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REPORTS

ON THE

DURABILITY OF NEW ZEALAND TIMBER

IN

CONSTRUCTIVE WORKS,

ETC., ETC.

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CONTENTS.

DURABILITY OF NEW ZEALAND TIMBERS.

REPORT ON THE DURABILITY OF NEW ZEALAND TIMBERS IN CONSTRUCTIVE WORKS.

(With Appendices "On the best Season for falling Timbers in New Zealand," and "On the New Zealand Teredo, or Ship-worm.")

By T. Kirk, Esq., F.L.S.

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 symmetrical 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 destitute of heart-wood. Many 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 felled 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 elapse 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 watermark—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 years 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 weather-boards 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 watermark 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 spectabile*), 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 frequently 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 them 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.

With the view of obviating the confusion caused by the misuse of the common names hitherto applied to the New Zealand beeches, I would suggest the adoption of new names based on the obvious characteristics of their foliage:—For *Fagus fusca*, tooth-leaved beech; for *Fagus solandri*, entire-leaved beech; and for *Fagus menziesii*, round-leaved beech. Should this suggestion be adopted by the Public Works Department, and the names be introduced into specifications, their use by timber merchants and bushmen would follow as a matter of course. It might be advisable to deposit for public inspection an authenticated specimen of the timber of each, and a dried specimen of the foliage, at the central and district offices of the department.

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.

For this species I propose the name "entire-leaved beech."

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.

I propose the name "round-leaved beech" for this species."

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 framework 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 ship-building 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 ship-building, 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, and although nearly valueless at present, might be advantageously exported if sawn into planks from 3 to 6 inches in thickness, and dried in airy sheds. From its liability to become "foxy," it would be useless to ship it in an unseasoned condition, as it would become worthless during the voyage. I am convinced that if once fairly established in the London market, the demand would speedily exceed the supply, so that good prices would be realized. At present, thousands of trees are destroyed yearly with the progress of clearing, so that its utilization in any way would be of great advantage. As it is a timber, even when dry, of difficult combustion, it might be advantageously used for certain special purposes, irrespective of its beauty.

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 taraire 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.

The tawa is specially adapted for the manufacture of French bedsteads and other cheap furniture, as well as for general turnery purposes: in fact, it is available for all purposes to which beech is applied in Europe. I believe that if the Auckland and Wellington cabinetmakers were aware of the facility with which it could be worked, and the readiness with which any possible demand could be supplied, that it would be extensively used. As it can still be procured within three or four miles of Wellington, a large portion of the heavy cost attendant upon the long land carriage of totara or rimu might at once be saved.

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 machinist, 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 it 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 zealandiæ.*)

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.

APPENDICES.

1. On the best Season for Falling Timber in New Zealand.

Wellington, 11th July, 1874.

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 property 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, July, and August. 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. South of Banks' Peninsula, the falling season might certainly be extended through August.

2. On the New Zealand Teredo, or Ship-worm.

Wellington, 11th July, 1874.

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 animal 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 gum 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 advantages 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 watermark. 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, allied to *Limnoria 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 crustacean 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 limnoria. 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.

RESULTS OF A SERIES OF EXPERIMENTS ON THE STRENGTH OF NEW ZEALAND AND OTHER COLONIAL WOODS;

Conducted at Dunedin, for the Commissioners of the New Zealand Exhibition, by
James Melville Balfour, C.E.

Dunedin, 15th December, 1865.

In entering on their arduous duties, the Commissioners justly considered it of the utmost importance to investigate the properties of the materials used in construction in the Colony, with regard to which, up to the present time, comparatively little information has been collected; the estimation in which the different kinds are held being to a great extent local, and founded much more on opinion (perhaps sometimes on prejudice) than on any scientific and exact knowledge of their qualities. In prosecution of this important object, the Commissioners particularly called for samples of all colonial woods for testing, and it is greatly to be regretted that that call was not more fully responded to, and that the information furnished along with the specimens sent was not more full and precise; at the same time, many gentlemen have taken great pains in collecting samples, and it is hoped that the results in the following tables will be found useful, though not so complete and exhaustive as was to be desired. The principal exhibitors of New Zealand timbers were C. and J. Ring (28*) and R. B. Shalders (32), Auckland; C. Webber, C.E., Provincial Engineer (128), Hawke's Bay; Hon. W. Petre (206), Wellington, who sent a valuable collection of no less than fifteen different kinds of timber; G. Holmes, C.E. (415, 416, 417), Canterbury; and J. W. F. Robinson (546) and A. H. Ross (547), Otago.

Tasmanian woods were well represented, the principal exhibitors being J. C. Boyd (2,823), Port Arthur; and Dr. Crowther (2,825), Hobart Town; and the value of these samples was greatly increased by the full information as to the dimensions, durability, and uses of the different timbers, which was sent with them. From New South Wales, Professor Smyth, Sydney University, sent a valuable collection of small samples for testing purposes, the importance of which is greatly enhanced by the information which he kindly procured, as to the estimation in which the different varieties are held in that Colony, &c., and by information as to the botanical and native names of the woods, from the pen of Sir William Macarthur, Chief Commissioner for the Colony of New South Wales at the Paris Exhibition of 1855, all of which has been incorporated in the General Table (No. 1).

* Catalogue number.—Ed.

The New South Wales woods possess a further value, from the fact that they have all been tested at Sydney (1860–61), by E. W. Ward, Esq., Deputy Master of the Mint, and a number of them also at Paris, in 1855, by Captain Fowke, R.E.; so that they form, as it were, a connecting link between the New Zealand experiments and those which have been conducted elsewhere.

With regard to the distinctive names of the *Eucalypti*, Sir W. Macarthur remarks, "I cannot venture to give the botanical specific name to any of the family. It is acknowledged to be in great confusion, scientifically speaking, and requires a first-rate hand, with opportunities probably for full investigation on the spot, to put in order and describe." This statement may be illustrated by the fact that the Australian Lloyd's Regulations give *Eucalyptus mahogani* as the scientific name of the jarrah, or Swan River mahogany, a variety believed to be confined to the West Coast of Australia, while the printed account of experiments on the timbers of New South Wales and Queensland (1861) gives the same name to a Sydney wood which is probably a distinct species.

Similar difficulties beset the classification of New Zealand woods, though in this country the botanical names are probably better known, there being no family with such extended ramifications as the *Eucalypti;* but the Native and settlers' names appear to be different in different districts, and in many instances these only are given with the specimens exhibited. I have endeavoured to arrange the whole properly, but must entreat the indulgence of the reader for any unavoidable lapses or mistakes.

In issuing their programme, the Exhibition Commissioners being desirous to continue the series of numerous and exact experiments conducted at Paris by Captain Fowke, called for samples of the appropriate size, namely, 2 inches square and not less than 14 inches long, so that the Associate Committee of Consulting Engineers were tied down to these dimensions, though longer samples, if not larger scantlings, would certainly have been preferable.

Captain Fowke's experiments embraced, 1. Specific gravity. 2. Ultimate strength. 3. Crushing strain in line of fibre. 4. Crushing strain transverse to fibre. 5. Elasticity. The last, however, somewhat imperfectly, as the deflections on a 2-inch square sample, loaded at the centre, and with bearings only 12 inches apart, are necessarily very small.

In addition to the above, I suggested that the tensile strain in line of and transverse to fibre (the latter a new experiment, and one that promised to give valuable information as to the lateral cohesion of the fibres) should also be ascertained, and, in addition, that subsidiary experiments on small samples, fixed at one end and loaded at the other, should also be made, as tending to give a more delicate measure of the elasticity of the various woods, as well as to corroborate the values of S obtained from the larger samples.

These suggestions having been approved of, sketches were made of a hydrostatic press working vertically, and so arranged that the pressure exerted should be at all times indicated on a large dial, whose indications could be checked from day to day by the application of actual weights to the plunger of the press, so as to eliminate the disturbing influences of friction; and subsidiary parts were also designed to enable it to be employed for crushing cubes of wood and stone, for testing the tensile strength of timber, &c. Sketches were also prepared for a small testing machine for 1-inch square samples of timber fixed at one end and loaded at a point 12 inches from the point of support, the force applied being measured by a spring steelyard, and proper arrangements being made for measuring the flexibility of the specimens, and for keeping the one set of observations entirely independent of the other.

