, informed me they had been driven ten years.

I have been unable to find another instance in which the miro has exhibited equal durability in exposed circumstances. Used as piles for fresh-water bridges, it has decayed in less than seven years.

7. Tanekaha. (*Phyllocladus trichomanoides.*)

A straight, handsome tree, 50 to 60 feet high, trunk rarely exceeding 3 feet in diameter. Common in hilly districts in the North Island, and more abundant in the Province of Auckland. The timber is white, dense, and heavy, closely resembling the best crown memel of Europe in everything but size. No experiments have been made to test its strength and elasticity, but it appears to be one of the strongest timbers in the colony, and one of the most durable, although, from its occurring most freely in the kauri district, it has scarcely been utilized at present.

On the Thames Gold Field it is greatly valued for mine props, struts, and caps, which were perfectly sound after having been in use six years. Tramway sleepers were in the same good condition after having been laid five years. Used as round piles, it was sound, fresh, and untouched by teredines after being driven four years.

Squared land piles in the Waikato Coal Mines showed the sappy edges decayed after having been driven nine years, but the heart in excellent condition. Totara from small trees, and large manuka, under exactly the same conditions, were badly decayed at ground level: miro and rimu were worthless.

A quantity of railway sleepers, split at the commencement of the Auckland and Drury Railway, in 1865, were stacked in Mr. Hay's paddocks at Papakura, where, in consequence of the discontinuance of the works, they remained untouched until 1873, when the stacks were taken down. The bottom layer of one of the stacks was composed of tanekaha sleepers, which had been laid directly on the grass, and although in this trying position for about eight years, had remained perfectly sound, with the exception of some trivial patches of sap, which had decayed without affecting the heart-wood.

I have been informed that tanekaha has been used for water-tanks at the Bay of Islands, and has remained sound after being eighteen years in use.

This timber appears specially adapted for railway sleepers and for road planking for bridges. As it occurs in several places near the line of the Auckland and Waikato Railway, its durability may be readily tested.

8. Cedar—Pahautea. (*Libocedrus bidwillii.*)

A handsome, conical tree, 60 to 80 feet high, 2 to 3 feet in diameter, producing a dark red close-grained timber of great durability but rather brittle. Found on the central ranges of the North Island, and sparingly throughout the South Island: most abundant in Otago, but never descends below 1,000 feet.

For my knowledge of the value of this timber for constructive works I am entirely indebted to Mr. W. N. Blair, who is now using it for sleepers on the Otago railways. He showed me a fencing post, taken up at Tokomairiro after having been in the ground sixteen years. The post showed slight symptoms of decay, but would probably have lasted two or three years longer. The timber is now largely employed in the district for fencing purposes, and is preferred to totara.

Mr. J. E. Brown, engineer to the Southbridge Highway Board, in a letter to Mr. Blair, states that a bridge constructed chiefly with this timber over the Tokomairiro River in 1868, having the piles driven 12 feet into the bed of the river, is still in good condition, but has had the roadway renewed, the 3-inch planking originally laid not having proved equal to the heavy traffic.

Other bridges of the same material in the same district, but laid with 4-inch road planking, have withstood the effects of heavy traffic without requiring repairs.

It appears to be a timber well adapted for railway sleepers, if cut of somewhat larger scantling than usual; but I should be inclined to question the propriety of employing it for the bearing timbers of bridges of large span subject to heavy traffic.

Mr. Blair suggests that many of the prostrate logs found on the Otago mountains in all probability belong to this species.

Note.—In the North Island the native kohe-kohe (*Dysoxylum spectebile*), which yields a tough reddish-coloured wood, useful for the manufacture of furniture, but liable to be injured by insects when exposed, is also called cedar by the settlers.

9. Manuka—Rawiri—Teatree.—(*Leptospermum ericoides.*)

A well known tree, 40 to 50 feet high, with the trunk 15 to 30 feet in length and 1 to 2 feet in diameter, wood hard and dense, much used for house blocks, fencing-rails, and especially valued for small marine piles.

This timber has been largely used throughout the colony for piles in the construction of jetties, wharves, &c., where timber of large dimensions is not required. It exhibits greater durability in marine structures than when driven for land or fresh-water bridges, &c. House blocks, even in dry situations, rarely continue in good condition for more than ten years. Used for land piles it usually decays at the ground level in six years, although that part of the pile above ground may remain perfectly sound. On the other hand, piles in marine works in Auckland and Dunedin have remained sound after twenty years use, which may probably be taken as the average limit of its durability. In Lyttelton Harbour a piece of shore piling is perfectly sound after being constructed fourteen years.

In Otago, it is considered to resist the attacks of teredo better than any other timber, but I observed some fender piles at Port Chalmers much perforated. In Auckland I have seen it attacked within two years and seriously injured in less than four years. Mr. D. E. McDonald, engineer to the Auckland Harbour Board, informs me that he has found manuka piles cut during the growing season, resist the attacks of teredo much longer than those cut in the winter.

In the North it is generally used for fencing-rails, for which it is considered superior to all other timbers.

10. Puriri.—(*Vitex littoralis.*)

This tree attains a height of from 40 to 60 feet, with a trunk from 3 to 5 feet and upwards in diameter. It does not occur south of a line drawn from the East Cape to Stoney River, Taranaki, and although often found solitary or in groups, forms the greater part of the forest in some localities on the west coast of the Kaipara. It has been appropriately styled the New Zealand teak: it is, in fact, closely allied to the Asiatic teak, and affords a timber of great density and extreme durability, closely resembling lignum vitæ in general appearance. In durability it probably excels all other New Zealand timbers.

The growing tree is subject to the attacks of the larva of the puriri moth, which bores holes sometimes three-eighths of an inch in diameter, but the durability of the timber is not directly affected, and the timber is never attacked when worked up.

It is in general use for house blocks in all districts where it can be procured. In the oldest houses taken down in Auckland, the blocks are almost invariably in a perfectly sound condition, after having been in use from twenty to thirty years.

It is extensively used for fencing-posts, which always command the highest price in the market on account of their great durability. Even the sap-wood alone of old trees will last several years, and it is no uncommon thing to see fencing posts without a particle of heart-wood. Heart posts which have been in the ground twenty years are still sound and good.

It has been used for piles for bridges, and in all cases known to me, the piles are as good as when first driven, but the dates of erection are too recent to allow of its durability being tested. No instance of its use in marine structures has come under my notice. Small logs exposed in situations where other timbers have been attacked by teredines, remained untouched for several years.

Railway sleepers, split about 1864 or 1865, were largely used on the Tararu and Grahamstown Railway about four years ago, and will afford evidence as to the durability of puriri for this purpose at some future day.

On account of its great strength it is highly valued on the Thames Gold Fields for mine props, caps, &c., but the supply is not nearly equal to the demand.

11. Black Birch of Auckland and Otago, Red Birch of Wellington and Nelson: Hutu-Tawhai.—(*Fagus fusca.*)

The true black birch is a noble tree, found from Kaitaia, in the North Island, to Otago, but often local and absent from extensive districts. It ascends the mountains from the sea level to 3,000 feet. The tree is usually from 60 to 90 feet in height, with a trunk from 3 to 8 feet in diameter. In many districts it is abundant, and forms a large portion of the forest.

So much confusion has arisen from the misapplication of the names "black birch," "red birch," and "white birch," that without actual examination it is difficult to say what tree may be intended in any particular instance. In many parts of the colony, the small-leaved tarata (*Pittosporum tenuifolium*) is called black birch; in others, the name is applied to the tawhero (*Weinmannia racemosa.*) In fact, the term "birch" may be regarded as a generic name applied by bushmen to any small-leaved tree, and qualified with the prefixes "black," "white," or "red," at the caprice of the individual, or as may be suggested by the colour of the foliage, bark, or timber.

It is certain that the reputation of *Fagus fusca* has suffered from the substitution of other timbers known as "black birch," notably of the next species, *Fagus solandri*, and of the tawhero (*Weinmannia racemosa*). The timber of the latter greatly resembles that of the true black birch, but may be at once distinguished by its lighter specific gravity.