The smaller machine was very satisfactorily completed by the contractors, Messrs. Wilson Brothers, Dunedin; but the contractors for the hydrostatic machine, unfortunately, never succeeded in making it work properly, and, after long and most vexatious delays, abandoned it altogether, to the great annoyance of the Commissioners, who were thereby compelled very materially to curtail their plans. In consequence, all experiments on the crushing strength of stones and a large proportion of the intended experiments on woods were abandoned, and the results in the tables were ascertained by the small machine from samples of the unsatisfactorily small dimensions of 1 inch square and 12 inches long. This is much to be regretted, as there can be no doubt that experiments on a larger scale would have been much more to be depended on in all cases; while some cross-grained varieties of wood, such as curled blue gum (53 in the detailed Table I.), waved kauri (26 in Table I.), and red pine (32 in Table I.) probably give absolutely delusive results when tested on so small a scale, as the "wave" or curl of the fibre, which would be to a great extent eliminated in larger samples, runs entirely across the small specimens, which were all found to break nearly square across. At the same time, the arrangements of the small testing machine were very delicate: the indications of the spring were frequently tested by actual weights, and the applied strain could be measured to the nearest pound, and the resulting deflection to the fiftieth of an inch, so that it is believed that all ordinary straight-grained varieties of wood are fairly represented in the tables, while there can be no doubt that the different results are comparable *inter se*; and, as already pointed out, the New South Wales woods, having been before experimented upon elsewhere, give as it were a scale by which the results at Dunedin may be compared with others.

On instituting such a comparison, it will be observed that the Paris and New Zealand experiments agree very well, making due allowance for the fact that the woods in most cases came from different districts. In one case the Sydney results are higher than those obtained in New Zealand (spotted gum); in another (blue gum), the mean of all the experiments at Dunedin is not far above the Sydney results; but in all the others the values of S as found at Sydney are considerably below those found at Dunedin, in several cases by about one-third of the higher result; at the same time the values of E agree much more nearly, and in a number of instances, while the Sydney experiments make the breaking weight considerably under the results ascertained at Dunedin, they make the weight which is carried with unimpaired elasticity absolutely higher. When the results of experiments on New Zealand woods are similarly compared, it will be found that in nearly every instance in which the Sydney results make S lower, they at the same time make E higher, the weights carried with an impaired elasticity being also higher. In endeavouring to account for these somewhat remarkable results, I was led to compare, in all cases, the breaking weight with the weight carried with uninjured elasticity, and eventually to introduce such comparison into the tables in a fractional form (Col. $\frac{W'}{S.}$); as it seems, if not to give a complete solution to the discrepancy, at least to show that it is a matter of little practical consequence. Thus it will be observed that, in the Sydney experiments, towai carried with unimpaired elasticity 0·932 of its breaking weight, matai 0·942, tawa 0·909, taraire 0·895, and totara 0·826; whereas in the New Zealand experiments those fractions are very much smaller, the highest fraction for a New Zealand wood being for maire, 0·670, the greater part being under 0·5. On reducing the experiments in Barlow's work on "Materials and Construction" in a similar manner, it will be found that this fraction ranges from 0·3 to 0·5, or a little more, so that the Sydney results may be considered, from whatever cause, as abnormal.

The practical result, however, is that, after the usual allowance for safety has been made in calculating the strength of any beam from the values of S found by the New Zealand experiments, the load will be found to be satisfactorily within the elastic load of the same timber as found from the Sydney results, so that, notwithstanding all discrepancies, the Dunedin results may be considered as sufficiently trustworthy for practical application. At the same time, the tables show that the strength of the same wood varies greatly according to the locality from whence the specimens come, and it would consequently be only a wise precaution to test samples of the wood actually proposed to be employed, before fixing the dimensions of the principal timbers in any important engineering structure.

On the commencement of the experiments it was found that they required so much personal supervision, and to be conducted in so regular and systematic a manner, that it became desirable that they should be under the sole superintendence of one person; and as I took a very lively interest in the subject, and could devote more time to it than my colleagues on the Associate Committee could satisfactorily spare from their other duties, I volunteered to take the entire superintendence, and am, in consequence, solely responsible for the work as completed; a number of the earlier experiments and a very large proportion of the calculations having been made by myself, and the remainder, subject to my revision, by Mr. R. W. S. Grieve, C.E., Superintendent of the Machinery Department of the Exhibition.

The experiments were conducted in the following manner: — A pressure of 50 lbs. was applied for two minutes (as measured by a sand glass), and the sample was then released; 75 lbs. were then applied for the same time; then 100 lbs., and so on, increasing by 25 lbs. each time. Each time the sample was released the point on the deflection scale to which it returned was read, and when it came to be notably under the original reading, the specimen was allowed to remain unloaded for two minutes, to see whether it would in time further recover itself. When, however, there were indications that the point of fracture was nearly attained, the pressure was gradually and steadily increased, without being again removed, until the specimen broke, the observer keeping his eye on the deflection scale, and noting its reading at the first crack, the maximum pressure exerted being indicated on the proper scale by a simple self-registering arrangement. After a certain number of specimens of the wood being examined had been treated in this way, the remainder, if any, were broken more rapidly by a gradually increasing steady pressure which was never relaxed. These experiments are specially noted in the "Remarks" column. This system was used throughout, except that when the first experiment showed that the wood was very weak, the first weight applied was 20 lbs. only, and the regular increment varied from 10 lbs. to 20 lbs. according to the circumstances of the case.

The period during which each pressure was applied was certainly rather short to allow the weight to have its full effect, but it was adopted as a necessary compromise between the work to be overtaken and the time in which it required to be done. The rapidity with which the experiments were carried on may have had the effect of making the results somewhat high, but as the values of E should be equally influenced with those of S, and as the values of E are, as already shown, not inconsistent with those ascertained at Sydney, there is no evidence that such has been the case.

The first table contains, in a condensed form, the results of all the experiments; the second, or Abstract Table, is a digest of the first, giving the average results for each different wood in one line, except in one or two peculiar instances. Thus the value of greenheart is given twice (4 and 17, Table II.), the first being the result of the Paris experiments, and the second being extracted from Barlow's work. I can only account for the very great difference in the two values by the supposition that the woods came from very different soils, or were actually different timbers possessing sufficient resemblance to have received the same name (a very common occurrence).

Tasmanian blue gum (8 and 26), kauri (38 and 48), and red pine (43 and 52) are also twice entered in the abstract, but I consider the higher values (8, 38, and 43) to be not above fair averages, and to be those which should be used as the data for calculating the proportions of structures; the smaller results being lowered by their including the experiments on waved, curled, and ornamental varieties, which would certainly never be selected for engineering works—indeed, I consider even the higher value for red pine to be at least a low average, as it includes experiments on an ornamental plank from Mount Flagstaff, which are considerably under the other averages.

The woods are arranged in both tables in the order of the mean values of S. In Table I. they are further so arranged that the highest mean result shall be first, and each single experiment is similarly classified. The numbers in the first column are consecutive, and only applied to those experiments which were made at Dunedin, the Sydney and Paris results being otherwise distinguished. Column 2 contains the native, common, and scientific names of the woods, and, when known, the district from which they came; and column 3 contains all the information that could be collected as to their qualities, habits, and uses.

To ascertain the specific gravity (col. 4), and the weight of a cubic foot (col. 5, headed W), the samples were all dressed exactly to 1 inch square and 17·28 inches long by gauge, the weight in Troy grains divided by 70 gives the weight of a cubic foot in pounds avoirdupois, and this multiplied by 0·016046 gives the specific gravity. The next column, E, was ascertained from the formula $*E = \frac{l^3 W'}{a d^3 \delta}$, or, as in these experiments, l, a, and d were all $= 1$, $E = \frac{W'}{\delta}$ simply. The value of E was calculated from all the deflections and weights producing them, so long as the elasticity remained uninjured, so that the tabular value is a mean, sometimes of as many as 9 or 10 results. (The theory requires that these results should be identical, and it was found that they were so in practice within reasonable limits.)*

* In Barlow's work, E is calculated for a unit of 1 inch long and 1 inch square. In this table the unit has been assumed as 1 foot long, so that Barlow's E has to be divided by 12^3 or 1728, and *vice versâ*, to get the corresponding quantities

The next two columns (headed δ and W′) are intimately connected, the one being the greatest weight carried with unimpaired elasticity, and the other the deflection caused by that weight. In the Dunedin experiments the weights were generally increased by 25 lbs. at a time, so that W′ is always some multiple of 25, except in a few instances where the increment of weight was different, or where the results had to be reduced owing to the specimens not coming up exactly to the standard dimensions. In every case a value for W′ was selected *before* the corresponding deflections had become irregular or excessive, so that the tabular values may be considered safe and low. δ is the deflection corresponding to such value of W′.