The tree, when growing, may be distinguished from the other species of *fagus* by its sharply serrated leaves. The timber is red, rather stout in the grain, and very durable. It seems well adapted for sleepers and upper timbers for bridges, wharves, and jetties: it has also been used for piles.

In the North, the abundance of kauri and other timbers has led to its neglect, even for fencing purposes. The first instance of its being used to any extent was on the Thames Gold Fields, where it was largely employed for sleepers on the tramways, and is still perfectly sound, except where sap has been used, after being laid five years. On account of its strength and durability it is highly valued for mine props, cap pieces, &c., &c.

In Wellington, it is highly valued for fencing purposes, and especially for posts; the next species being freqently used for rails. Fences of this species are said to remain in good condition for fifteen years and upwards.

In Nelson it has been sparingly employed, with the next species, for marine piles. Mr. Akerson, of Nelson, informed me that he has taken up piles of this species which had been driven seventeen years, and found thereon perfectly sound except where attacked by teredo. He also stated that, in addition to its superior durability, it had the power of resisting the attacks of the teredo for a longer period.

I am informed by Mr. Blackett that the Waiau-ua Bridge was constructed eleven years ago entirely of this timber (*Fagus fusca*), and that on a recent close examination no trace of decay could be detected.

12. White Birch of Nelson and Otago, Black Birch of Wellington, Canterbury, and Nelson.—(*Fagus solandri* and *F. cliffortioides*)

This tree occurs from the centre of the North Island to Otago, and is often found in much greater abundance than the preceding species. It attains similar dimensions, but is easily distinguished by the entire leaves. The heart timber is of a darker colour, and the white sap-wood much larger in proportion, which has probably led to its being called white birch, in certain districts.

The timber is certainly less durable than that of *Fagus fusca*, but owing to the confusion arising from the misapplication of the common names of the different beeches even in the same district, I have been unable to obtain precise and satisfactory evidence on this point, except with regard to its employment for piles.

For fresh-water piles it is said to last eight years in good condition. In marine situations it is usually attacked by the teredo as soon as the bark is detached, and is often much damaged in two or three years, but will stand for ten years without requiring removal. Mr. Akerson, of Nelson, is of opinion that it would stand for more than twenty years, if protected with copper sheathing. Piles drawn thirteen years after being driven had the parts exposed to the attack of teredo perforated to the centre and badly decayed: the upper and lower portions of the pile in fair condition, but not equal to *Fagus fusca* under similar circumstances.

Mr. Thornton, engineer for the Province of Canterbury, informed me that the first sleepers used on the Lyttelton Railway were of this species, and that they were so badly decayed within eighteen months as to require removal. He attributed this rapid decay to their indifferent and sappy quality.

13. Red Birch.—(*Fagus menziesii.*)

Although this handsome tree has the same general distribution as *Fagus solandri*, it is much more local, and occurs in smaller quantity. It is rarely more than 3 feet in diameter. The timber is said to be durable, but I have been unable to procure direct evidence respecting it. It is chiefly used in the Lake district of the South Island.

14. Pohutukawa.—(*Metrosideros tomentosa.*)

This tree is almost peculiar to the Province of Auckland, where it is abundant on rocky coasts, sometimes attaining the height of 70 feet, or more, but with a comparatively short trunk, 2 to 4 feet in diameter, and numerous massive tortuous arms. Its peculiar habit, combined with its great durability, renders it specially adapted for the purposes of the ship-builder, and it has usually formed the frame-work of the numerous vessels built in the Northern province. For this purpose it is superior to the Northern rata (*Metrosideros robusta*) and to the Southern ironbark (*Metrosideros lucida*), both of which are now used. I am not aware that it has been used for constructive works, but its density and durability render it valuable for the framing of dock gates, sills, &c. I have never seen a log of this timber perforated by teredines except in the most superficial manner.

15. Ironbark—Rata.—(*Metrosideros lucida.*)

Usually found in hilly situations, from Cape Colville southwards. Descends to the sea level in the Bluff Harbour.

A handsome tree, 30 to 60 feet high: trunk usually 2 to 5 feet in diameter; often short. The timber resembles the preceding, but is less dense in texture, and has the disadvantage of splitting freely. It has been used in shipbuilding in the South Island, and has lately been utilized in the construction of goods trucks on the Invercargill Railway, for which its great strength and durability render it well adapted.

16. Rata.—(*Metrosideros robusta.*)

Almost confined to the North Island, and specially abundant in some parts of the Kaipara district, where it attains its maximum of development. Height, 60 to 100 feet; diameter of trunk, 5 to 12 feet and upwards. The timber closely resembles the preceding in its appearance, and is equally dense and durable, while it can be obtained of much larger dimensions, so that it affords greater facilities for the manufacture of railway wagons. It is used for shipbuilding, but for this purpose is inferior in durability to the pohutukawa, although, as it can be more easily procured in some situations, it will doubtless be frequently substituted.

On the tramways at the Thames it has been used for sleepers, which are perfectly sound after five years' use.

17. Hinau.—(*Elæocarpus dentatus.*)

Common throughout the colony; especially plentiful in some parts of the Province of Wellington.

At the Taupiri Coal Mines, I examined some sleepers and props which had been in use nine years, and were then perfectly sound and in the best possible condition. The logs from which the props and sleepers had been split were taken from the bed of the river when clearing it of obstructions; and the mine manager assured me that the timbers had become harder since they had been in use. The hinau is much valued by the settlers in the Province of Wellington, as affording most durable fencing posts and rails. I have also seen it employed in the construction of one or two bridges, but of too recent date to afford any proof of its durability. It appears, however, to split too freely for purposes of this kind, even when it can be procured of the requisite dimensions. The heart-wood is well adapted for sleepers.

The timber is of a light, dull brown colour, very tough, strong, and durable.

18. Kowhai.—(*Sophora tetraptera.*)

Found throughout the colony; varying in size from a small shrub to a tree 30 to 40 feet high, with a trunk 1 to 3 feet in diameter. The timber closely resembles the European laburnum, and is of great strength and durability; but the supply of large timber is extremely limited, the tree being often reduced to a mere bush.

It has been occasionally used for sleepers, piles, house blocks, &c., &c., and is everywhere valued for its durability. Fencing posts, piles, and house blocks, which have been fixed for nearly twenty years, in Dunedin and other places, are still sound and good.

19. Maire-tawhake.—(*Eugenia maire.*)

A small tree about 40 feet high, 1 to 2 feet in diameter. Common in swampy land in the North Island. Timber compact, heavy, and durable.

This has been utilized for mooring-posts and jetty-piles on the Waikato, where I observed many instances in which it was perfectly sound after having been in use for seven years. It is highly valued for fencing, and, in localities where it is plentiful, might be advantageously employed for railway sleepers.

20. Tawhero.—(*Weinmannia racemosa.*)

A small tree, 30 to 40 feet high, 1 to 2 feet in diameter, found from the Middle Waikato southwards. Often called black birch, and substituted for that timber, to which it is greatly inferior in strength and durability. Bark much used for tanning.

At the Bluff Harbour, I observed small specimens of this timber which had been driven nine years and were still sound and good; but on examining larger specimens which had been lying in the forest for some years, I found them much decayed and worm-eaten.

Mr. J. Hawkins informed me that he had found it serviceable for railway sleepers, which had lasted five years in good condition, but that it was difficult to find trees of sufficient size to yield more than two lengths.

The towai (*W. silvicola*), a closely allied tree, which is abundant in some parts of the North, and attains a larger size, would probably prove more durable.

21. Rewa-rewa.—(*Knightia excelsa.*)

This is usually esteemed a perishable timber, and, I think, with justice. The late Mr. Millett, Gold Fields Engineer at the Thames, held a different opinion, and employed it experimentally for sleepers on a small portion of one of the tramways, I believe about two years ago, but I have not learned the results. I examined a pile in a jetty at the Thames, which was perfectly sound, even the sap fresh, after having been driven five years. The base was attacked by teredines, but not greatly damaged. I have also seen fencing-rails perfectly sound after five years' use. On the other hand, trees cut down and left in the bush are often badly decayed within a year.