In reducing δ from the results of experiments at Sydney and elsewhere on specimens of larger scantlings, it was assumed that a certain elongation of the upper fibres, which will be the same in all beams of the same timber, must be the limit of safe deflection; or, in other words, that the element of maximum safe deflection, as well as the element of deflection at the instant of fracture, must be a constant quantity, and that therefore the actual deflection in any case will vary as $\frac{d}{l^2}$ (see Barlow, p. 95) where $d =$ the depth of the beam, and $l =$ its length. Therefore, putting $\Delta =$ the limit of safe deflection as observed in beams of any scantling, δ for these Tables will be found from the formula $\delta = \frac{d\,\Delta}{l^2}$, observing that only half the length of the beam must be taken for l in the case of beams supported at the ends and loaded in the middle.* The value of W′ is then found from the formula $W' = \delta\, E$.

The next column, S, is the most important of all, as giving the ultimate strength of the timber. The values extracted from Barlow's work and elsewhere have been divided by 12, to reduce the results to a uniform standard of 1 foot long, which is considered more convenient than the old unit of 1 inch.

The next column, headed δ', is the ultimate deflection. When results had to be reduced from other scantlings, the same formula was used as was applied to calculate δ, but, as the final deflections are always irregular, too much dependence should not be placed on the results.

Column $\frac{\delta'}{\delta}$ is perhaps more curious than useful, but it is interesting as an analysis of the varying characteristics of woods of different countries, and the information it contains may at times be found of service.

Column $\frac{W'}{S}$ was calculated mainly for the purpose of investigating

* This formula may be applied to existing works in which the beams show considerable deflection, to ascertain whether the limit of safe deflection has or has not been exceeded. Of course, the results must be considered as only approximate.

some discrepancies between the results of experiments at Dunedin and those conducted elsewhere. It also affords a rough indication of what fraction of the breaking weight of a beam might be assumed as the safe load, and shows that one-fourth of the breaking weight may, in most cases, be considered *very safe* for New Zealand woods.

The two last columns, headed λ and W″ are the results of an attempt to render visible the effect of the specific gravities of the different timbers. The attempt has not been very successful, and probably some better method of attaining the same end may occur to others, but the results are interesting, and not without a practical value. Column λ shows the length of a beam measuring 12×6, which will just break with its own weight, when supported at both ends; it was calculated from the formula $l=\sqrt{\frac{13824}{W}}$, where W= the weight of a cubic foot $\left(l=\frac{8bd^2S}{W}\right.$=formula for distributing load; in this case $b=6, d=12$, and $W=\frac{1}{2}\,l\,W$; hence doubling the numerator $l^2=\frac{13824\,S}{W}$, and l is found as in the formula.$\left.\right)$ The results show that the ultimate strength of the woods is intimately connected with their weight or specific gravity. The *absolute strengths* range from 468·6 to 32, or upwards of 14½ to 1, while the lengths of themselves that the woods will carry range only from 324½ to 154, or a little more than 2 to 1, so that the strength obviously increases very little faster than the weight.

Column W″ shows the breaking weight of a beam with a clear space of 20 feet supported at both ends and loaded in the middle, the proportions being in all cases the same, or depth = twice breadth, but the actual dimensions being varied so as to reduce all kinds to a uniform weight of 20 lbs. per lineal foot, this weight being adopted as 40 lbs. per cubic foot may be considered a fair average of the weight of light woods. The results are very curious, and show that the light woods when treated in this way are invariably the strongest, if we except the Jamaica ironwood, which is in every respect an extraordinary timber. It will be observed that whau is actually, when treated in this way, the strongest wood in the table, as its breaking weight is 15½ tons, while the best Tasmanian blue gum breaks with about 10 tons. This apparently anomalous result will become intelligible when the actual dimensions of the beam are calculated, the blue gum beam being 4·67 inches broad by 9·34 inches deep, and the Native cork wood (whau) beam, 11·07 inches broad, and 22·14 inches deep.

The results in this column were calculated by the formula $W''=\frac{29{\cdot}52\,S}{W^{3/2}}$, which was arrived at as follows:—b and d being the breadth and depth of the beam as usual; W, weight of a cubic foot;

and S the tabular value of the wood; a $6'' \times 12''$ beam has a sectional area of 72 square inches, and the assumption is that such a beam is to weigh 40 lbs. per cubic foot; $\therefore$ area $\times$ W $=72 \times 40$; but the breadth is in all cases to be half the depth, $\therefore b=\sqrt{\frac{\text{area}}{2}}$, and area$=2\ b^2$, therefore substituting and dividing, $2\ b^2=\frac{72 \times 40}{\text{W}}$, and $b=\frac{37{\cdot}95}{\sqrt{\text{W}}}$. Again, the usual formula for a beam loaded in the centre is $\text{W}=\frac{4bd^2\text{S}}{l}$, and here $d=2\ b$ and $l=20 \therefore \text{W}=\frac{16b^3\text{S}}{20}$, and further dividing by 2240 to reduce the results to tons, $\text{W}=\frac{16b^3\text{S}}{4480}=\cdot000357b^3\text{S}$, and substituting the value of b found above, $\text{W}=\cdot000357\ \text{S}\left(\frac{37{\cdot}95}{\sqrt{\text{W}}}\right)3=\frac{19{\cdot}52\ \text{S}}{\text{W}3/2}$.

The inferences to be drawn from columns λ and W″ are somewhat important. They show that, in very long spans at least, a greater proportion of the strength of a heavy timber is absorbed by its own weight than is the case when lighter timber is used, and they also serve to indicate the most suitable timber to be employed in any particular case. Thus, when the weight must be limited, but size is of no consequence, a timber of low specific gravity will make the strongest work; when, on the other hand, it is an object to keep down the sectional area, greater strength will be obtained in moderate spans by the use of a denser wood. Thus, for the cross-ties and walings of a timber jetty in an exposed situation, I should be inclined to select a dense timber, so as to procure the necessary strength while exposing but a small surface to the waves, while for the deck beams I should prefer a lighter wood as forming stronger work. For the floor of a warehouse, if there be plenty of room, the wood of low specific gravity would, weight for weight, make the most satisfactory work, and so on.*

In pointing out these peculiarities, it is proper to state that when the weight of the structure itself is taken into account, as it always is by properly-educated practitioners, the ordinary formulæ will answer every purpose, and, indeed, must be used to arrive at the proper dimensions to be adopted. It is only claimed for the Table that it renders the effect of specific gravity more visible, so as to arrest the

* The results in the four last columns of the Abstract Table will not be found altogether to agree with the results which would be arrived at by the proper formula when applied to the given data. The reason is that S in the Abstract Table is the mean of all the experiments recorded, while W″ is the mean from those experiments only which furnished the necessary data. I did not consider it necessary to calculate a fresh value for W″ for the Abstract, as the results given are sufficiently accurate for the object in view. A similar explanation applies to discrepancies in the other columns.

attention, and to indicate, at least approximately, the most suitable timber for any case which may arise.

On an examination of the General Table, it will be seen that the New Zealand woods compare very fairly with those which we have been accustomed to consider as standards, the absolute strength of very many being above that of British oak, and all being stronger than elm (except whau, which can scarcely be called a wood). New Zealand woods are certainly for the most part short in the grain, and break with little warning—though there are a number of valuable exceptions; but it will be observed that the ratio of safe load to breaking weight is high, which to a great extent compensates for this peculiarity. The table indicates the probability that black and red birch will be largely used for public works in future, as they grow to a very large size, and possess many valuable properties. Red pine should come into more general use, displacing for many purposes the woods imported from America and the Baltic: indeed, it is believed that had the Waikava, Catlin's River, and Stewart's Island red pine been represented in the experiments, (and it is greatly to be regretted that the mill-owners sawing these woods did not respond more freely to the call of the Commissioners), the average result would have been higher than it is.

Kauri is too well known to require mention here, and totara is also well known, though not so extensively and so highly esteemed as it seems to deserve. It is certainly desirable that all the experiments should be repeated and verified on a larger scale, and it is to be hoped that the General Government will take such steps as to be in a position to undertake to test all samples which may be forwarded to them for the purpose from any part of the colony. Another point which calls for further investigation is the proper season for felling timber, about which little is known. In countries where the winter is more severe, it is generally considered that the best time to fell timber is in midwinter, when the trees are almost entirely free from sap, and the last-formed wood has to some extent consolidated; but the next best period is considered to be about midsummer, after the foliage has been fully developed, when the tree appears to *rest* before commencing the formation of wood,—at which time also it is remarkably free from sap. Spring and autumn are the worst seasons for felling. As, owing to the mildness of the New Zealand winter, trees, except at considerable elevations, never entirely cease to grow, it may probably be found that midsummer is the best season for felling in this colony; but the subject requires and deserves a thorough investigation, there being few questions which could be taken up by the Colonial Government with a better prospect of ultimate public benefit. When the proper season for felling has been ascertained and adopted, and when more attention is paid to the important question of careful seasoning, it will probably be found that the New Zealand woods will give even higher results than those in the tables.

I append a copy of the Class Table published by the "Australian Lloyd's," from which it appears that but one New Zealand timber—kauri—is officially recognized. Such woods, however, as manuka, kowhai, black birch, rata, black pine, maire, red birch, red pine, and totara, probably require only to be better known, to be admitted for those purposes for which each is best adapted.

With regard to *durability in moist situations*, it is difficult to collect authentic information, as so much depends on climate, and the climate of New Zealand is very variable. The most generally esteemed woods, however, appear to be manuka, totara, black birch, black pine, red mapau, and a wood not represented in the Exhibition, puriri; but doubtless there are others which have a high local reputation.

Another question most difficult to answer is that which refers to the *durability of different woods in the sea*, and especially their *resistance* to the *marine boring worms*. So much depends on the quality of the timber itself and the soil on which it grew, so much on the size of the specimens, and so much on the locality where they have been used, (the worms being much more numerous and active in some places than in others), that it is impossible to arrive at any definite conclusions on the subject.

At Dunedin, situate at the head of a bay or inlet, about twelve miles from the open ocean, where there is no current, and where the water is to some extent freshened by the drainage of the town and a few small streams, manuka, kowhai, and miro, and probably some other woods, are perfectly sound after standing thirteen years in the old jetty, though the piles are little better than saplings.

At Port Chalmers, again, six miles from the sea, the manuka piles are perfectly sound after being driven about five years, while miro fender piles were very seriously injured in twenty-one months by the teredo. Kowhai piles at the same place were entirely eaten through in less than fourteen years, mainly by the limnoria, though it was also attacked by the teredo; and it is worthy of notice, that while the smaller worms did not appear to work below the surface of the ground, the teredo flourished a considerable way down. At Moeraki, on the coast, totara was attacked in sixteen months; but the piles were mere saplings, some 10 to 12 inches in diameter, so that the native woods can scarcely be said to have been put on their trial yet in Otago.

In Wellington and Auckland, totara, when well grown, is considered one of the best pile timbers in New Zealand, though not proof against the worm. The Harbour Master at Auckland, W. Ellis, Esq., informs me that after red totara piles had been driven six years, the worm had cut clean through some of them, chiefly about low water-mark, but that not more than about 8 per cent. of the whole were attacked. He states that the general opinion is that red totara piles, if driven immediately after being felled, and with the natural juices still in them, are proof against the worms, and considers that the fact that numbers of the piles are still untouched is in favour of the accuracy of this supposition. On the whole subject further observation and longer experience is required, the probability being that no wood is absolutely proof against these destructive borers, though one wood may stand well in one locality and another in another. It is not at all improbable that the totara juices may be inimical to the worms, and so may retard their progress, but it will probably be *only retarded,* as the juices must get dried up or diluted in time, or the worms may become accustomed to them. I have seen the *Limnoria terebrans,* in Scotland, revelling on timber thoroughly saturated with creosote, which in some parts of England appears to be a specific against them; and it has been experimentally proved that low organisms can thrive under apparently impossible conditions, one observer having succeeded in accustoming the common cheese mites, by degrees, to strychnine, so that at length they lived and throve on that deadly poison in an absolutely pure state.

More information is, then, absolutely required as to the durability of New Zealand woods in the sea at different parts of the coast; meantime, manuka may be considered, in the southern portions of the colony at least, as decidedly the most durable, and totara also occupies a foremost place. Black pine has a good name also for durability, but it has not been extensively used in exposed situations; and it is probable that rata would stand well.

Appended is a table (also copied from the "Australian Lloyd's" Regulations) showing the action of marine worms on different woods in Victorian waters, from which it will be seen that Swan River mahogany appears to stand pre-eminent for durability, and that she oak (unfortunately a small tree) is next best; blue gum, on the whole, appears to stand third, but it has no very decided advantage over the others; and indeed the whole table, though very valuable, only shows how much room there still is for further observation on the subject.

As works of reference are difficult of access in New Zealand, I shall conclude by giving as shortly as possible—

Rules for Calculating the Strength, &c., of Beams from the Tabular Numbers.

Putting—

S = the tabular number for the absolute strength of the wood.
b = the breadth of the beam in inches.
d = the depth of the beam in inches.

l = the length of the beam in feet.
W = the breaking weight of the beam in lbs.

1. To find the strength of a beam fixed at one end and loaded at the other. $W = \frac{b\,d^2\,S}{l}$. In words, multiply the tabular number S for the given wood by the breadth of the beam in inches and by the square of the depth in inches, and divide the result by the length of the beam in feet—the result will be the weight in lbs. which will just break it.

Note.—This rule will apply to a crane post not supported above the ground, the dimensions being measured at the throat, and the radius of sweep of the crane being taken as the length of the beam.

2. When the beam is fixed at one end and uniformly loaded over its whole surface, the breaking weight will be twice as great as in the first case, or $W = \frac{2b\,d^2\,S}{l}$. This would apply to a corbelled balcony, or landing-place projecting from a jetty.

3. When the beam is supported at both ends and loaded at the centre, $W = \frac{4b\,d\,S}{l}$, or four times the result found by the first rule.

4. When the beam is supported at the ends and uniformly loaded, as in a granary or warehouse floor, the breaking weight will be eight times the result found by the first rule, or $W = \frac{8b\,d^2\,S}{l}$.

5. When the beam is securely fixed at the ends and loaded in the middle, the strength will be six times the first result, or $W = \frac{6\,b\,d^2\,S}{l}$, and when similarly fixed and uniformly loaded, it will be twelve times the first result, or $W = \frac{12b\,d^2\,S}{l}$; but these two cases can scarcely ever occur in practice, from the impossibility of fixing the ends of the beams in a sufficiently rigid manner. The only case which at all approximates to a beam *fixed* at the ends is when the same beam extends continuously over several supports, and in that case accordingly some increase of strength over that found by Rule 3 or 4 may be counted on.

In practice, the beam should never be loaded with *more* than one-fourth of the breaking weight, as ascertained above, but it must be left to the judgment of the designer to determine how much less than one-fourth should be considered the safe working load. In deciding this, attention has to be paid to the nature of the structure and its exposure to the weather, and also to the nature of the load; for example, whether it is a steady weight, or whether heavy masses will sometimes be thrown down over the beam, &c. For bridges, some engineers make the breaking weight of the beams ten times the maximum load the bridge will have to carry.

6. The length and breaking weight of a beam being known, to find its dimensions (the breaking weight being assumed as at least four times what the beam will require to carry). Suppose the beam supported at the ends and loaded at the centre; this can only be solved by assuming a dimension for either the breadth or the depth. Suppose the breadth assumed, then $d=\sqrt{\frac{l\,W}{4b\,S}}$; or, in words, the depth will be found by dividing the length, multiplied by the breaking weight, by four times the assumed breadth multiplied by the tabular number S, and taking the square root of the quotient.

If the depth be assumed $b=\frac{l\,W}{4d^2\,S}$; or the length multiplied by the breaking weight and divided by four times the square of the depth multiplied by the tabular number. If the beam be to be square, the side of the square will be found from the formula $b=d=\sqrt[3]{\frac{l\,W}{4\,S}}$, or the cube root of the length multiplied by the breaking weight and divided by four times S

7. When the beam is fixed at one end and loaded at the other, the formula will be $b=\frac{l\,W}{S\,d^2}$, $d=\sqrt{\frac{l\,W}{b\,S}}$; in square beams, $b=d=\sqrt[3]{\frac{l\,W}{S}}$, or the same formula as before, taking S only instead of 4 S.

When the weight is uniformly distributed, the same formula will apply; but W in this case will represent only half the required or given weight.—("Barlow on Materials and Construction," p. 144.)

8. Cylindric beams, such as crane posts, are two-thirds the strength of a square beam of the same length, the diameter of the cylinder being equal to the side of the square.