This ornamental timber is used by cabinetmakers and inlayers.

22. Mapau.—(*Myrsine australis.*)

23.—Tipau, Toro of the South Island (not of the North.)—(*Myrsine salicina.*)

These have been used, in places where good timber is scarce, for house blocks, fencing, &c., but cannot be considered durable, although valued for inlaying, veneers, &c.

24. Tawa.—(*Nesodaphne tawa.*)

25. Taraire.—(*Nesodaphne taraire.*)

Handsome trees, 40 to 50 feet high, trunks 1 to 2 feet in diameter; timber compact, and taking a fine surface, but not durable when exposed.

The tawa occurs throughout the North Island, and sparingly in the northern part of the South Island. In some localities in the Northern Island it often forms two-thirds of the forest. It has been sparingly utilized in the manufacture of tubs, buckets, &c. The tarire is not found south of the Lower Waikato. It yields a finer timber than the Tawa, and occurs in large quantity, but has only been utilized for shingles.

26. Mangeao.—(*Tetranthera calicaris.*)

A small tree, most plentiful north of the Auckland Isthmus; height 40 feet; timber close-grained and tough. Utilized for the manufacture of ships' blocks, &c.

27, 28. Maire.—(*Olea cunninghamii* and *O. lanceolata.*)

29. Black Maire.—(*Olea apetala.*)

30. Maire.—(*Santalum cunninghamii.*)

These afford fine-grained timber of great density, and are extremely durable. All are commonly called "Maire" alike by settlers and Natives. Black maire usually attains the largest dimensions, and is sometimes found 40 feet high or more. *Santalum* is the least of the group, but even stems of this, no thicker than a man's wrist, make durable fencing rails.

The timber of the olives has been occasionally utilized for machine beds, as at the Thames Gold Fields, but deserves to be much better known.

Most of the wood sections labelled *Santalum cunninghamii* in our museums belong to *Olea apetala*, the black maire.

All the kinds are confined to the North Island, and are most plentiful in the Province of Auckland.

31.—Kohe-kohe.—(*Dysoxylum spectabile.*)

A handsome tree, with the trunk 2 to 3 feet in diameter: heart-wood reddish, tough, but not durable.

The timber is occasionally used by the cabinetmaker, but is not so well known as it deserves to be.

32.—Titoki.—(*Alectryon excelsum.*)

This well-known tree is generally distributed through the colony, except, perhaps, in the extreme South, and affords a tough, close-grained timber, well adapted for the purposes of the machinest, but not durable when exposed.

33.—Kawaka.—(*Libocedrus doniana.*)

This noble tree may be found from 60 to 100 feet high, the trunk from 3 to 5 feet in diameter. I am not aware that the timber has been utilized except for fencing-rails, but there can be little doubt that it will prove equally durable with its congener, *L. bidwillii*, which has already been noticed. Some of the finest specimens known to me are in the Hunua district, but is is generally scattered through the North Island.

34.—Manoao.—(*Dacrydium colensoi.*)

A small tree, 30 to 40 feet high, found in various places from the Bay of Islands to Dunedin, but has scarcely been utilized except locally for house building, although well known to the Natives as one of the most durable timbers in the colony. Mr. Bell, of Whangaroa, informed me that round piles, the thickness of a man's arm, driven into the bed of the river at Waimate, in the construction of a Native pah, were perfectly sound, although eighty years old.

35.—Kohutuhutu—Fuchsia.—(*Fuchsia excorticata.*)

Appears to furnish a durable timber. House blocks in use in Dunedin for more than twenty years are still sound and good.

36.—Pokako.—(*Elæocarpus hookerianus.*)

This timber has been utilized on the Invercargill railways, for the construction of earth-wagons, with excellent results.

37.—Pukatea.—(*Atherosperma Novæ Zelandiæ.*)

A striking tree, sometimes 150 feet high, with a trunk 3 to 6 feet and upwards in diameter. Common in swampy places. Timber soft, but apparently durable in water. It has been used in Auckland for boat building, but is not valued.

38.—Toro.—(*Persoonia toro.*)

A small tree, 20 to 30 feet high, confined to the Province of Auckland. Wood dense, dark red, and apparently durable, but has only been used for inlaying.

APPENDIX.

I.—On the best Season for Falling Timber in New Zealand.

Considerable misapprehension on this subject has arisen from the prevalence of the erroneous idea that trees have no period of rest in this colony—that they continue to grow alike at all periods of the year; an idea which may have been caused by certain fancied resemblances between the climate and vegetation of New Zealand and of tropical countries, but for which there is very slight foundation.

It is true, that on the coast north of the Auckland Isthmus, especially on the eastern side, frosts are but little known, so that vegetation does not receive the sudden check which is felt in other places on the approach of winter; but it by no means follows from this, that trees are growing as freely as during the spring and summer months. Even at the Bay of Islands, deciduous trees shed their leaves. The oak, ash, elm, sycamore, &c., &c., are as bare of leaves during winter as in any part of Europe: it is, therefore, obvious that a complete cessation of growth takes place.

At Mangere, only eleven miles from Auckland, I have seen transplanted specimens of the Native puriri, which chanced to make late autumnal shoots, much injured by frost, while older trees in the immediate vicinity were untouched. At Pokeno, the pohutukawa, under similar circumstances, is cut back to the old wood, while small established specimens sustain no injury; and in the adjacent forest, the kauri, the most tender of all our native trees, does not exhibit the slightest discolouration. It is, therefore, evident that at least a vast diminution in the activity of arboreal growth must take place during the winter months, and this is demonstrated by an examination of the terminal shoots of any forest trees, when it is found that the soft pulpy condition characteristic of summer growth has become hardened in a greater or lesser degree. Some portion of the herbaceous and fruticose vegetation, under the favouring shelter of the larger forest trees, is doubtless in a more active condition; but even here growth is often reduced to a minimum, and many winter-flowering shrubs do not produce new leaves until the spring.

The prospects exhibited by summer-felled totara, of resisting the attacks of teredines for a longer period than that felled in the winter, appears to be dependent upon causes connected with the greater activity of the sap at the former season as compared with its dormant condition in the latter.

There can, therefore, be no question that, even in the warmest parts of the colony, the circulation of the sap in trees is in a much less active condition in the winter season than in the summer, and consequently that the durability of timber felled in the winter is much less likely to suffer from the process of fermentation than that felled during the spring or summer months.

With regard to the southern parts of the colony, an examination of the arboreal vegetation at Nelson, Christchurch, Dunedin, and the Bluff, shows that the growth of trees is arrested in the months of April, May, June, and probably July. So obvious is this that I can only suppose observers have been so deeply impressed with the occasional flowering of certain herbs and small shrubs, during the winter months, in places near the sea, as to lead to the inference that a similar state of activity must of necessity pervade the forest vegetation—an inference scarcely more reasonable than it would be to suppose that the winter flowering of certain plants in favourable localities in the British Islands, evidenced similar activity in the oak, ash, elm, and pine of northern countries.

A partial exception to the general rule may perhaps be found in the case of the kauri, which evinces a decided preference for growing in sheltered places, even in the warm and limited area to which it is naturally restricted. This appears, in ordinary seasons, especially when growing in rocky soils, to suffer an arrest of growth immediately after the hot weather and diminished rainfall usually experienced in January and February. In compensation for this, it usually commences its spring growth earlier than the totara, black birch, rata, &c., &c., in its immediate vicinity. This arrest of growth in the kauri is probably facilitated by the comparatively shallow depth to which its roots penetrate, and the absence, in kauri forests, of the dense shrubby vegetation so abundant under all other northern trees.

I have therefore no hesitation in recommending, as a general rule, that timber should not be felled before April or later than July, except in the case of the kauri, which in many situations may be felled from March to June; but much must be left to the judgment of the forester.

II.—On the New Zealand Teredo, or Ship-worm.