In calculating the elasticity of a beam, the simple formula for a beam fixed at one end and loaded at the other is $E=\frac{l^3\,W'}{a\,d^3\,\delta}$, from which the tabular values of E are calculated, δ being the observed deflection, and W' the weight which produces it. Thus, any four of the five qualities, l, W', a, d, and δ, being known or assumed, the fifth may be calculated from this formula, when properly inverted, as follows:—

$$a=\frac{l^3\,W'}{E\,d^3\,\delta};\quad d=\sqrt[3]{\frac{l^3\,W}{E\,a\,\delta}};\quad \delta=\frac{l^3\,W}{a\,d^3\,E};\quad W'=\frac{a\,d^3\,\delta\,E}{l^3};\ \text{and}$$

$$l=\sqrt[3]{\frac{a\,d^3\,\delta\,E}{W'}}.$$

9. When a beam is supported at both ends and loaded in the

middle, the prime formula is $\frac{l^3 W'}{16\, a\, d^3 \delta}$ = the same E as before, from which, by inversion, we have $a = \frac{l^3 W'}{16\, d^3\, \delta\, E}$; $d = \sqrt[3]{\frac{l^3 W'}{16 a\, \delta\, E}}$, and so on.

10. When a beam is fixed at the one end and uniformly loaded, the prime formula is $\frac{3\, l^3 W'}{8\, a\, d^3 \delta} = E$.

11. When a beam is supported at both ends and uniformly loaded, the formula becomes $\frac{5\, l^3 W'}{128\, a\, d^3\, \delta} = E$; both of which formulæ may be treated to find any one unknown element as illustrated in No. 8.

Lastly, if it be desired to ascertain whether the deflection of any beam in an existing structure be within the limits of safety, the approximate formula $\delta = \frac{d\, \Delta}{l^2}$ may be applied, where Δ is the observed deflection of the beam, and the resulting δ should be within the tabular safe deflection (column δ); the result, however, must not be too much depended on, as the deflection may be complicated by the "casting" or warping of the timber.

The formulæ depending on E are very seldom used, as, if the timber be never loaded in excess of one-fourth of the calculated breaking weight, its elastic force will never be impaired, and it is seldom of consequence to know what the actual amount of deflection will be; as, however, special cases sometimes occur in which the deflection must not exceed special limits, it has been considered advisable to show the method by which the proper proportions may be ascertained.

In conclusion, I have only to apologize for the imperfect manner in which my task has been accomplished, and to entreat forbearance towards any errors which may be detected. Many thousand operations were required in calculating the tables, and I cannot expect to have succeeded in keeping the work entirely free from mistakes: great care has, however, been taken, and whatever errors there may be will not, it is hoped, vitiate the results to any extent. The work, though laborious, has been a labour of love, and I trust my professional brethren in New Zealand will look kindly on this first attempt at supplying a want which all must have often felt, viz., a full and complete account of the native woods, and reliable data from which to calculate the proportions of structures.

JAMES M. BALFOUR,
Marine Engineer.

Dunedin, December 15th, 1865.

APPENDIX C.

No. 1.—*TABLE of Results of Experiments on New Zealand and other Colonial WOODS, made for the Commissioners of the New Zealand Exhibition under the direction of James Melville Balfour, C.E., Provincial Marine Engineer of Otago.*

NOTE.—The Woods are arranged in the order of the mean values in Column S, any exceptional specimens being omitted in calculating the mean. The different experiments on each variety of Timber are also arranged in the order of the values of S. The experiments made at Dunedin are numbered consecutively in the First Column. Those which are not numbered, but marked with an asterisk, were made at Sydney Mint, in 1856, by Capt. Ward, R.E., and are added for the sake of comparison.

Consecutive Number of Experiment.	NAME OF WOOD. — 1st, Native Name. 2nd, Settlers' Name. 3rd, Botanical Name. — 4th, Locality from which specimen comes.	Average dimensions of Timber; also, its qualities and uses, and the nature of the soil on which it thrives best.	Number of Specimen.	Specific Gravity.	Weight of a cubic foot.	Elasticity, from the formula $E=\frac{l^3 W'}{b d^3 \delta}$ In these experiments $=\frac{W'}{\delta}$	Greatest deflection in inches, elasticity remaining uninjured.	Greatest weight carried with unimpaired elasticity. Generally δ E	Ultimate strength, from the formula $S=\frac{l W}{a d^2}$ In these experiments S=W simply.	Deflection in inches at instant of fracture.	Ratio of flexure at point of fracture to safe deflection or $\frac{\delta'}{\delta}$	Ratio of weight carried with unimpaired elasticity to breaking weight or $\frac{W'}{S}$	Length of a beam 12 inches deep and 6 inches broad, supported at both ends, which will just break with its own weight, from the formula $\lambda=\sqrt{\frac{13824 S}{W}}$	Breaking weight at centre of a beam 20ft. clear span (supported at ends), reduced to a uniform weight of 20lbs. per lineal foot, and of the proportions, depth equal twice breadth, from the formula $W''=\frac{19{\cdot}52 S}{W^{\frac{1}{3}}}$	REMARKS.
			No.	S.G.	W lbs.	E $\frac{W'}{\delta}$	δ ins.	W' lbs.	S lbs.	δ' ins.	$\frac{\delta'}{\delta}$	$\frac{W'}{S}$	λ feet.	W'' tons.	
1	MAIRE—	Small tree with the habit of a	1	1·133	70·63	322·5	·80	225	335	2·00			255·89	11·040	Good fibrous fracture.
	Black Maire	*Metrosideros* (Rata).	2	1·166	72·68	250·0	·80	200	335	2·00			252·42	10·550	Broke suddenly.
	Eugenia maire, var.		3	1·147	71·47	290·2	·70	200	327	2·22			251·49	10·560	Good fibrous fracture.
	Hawke's Bay		4	1·193	74·40	229·4	·64	150	260	2·00			219·8	9·907	Broke at a slight flaw.
			M	1·159	72·29	273·0	0·73	193	314·2	2·02	2·77	·614	244·90	10·014	*Mean results.*
2	TITOKI—	Trunk 15 to 20 feet high and 12 to 20 inches diameter.	1	·929	57·94	231	·56	125	250	3·20			244·23	11·06	Good warning. Strong fibrous fracture. All similar. In all neutral axis very high, arguing a high resistance to tension.
	Titoki	The wood has similar properties to ash, and is used for similar purposes.	2	·915	57·06	234	·42	100	248	2·40			245·14	11·23	
	Alectryon excelsum	Its toughness makes it valuable for wheels, coach-building, &c.	3	·904	56·31	222	·56	125	246	2·60			245·74	11·36	
	Wellington		M	·916	57·10	229	·51	116	248	2·73	5·35	·468	245·03	11·22	*Mean results.*

3	Mapau, also Tarrata (Hector) Black Mapau *Pittosporum tenuifolium* Vicinity of Dunedin [In the Auckland Collection Mapau is called Birch.]	Never attains to any great size, though in woods it shoots up to a considerable height. Used for fence rails occasionally.	1						300	2·00					1. Broken by a gradually increasing pressure. 2 and 3. Very tough and fibrous, only crippled at last. 4. Broken by a gradually increasing pressure. 5. Tough and fibrous.
			2	·959	59·79	218·5	·56	125	270	2·64			249·81	11·396	
			3	·964	60·07	213·0	·58	125	225	2·20			227·54	9·431	
			4						220	2·26					
			5	·972	60·57	214·0	·60	125	200	1·54			217·93	8·788	
			M	·965	60·14	215·2	·58	125	243	2·13	3·67	·514	231·76	9·872	*Mean results.*
4	Manuka— Manuka *Leptospermum ericoides* Wellington		1	·943	58·77	266·9	·52	150	302	2·72			266·53	13·081	1. Yielded gradually—very fibrous. 2. Hung some time before parting—fibrous.
			2	·872	54·39	190·7	·52	100	225	2·20			239·15	10·948	
			M	·907	56·58	228·8	·52	125	263·5	2·46	5·7	·474	252·84	12·014	*Mean results.*
5	Manuka— Manuka *Leptospermum ericoides* Vicinity of Dunedin	Highly valued in Otago for jetty and wharf piles, as it resists the marine worm better than other timber found in the province. It is also extensively used for house piles, fencing, and especially for firewood. Its durability and other valuable qualities would insure its much more extended use were it to be had of larger sizes. 28 to 30 feet long, 14 inches diameter at the butt, and 10 inches at the small end, may be considered the largest attainable dimensions, though shorter lengths can be procured in quantities, with a diameter considerably greater.	1						280	1·90					1. Broken by gradually increasing pressure. 2. Good warning, fibrous. 3. Gave way very slowly. 4. Broke suddenly at a flaw—final deflection not noted. 5. Av. sample. 6. Fibrous fracture.
			2	·967	60·28	229·1	·68	150	255	2·60			241·80	10·63	
			3	1·042	64·95	242·2	·32	75	245	2·0			228·36	9·135	
			4	·953	59·38	250	·40	100	245				238·82	10·45	
			5	·941	58·64	242·2	·32	75	215	2·0			225·14	9·345	
			6	·955	59·54	214·6	·48	100	200	1·4			215·48	8·49	
			M	·972	60·96	235·6	·44	100	240	1·8	4·1	·417	229·92	9·61	*Mean results.*
*	Manuka	Affects a comparatively poor soil, and grows on large tracts, to the exclusion of all other trees.	1 } 2 }	·906	56·46	260·08	·57	145	211·8	2·277	4·0	·686	227·72	9·969	1 and 2. Mean of two experiments at Sydney Mint. Specimens were 1·9 in. square and 5 ft. long between supports.
	Manuka	The lightest coloured wood, called "White Manuka," is considered the toughest, and forms an excellent substitute for "Hornbeam" in the cogs of large spur wheels.	Av.	·943	59·0	239·5	·49	115	239	2·05	4·43	·482	234·52	10·224	General average of all recorded experiments on Manuka.
6	Kohwai— Kohwai *Sophora tetraptera,* var. *grandiflora* Wellington	Said to attain a large size in the interior of the North Island, but rarely over 12 to 16 inches in diameter in Otago. Timber is durable, and is used for piles in bridges, wharfs, &c., and for fencing. The wood has a strong resemblance to laburnum, the	1	1·006	62·69	194·7	·66	125	275	3·16			246·26	10·813	1. Only crippled at last. 2. Very strong and flexible, only crippled at last. 3. Crippled completely, but fibres only partially separated.
			2	1·029	64·19	208	·36	75	275	3·36			243·37	10·436	
			3	1·037	64·66	257·5	·46	100	265	3·22			238·03	9·95	
			M	1·024	63·85	220·1	·49	100	271·7	3·25	6·43	·368	242·55	10·399	*Mean results.*