Only one species, *Teredo antarctica*, Hutton, has at present been described as a native of New Zealand: it is distinguished from all kinds known to me by its beautifully sculptured pallets. The animal has a worm-like body, terminating on the exterior in two siphonal tubes, one of which takes in water containing food and air, the other serving for the discharge of the minute particles of wood which the animally is continually excavating. The animal lives in a tube from a few inches to two feet in length, and sometimes half an inch in diameter at the inner extremity, excavated in timber exposed to the influence of salt water, and invariably lined with shelly matter. The outer extremity of the tube is scarcely larger than the head of a pin, and the body of the animal is attached just within its mouth in such a way that it can be slightly protruded at pleasure. The entrance to the tube itself can be barred by two curious shelly processes, called pallets, shaped something like sheath-knives with narrow hafts. At the inner extremity of the animal are two convex shelly valves, somewhat triangular in shape, and curiously lobed or toothed, so that they fit into each other, completely surrounding the body. These valves are popularly supposed to form the boring apparatus, but, I think, erroneously. The rapidity with which timber exposed to the ravages of this little animal is rendered useless is most

astonishing. Portions of the upper works of the steamer "Taranaki," which was sunk in Tory Channel on August 10th, 1868, and remained under water thirteen months, were so closely perforated that they could be broken by the fingers, and it was found unsafe to walk on the decks until they were covered with new planks. Mr. George informs me that in Wellington Harbour he has seen Quebec oak rendered useless in less than five months, and red birch used for staging piles was completely honeycombed in twelve months. In Auckland, blue gums piles, 15 to 20 inches in diameter, were attacked within six months of being driven, and eaten almost through in less than eighteen months. Unprotected manuka piles driven in 1871 are now seriously damaged, and in some cases almost useless. Small pieces of sappy timber have been honeycombed in a single month. I have seen substantial totara piles attacked within two years, but it is often exempt for three or four years, and resists the teredo for a longer period than any other New Zealand timber, except perhaps puriri. The substantial wharf at the Bluff Harbour, which was constructed less than ten years ago, is seriously injured. Fine totara piles drawn about three years ago were sparingly perforated almost to the centre, so that in three or four years more, extensive repairs will be necessary to preserve it from complete destruction, although the timber between the perforations is at present perfectly sound.

In Nelson, black birch piles are much injured in three years, and rarely last more than eight or ten years.

Puriri is the only New Zealand timber that I have never seen perforated by teredos, but it is very rare to find it used in marine situations where any part of it is continually submerged. I have seen it untouched amongst other timbers which have been attacked, although exposed to the air after the ebb of the tide. Pohutukawa is sometimes attacked, but I have never seen it perforated so much as three inches from the exterior. Matai has considerable power of resistance, but not nearly equal to totara. Kauri, especially if sappy, is speedily destroyed, but I have seen heart of kauri exposed four years without being attacked.

A remarkable fact connected with the operations of the teredo is that it lacks the power to bore through bark. I have never seen a perforation made through the bark of any timber. Mr. D. E. McDonald, engineer to the Auckland Harbour Board, informed me that he had never seen bark perforated by teredines. Mr. Akerson, of Nelson, considers that piles of black birch driven with the bark intact will last three years longer than if without the bark. A small piece of a branch picked up in Wellington Harbour shows this peculiarity in a marked form: it is closely perforated from the fractured ends only, the bark being untouched. I have deposited the specimen in the Colonial Museum. Unhappily, the advantage to be derived from this peculiarity are extremely limited, except perhaps in some protected works. After a brief maceration, small particles of the bark are easily detached by the friction of boats, floating timber, and a variety of causes, so that the mollusc, which commences its operations when it is no larger than a pin's head, readily gains access, and burrows in the greatest security.

In large piles the tubes are bored upwards, and in the direction of the grain, although they often turn abruptly at a right angle. Piles are never perforated below the ground level: in fact, where either mud or sand is awash, teredines cannot exist. I believe the borings in some instances extend to within two feet of high water-mark. The external apertures are occasionally seen in situations where the tide has access to them for not more than four hours at each flow; but, as might be expected, the animals and their tubes are but small. In the case of the "Taranaki," their operations were carried on at a depth of 105 feet, the greatest depth, I believe, at which true teredines have been known to work.