APPENDIX C.—TABLE OF WOODS—*continued.*

No.	Name, &c.	Dimensions and Uses.	No.	S.G.	W lbs.	E $\frac{W'}{\delta}$	δ ins.	W′ lbs.	S lbs.	δ' ins.	$\frac{\delta'}{\delta}$	$\frac{W'}{S}$	λ feet.	W″ tons.	Remarks.
7	Kohwai— Kohwai, or Goa Vicinity of Dunedin	medullary plates, as in that wood, being lighter in colour than the woody fibre. It is well adapted for cabinet work and turnery.	1	1·03	64·11	166·8	·80	125	212	2·6			213·8	12·735	These samples were cut from a pile which had been twelve years in the Old Jetty, Dunedin, and alternately wet and dry, but still perfectly sound.
			2	·834	51·98	184·2	·80	125	200	2·6			230·62	10·414	
			3	·942	58·71	166·7	·70	100	174	2·4			202·42	7·548	
			4	·880	54·85	139·7	1·10	125	170	2·8			207·0	8·166	
			M	·922	57·41	164·35	·85	119	189	2·6	3·06	·630	213·46	9·716	*Mean results.*
8	Kohwai— Wakatipu District, Otago		1	·667	41·57	187·4	·38	75	185	2·38			248·04	13·47	1. Broke slowly with fair warning. 2. Do., do.
			2	·681	42·46	251·0	·44	100	184	1·6			244·75	10·77	
			M	·674	42·01	219·2	·41	87	184·5	1·99	4·85	·472	246·39	12·12	*Mean results.*
9	Kohwai— Wakatipu District (Another specimen)		1	·861	53·66	179·5	·60	100	202	2·9					1. Gave fair warning. 2. Do., fibrous bark. 3. Carried last weight about 3 minutes, parting slowly the while.
			2	·841	52·41	240·0	·28	50	185·4	2·44					
			3	·803	50·01	200·99	·44	83	163	1·96					
			M	·835	52·03	206·83	·44	78	183·5	2·43	5·52	·425	220·46	9·513	*Mean results.*
			Av.	·884	55·11	198·05	0·584	98	207·5	2·62	4·82	·487	227·97	10·236	General average on all the experiments on Kohwai.
10	Tawa— Tawa *Nesodaphne tawa* Wellington	Wood said to be inferior in quality and not durable. The Maoris use this wood for spears.	1	·808	50·40	199·2	·72	150	240	2·12			256·57	1·309	1. Sudden short fracture, resists compression well. 2. Broke very suddenly; short grain.
			2	·790	49·26	209·9	·56	125	208	1·8			241·61	11·742	
			M	·799	49·83	204·5	·64	137	224	1·96	3·06	·612	249·09	12·416	*Mean results.*
*	Tawa		1	·685	42·69	201·42	·76	153·1	168·4	1·03	1·36	·909	223·01	11·78	Result of experiments at Sydney Mint, rejecting a sample stated to have been unsound. Dimensions of sample 1·9 in. square, and 5 feet long between supports.
			GM	·761	47·45	203·47	·68	142·4	205·5	1·65	2·49	·711	240·39	12·204	*General mean* of all experiments on Tawa.
11	Towai— Black Birch *Fagus fusca* Wakatipu, Otago	A large tree, 40 to 60 feet high, often attaining a diameter of 8 feet to 12 feet.	1	·715	44·57	214·5	·44	100	250	2·30			278·46	16·397	1. Fibrous. 2. Ditto, parted quickly. 3. Long fibrous fracture.
			2	·759	47·31	203·8	·74	150	235	2·44			262·03	14·092	
			3	·664	41·40	225·0	·44	100	211	2·38			265·42	15·456	
			M	·713	44·43	214·4	·54	116	232	2·37	4·4	·50	268·64	15·315	*Mean results.*
12	Towai— Wellington	A valuable timber, highly esteemed in Nelson and Wellington for public works, as being both strong and durable in all situations. Black birch is the only wood used in the construction of	1	·911	56·76	239·0	·42	100	239·4	2·30			241·47	10·926	1. Long diagonal non-fibrous fracture. 2. Fibrous. 3. Longer cut and drier than the others.
			2	·847	52·8	230·0	·44	100	225·0	2·80			242·71	11·445	
			3	·695	43·33	159·0	·60	100	135·0	1·50			207·54	9·238	

*	Towai	the Waiau-ua Bridge, designed by J. Blackett, Esq., C.E., Provincial Engineer of Nelson: a daring and very successful structure.	M	·818	50·96	209·3	·49	100	199·8	2·20	4·5	·50	230·57	10·536	*Mean results.*
			1	·869	54·16	265·32	·432	114·12	122·5	1·54	3·56	·932	176·82	5·998	Result of an experiment at Sydney Mint. Sample 1·9 inch broad, 3 inches deep, and 5 feet long between supports.
			GM	·78	48·62	219·5	·503	108·8	202·5	2·32	4·32	·56	239·20	11·936	*General mean* of all experiments on Towai.
*	MIRO— Miro, but frequently confounded with Black Pine or Matai *Podocarpus spicata*	This tree attains large dimensions—40 to 60 feet high, and 2 to 3 feet diameter—and is valuable, but inferior in durability to the true Black Pine (for which it is often mistaken), especially when exposed to the action of moisture. The wood is generally nearly white, and it is known from Black Pine by showing a kind of star pattern on the cross section. The growing wood is distinguished by the fruit—the Miro carrying a spike or cluster of berries, while the Black Pine berries are single. This wood is not well adapted for marine works, as the worms destroy it very rapidly. It would be excellent for joists and other work exposed to transverse strains, but protected from damp.	1 } 2 }	·957	59·64	280·25	·562	158	201·6	·866	1·54	·784	216·16	8·541	*Mean results* of experiments on two samples at Sydney Mint. Dimensions, 5 feet long, 1·9 inch square, supported at both ends.
13	Miro— *Podocarpus spicata* Wellington		1	·671	41·83	229·7	·60	125	198	2·0			255·81	14·284	1. Yielded slowly at first, and then snapped suddenly. 2. Broke suddenly. Sudden short fracture.
			2	·693	43·20	206·0	·66	125	195	1·82			249·80	13·403	
			3	·658	41·02	155·0	·62	100	190	2·16			253·06	14·117	
			M	·674	42·02	196·9	·63	117	194·3	1·99	3·16	·602	252·89	13·935	*Mean results.*
	Miro		GM	·787	49·07	230·24	·603	133	197·2	1·54	2·51	·675	238·20	11·777	*General mean* of all experiments on Miro.
14	RATA— Rata, sometimes Iron Wood *Metrosideros robusta*, possibly *M. lucida* Wellington		1	1·003	62·54	199·8	·48	100	236	2·86			228·45	9·313	1. Fibrous fracture, similar to Manuka. 2. Ditto. 3. Ditto, but somewhat sudden.
			2	1·005	62·83	223·7	·56	125	210	2·86			214·95	8·229	
			3	·880	54·86	218·5	·46	100	205	2·16			227·29	9·847	
			M	·963	60·08	214	·50	108	217	2·63	5·26	·50	223·56	9·130	*Mean results.*
15	Rata— *Metrosideros lucida* Stewart's Island	This tree attains a height of 30 to 40 feet, and a diameter of 2 to 6 feet, and is found in all parts of New Zealand. Rata is plentiful on the West Coast of Otago and in Stewart's Island, where it is much used for knees and timbers in ship-building. It is believed to be durable, and its strength would recommend its adoption in engineering works. It is a handsome cabinet wood, and would probably answer well for cogs of spur wheels.	1	1·146	71·429	330·5	·34	100	255·4	3·12			222·33	8·256	Results of experiments on two different samples of timber. General character the same in all the pieces, the fracture very slow, with good warning and great resistance to compression. Nos. 2 and 8 were broken by a gradually increasing steady pressure.
			2						244·0	2·44					
			3	1·078	67·191	263·3	·32	75	212·8	2·60			208·49	7·486	
			4	1·010	62·953	233·7	·50	100	200·0	2·20			211·65	7·971	
			5	1·045	65·155	188·97	·44	75	179·4	2·40			195·08	6·656	
			6	1·062	66·171	141·60	·54	75	175·0	1·84			191·21	6·345	
			7	1·073	66·857	137·50	·80	100	175·0	2·20			190·22	6·247	
			8						175	1·90					
			M	1·069	66·63	215·93	·49	87	202	2·34	4·77	·43	203·16	7·160	*Mean results.*

APPENDIX C.—TABLE OF WOODS—*continued.*

No.	Name, &c.	Dimensions and Uses.	No.	S.G.	W lbs.	E $\frac{W'}{\delta}$	δ ins.	W′ lbs.	S lbs.	δ ins.	$\frac{\delta'}{\delta}$	$\frac{W'}{S}$	λ feet.	W″ tons.	Remarks.
*	Rata	From its density, it would probably resist the marine worm well, and if it could be procured in quantities of good dimensions, might probably take the place of Manuka for piles in marine structures.	1, 2, 3	1·078	67·18	331·0	·55	98	159·3	0·83	1·51	·62	180·84	5·646	*Mean results* of three experiments at Sydney. Samples stated to have been somewhat cross-grained. One specimen was 1·9 in. broad, 3 ins. deep; the others 1·9 in. square, and all 5 feet long between supports.
			GM	1·045	65·13	244·2	·51	93	196	2·08	4·18	·50	202·68	7·274	*General mean* of all experiments on Rata.
16	Mapau— Red Mapau *Myrsine urvillei* Otago Peninsula [In the Auckland Collection called Red Birch.]	Small tree, seldom exceeding 12 ins. diameter in Otago; much used for fence-rails, also for piles in marine and other structures; said to be durable; a deep red colour, and would be handsome in cabinet work. The wood is extremely subject to the ravages of a boring beetle.	1						265	3·0					2. Sudden but fibrous fracture. 3. Ditto, stands compression well. 4. Broke short at last. 6. Gradual silent fracture.
			2	1·043	64·992	165·0	·48	75	225	3·0			218·77	8·381	
			3	·997	62·147	155·0	·68	100	222	3·4			222·22	8·843	
			4						192	2·0					
			5	1·048	65·32	176·5	·58	100	184	1·1			197·33	6·802	
			6	1·018	63·468	148·0	·54	75	175	2·28			195·24	6·755	
			M	1·026	63·98	161·1	·57	87	210·5	2·46	4·32	·413	208·39	7·695	*Mean results.*
*	Mapau, believed to be Red Mapau *Myrsine urvillei*		1, 2	·923	57·52	187·44	·58	107	138	·91	1·57	·777	181·97	6·164	*Mean* of two sets of experiments at Sydney—one specimen stated to have been inferior. Dimensions, 1·9 in. square, and 5 feet long between supports.
	Red Mapau		GM	·991	61·82	169·88	·57	92	192·4	2·07	3·63	·504	199·6	7·184	*General mean* of all experiments on Red Mapau.
17	Matai— Black Pine *Podocarpus ferruginea* Wakatipu District, Otago	A large-sized, valuable timber, sometimes attaining a diameter of 4 feet. The heart-wood of full-grown specimens is of a reddish hue, surrounded by about an inch of sap-wood concentric with the bark and well defined, which renders it easily distinguished from Miro when seen in section. It is considered durable both wet and dry, and is much used for piles in engineering structures.	1			163·4	·92	150	276·1	2·42					1 and 3 were, by oversight, not weighed: 5 was broken by gradually increasing steady pressure. The fracture in all was non-fibrous and sudden; several samples flew into three pieces with a loud report: at the same time the cohesion was obviously good, and the resistance to compression remarkably high.
			2	·756	47·09	189·8	·52	100	265·0	1·80			278·92	16·00	
			3			177·5	·86	150	263·9	2·14					
			4	·792	49·36	190·35	·64	125	200·0	2·00			236·68	11·256	
			5						172·4	1·50					
			M	·774	48·22	180·26	·735	131	237·5	1·96	2·66	·551	257·8	13·628	*Mean results.*

18	Matai— Wellington		1	·767	47·79	166·5	·60	100	203	1·70			242·33	11·99	1. Fracture short but ragged. 2. Carried last weight some time before parting. 3. Sudden fracture.
			2	·712	44·36	212·3	·58	125	200	1·36			249·65	13·21	
			3	·669	41·70	148·5	·66	100	175	1·40			240·86	12·68	
			M	·716	44·62	175·8	·61	108	192·7	1·49	2·44	·560	244·28	12·63	*Mean results.*
19	Matai— Wakatipu District, Otago		1	·607	37·86	136·0	·74	100	200	2·76			270·24	16·755	1. Sudden short fracture. Neutral axis very low. 2. Broken by gradually increasing pressure. 3. Sudden short fracture. 4. Ditto, very flexible specimen.
			2						200	2·4					
			3	·604	37·63	121·09	·64	75	175	2·8			253·55	14·795	
			4	·624	38·88	106·9	1·00	100	175	3·40			249·42	14·083	
			M	·612	38·12	121·33	·79	92	187·5	2·84	3·60	·490	257·74	15·211	*Mean results.*
20	Matai— Vicinity of Dunedin, Otago		1	·561	34·97	154·4	·64	100	170	2·00			259·23	16·043	1. Usual sudden fracture. 2. Broken by gradually increasing pressure. 3, 4, 5. Usual fracture.
			2						168·3	1·80					
			3	·597	37·19	165	·46	75	161	2·86			244·62	11·49	
			4	·572	35·66	125·0	·60	75	140	1·76			232·97	12·832	
			5	·601	37·45	115·9	·46	50	126·5	2·56			216·09	10·77	
			M	·583	36·32	140·1	·54	75	153·2	2·2	4·05	·496	238·23	12·784	*Mean results.*
*	Matai		1	·653	40·70	170·56	·77	131	138·8	0·82	1·06	·942	217·13	10·432	Results of an experiment at Sydney Mint; specimen 1·9 in. broad, 3 in. deep, and 5 feet long between supports.
			G M	·658	40·74	156·22	·67	103	190	2·08	3·10	·542	245·51	13·257	*General mean* of all experiments on Matai.
21	Maire— Maire *Eugenia maire* Wellington	Small tree, 30 to 50 feet high, with the habit of a *Metrosideros* (Rata). Affects swampy ground.	1	·943	58·77	224·4	·44	100	225	1·46			230·05	9·746	1. Short fracture; resists compression well. 2. Broke rather suddenly, but fibrous. 3. Good fracture. 4. A flaw in this specimen.
			2	·919	57·26	242·9	·66	150	224	2·02			232·55	10·090	
			3	·920	57·33	190·6	·56	100	223	2·56			231·89	10·036	
			4	·963	60·00	215·5	·48	100	175	1·40			200·80	7·349	
			M	·936	58·34	218·3	·53	112	212	1·86	3·50	·528	223·82	9·305	*Mean results.*
22	Maire— Hawke's Bay	Excellent for fencing.	1						170	1·6					1. Broken by gradually increasing pressure. 2. Good fibrous fracture. 3. Ditto. 4. Ditto. 5. Ditto. 6. Broke by gradually increasing pressure.
			2	·671	41·83	143·3	·72	100	150	1·9			222·65	10·87	
			3	·627	39·08	135	·76	100	150	2·2			230·34	11·98	
			4	·618	38·54	125	·80	100	150	1·8			231·94	12·23	
			5	·660	41·14	141·3	·72	100	140	2·0			216·89	10·35	
			6						135	1·6					
			M	·644	40·15	136·1	·75	100	149	1·8	2·40	·670	225·45	11·357	*Mean results.*
			GM	·790	49·24	177·2	·64	106	179·7	1·82	2·84	·590	224·63	10·331	*General mean* of all experiments on Maire.