The largest tubes I have seen were excavated in totara piles at the Bluff Harbour, but the perforations in each pile are not nearly so numerous as would be seen in Wellington or Auckland. In small pieces of timber, the perforations are so numerous that the tubes are frequently in contact, when the animal is small and short lived.

As a rule, they are extremely careful not to bore into each others' tubes. I never saw an instance of cross perforation in Auckland, but at Port Chalmers and the Bluff, several examples came under my notice. Unfortunately, I was unable to obtain perfect shells of the southern form, but coupling this unusual habit with a peculiarity in the boring of the tubes, it seems not unlikely that the southern form is distinct from the northern.

I have already stated that the timber between recent perforations is perfectly sound, but in most cases the interspaces speedily become disintegrated. A small boring crustacean, *Linnoria lignorum*, Rathke, takes possession of the abandoned tubes as soon as portions of the shelly lining become detached, and by countless thousands of small perforations, scarcely one of which is of greater diameter than a stout pin, reduces the timber to a mere mass of spongy tissue, which is gradually broken up and washed away by tidal action, until at length the pile becomes so eroded that it is broken on the application of the slightest force. Although, unaided, the *Linnoria* can perforate the hardest wood, yet it seems unable to work at any great distance from the surface of the timber until the solidity of the pile has been broken by the perforations of the teredo, when it seizes upon the abandoned borings, and performs its work so effectually that in some instances almost every particle of ligneous tissue is removed from the interspaces, and the remains of the shelly linings are left exposed.

Numerous methods have been proposed for arresting the ravages of this most destructive animal. At present, the only effective plan has been to protect the parts exposed with copper sheathing, but this must be most carefully attached, as the young teredo commences his work when no larger than a pin's head, so can obtain access through a very small opening. Piles imperfectly sheathed were driven in the Auckland Wharf in 1865 or 1866, but were so greatly injured as to require renewal in 1872 or 1873. I believe all new piles are protected by sheathing, and examined by divers after they are driven.

Covering the piles with brushwood is said to have been tried in Europe with success, but the process involved such continuous attention that it was abandoned. Saturation with creosote and metallic compounds has been tried in vain as a preventative against both teredo and linnoria. It has been proposed to infiltrate harbour piles with silicate of lime, but the expensive nature of the process has

prevented this plan from being carried out. The suggestion of Mr. J. Gwynn Jeffreys to apply a solution of silex with muriate of lime as a wash, seems one of the most practical that has been made of late years. If the solution can be applied in such a way as to penetrate the surface of the timber for even a trivial space, much will be done to set the teredo at defiance. Infiltration of the entire timber with the same solution was originally proposed by Mr. Hutton, of Hartlepool.

A great step towards reducing the ravages of teredo would, however, be taken by eliminating every particle of sap-wood from piles and timbers used in tidal harbours. The sap is, of necessity, the most easily perforated, and in the totara it is sometimes found that the animal has died out after having exhausted the sap-wood, being unable to attack the heart until it has been acted upon by sea-water for a longer period. The sap-wood thus affords shelter to a vast number of young teredines, most of which would probably perish if deprived of the support thus afforded. In this view of the case I am supported by Mr. D. E. McDonald, who considers that heart of totara piles would last thirty years.

In situations where puriri can be used, it would doubtless prove advantageous to employ it as much as possible. Unhappily, it cannot be obtained of sufficiently large dimensions for deep-water piles, but in many instances it would prove of the greatest value. More closely than any other New Zealand wood it resembles greenheart, almost the only known timber which is teredo proof.

In the present state of our knowledge it is advisable, on the score of economy alone, that throughout the colony all harbour works constructed of timber should have the exposed parts covered with copper sheathing, and that the use of sap-wood should be strictly prohibited.

It is generally believed that totara and manuka piles felled when the sap is in full activity, possess greater powers of resisting the attacks of teredo than if felled during the winter months. In this case, a direct extension of the period of immunity is gained; but sooner or later the action of sea-water neutralizes the active principle contained in the sap, and the destruction of the pile is simply a work of time.

By Authority: George Didsbury, Government Printer, Wellington.—1874.

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