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APPENDIX C.—TABLE OF WOODS—*continued*.

No.	Name, &c.	Dimensions and Uses.	No.	S.G.	~~W~~ lbs.	E $\frac{W'}{\delta}$	δ ins.	W′ lbs.	S lbs.	δ' ins.	$\frac{\delta'}{\delta}$	$\frac{W'}{S}$	λ feet.	W″ tons.	Remarks.
23	Tawiri Kohu Kohu (*Buchanan*) White Mapau [Called White Birch in Auckland collection.] *Carpodetus serratus* Otago Peninsula	A shrub, or small tree, 10 to 30 feet high, the trunk usually slender; suitable for axe handles.	1						210	3·90					1 and 2. Broken by gradually increasing pressure. 3 to 7. Tough; yielded slowly.
			2						200	3·40					
			3	·917	57·17	186·5	·52	75	191	2·80			214·73	8·608	
			4	·864	53·87	189·0	·44	75	180	3·76			214·92	8·885	
			5	·709	44·22	169·3	·80	125	170	1·76			230·54	11·280	
			6	·797	49·66	150·5	·56	75	156	3·80			208·38	8 698	
			7	·822	51·27	139·0	·36	50	136	3·30			184·11	6·426	
			M	·822	51·24	166·86	·54	80	177·6	3·25	6·0	·450	210·53	8·780	*Mean results.*
24	Kauri— Kauri (mottled var.) *Dammara australis* Auckland	A magnificent tree, sometimes 120 feet high and upwards, and attaining a diameter at the base of 10 to 20 feet. The trunk is sometimes 80 to 100 feet high before branching. Grows best near the sea, on wet clay land.	1	·646	40·29	190·7	·52	100	190	2·0			255·29	14·496	1. Sudden long diagonal fracture. 2. Broken by gradually increasing pressure. 3. Broke short and suddenly. 4. Ditto, ditto.
			2						187·7	2 2					
			3	·611	38·08	178·7	·42	75	185	2·0			259·14	15·187	
			4	·591	36·83	164·25	·62	100	168	1·78			251·11	14·668	
			M	·616	38·40	177·88	·52	92	182·7	2·0	3·84	·504	255·18	14·784	*Mean results.*
25	Kauri— Auckland	Forms excellent masts and spars, deck and other planking of vessels, and is largely used for house finishings. It works freely, and is one of the most useful timbers indigenous to New Zealand.	1	·578	36·07	212·80	·66	125	200	2·00			276·86	18·017	1. Good specimen; broke suddenly at last. 2. Ditto, ditto. 3. Good specimen; the fibres in tension broke square across. 4. Serrated fracture, after hanging a few seconds. 5. Broken by gradually increasing pressure.
			2	·575	35·84	261·50	·42	100	198	2·24			276·34	18·007	
			3	·633	39·47	186·10	·56	100	175	2·00			247·57	13·773	
			4	·579	36·08	183·70	·54	100	175	1·80			258·92	15·755	
			5						150	1·60					
			M	·591	37·11	211·0	·545	106	179·6	1·93	3·54	·590	264·92	16·388	*Mean results.*
26	Kauri— [Waved variety.] Auckland		1						57	·60					Broken by gradually increasing pressure. This variety of Kauri is very ornamental, but the "wave" in the grain, while adding much to the beauty of the wood, greatly diminishes its strength; though experiments on larger samples would probably give much higher results. Wood with this peculiarity would not be selected for ordinary work, so I have omitted their results in the general average.
			2	·660	41·14				56	·96			137·17	4·14	
			3	·700	43·66				56	1·10			134·87	3·94	
			4	·652	40·63				43				120·96	3·24	
			5	·683	42·56				27	·60			93·65	1·90	
			M	·674	42·0				47·8	·815			121·66	3·305	*Mean results.*

*	Kauri		1, 2, 3	·674	42·0	145·02	·61	90	119·1	1·24	2·03	·84	197·97	8·54	Average results of three experiments at Sydney. Two specimens 1·9 in. square, the third 1·9 in. broad and 3 ins. deep; all 5 feet long between supports.
	Kauri		GM	·623	38·96	181·27	·56	97	165·5	1·78	3·18	·586	241·91	13·552	*General mean* of all experiments on Kauri (omitting No. 26 as exceptional).
	Kauri		GM	·638	38·96			130·88	1·54				192·62	10·624	*General mean* of all experiments on Kauri (including No. 26).
*	Rewa Rewa— Rewa Rewa *Knightia excelsa*	A lofty, slender tree. Wood mottled red and brown, handsome and peculiar looking. Used for furniture and shingles.	1, 2	·788	49·11	247·38	·44	109	173	1·08	2·45	·632	221·0	9·839	Mean of two experiments at Sydney,—said to have been good samples and to have given fair warning. Dimensions, 1·9 in. x 1·9 in. x 60 in.
27	Rewa Rewa— Wellington		1	·809	50·40	177·6	·60	100	160	2·00			214·37	8·727	1. Broke very suddenly, with a short fracture. 2. Carried last weight about three minutes, slowly yielding. 3. Fair sample.
			2	·754	46·97	139·0	·52	75	150	1·60			210·11	9·094	
			3	·788	49·03	165·0	·46	75	150	1·50			205·66	8·527	
			M	·784	48·80	160·5	·53	83	153	1·7	3·20	·546	210·05	8·783	*Mean results.*
			GM	·785	48·92	195·25	·49	93	161	1·45	2·90	·580	214·43	9·205	*General mean* of all experiments on Rewa Rewa.
2	Towai— Red Birch *Fagus menziesii* Wakatipu District, Otago	A lofty tree, attaining a diameter of two to three feet. Durable and adapted for mast-making and oars, and for cabinet and cooper work. Promises to be one of the most useful timbers in the country, but has been little used hitherto, as it is found only in the interior in any quantity.	1						177	1·9					1. Broken by gradually increasing pressure. 2. Broke with little warning, after carrying the last weight one minute. 3, 4, 5, 6. Fair specimens; all broke suddenly. 7. Elasticity very early injured. 8. Very flexible — would scarcely break; fibrous.
			2	·632	39·36	130·0	·64	75	167	2·0			229	11·86	
			3	·602	37·50	115·4	·64	75	160	2·6			243	13·60	
			4	·604	37·65	152·0	·72	100	160	2·3			236	13·52	
			5	·641	39·95	105·6	·70	75	155	2·9			232	11·98	
			6	·624	38·86	115·3	·64	75	154	2·6			234	12·41	
			7	·653	40·78	87·0	·50	40	153	2·6			227	11·47	
			8	·624	38·86	106·5	·72	75	140	3·5			223	11·77	
			M	·626	38·99	116	·65	73·6	158·2	2·55	3·92	·465	233·4	12·37	*Mean results.*
29	Rimu— Red Pine *Dacrydium cupressinum* Wellington	50 to 80 feet high; 2 to 5 feet diameter. A valuable timber, much used for joisting and planking of public works in Otago, and for general building purposes. The old wood is handsomely marked, and is used for cabinet work.	1	·607	37·86	179·6	·56	100	184	2·64			259·20	15·415	1, 2, 3. Sudden long diagonal fractures.
			2	·613	38·20	174·1	·64	100	171	2·60			248·76	14·135	
			3	·607	37·86	169·6	·66	100	149	2·20			233·25	12·483	
			M	·609	37·97	174·4	·62	106	168	2·48	4·0	·595	247·07	14·011	*Mean results.*

APPENDIX C.—TABLE OF WOODS—*continued.*

No.	Name, &c.	Dimensions and Uses.	No.	S.G.	W lbs.	$\frac{E\ W'}{\delta}$	δ ins.	W′ lbs.	S lbs.	δ' ins.	$\frac{\delta'}{\delta}$	$\frac{W'}{S}$	λ feet.	W″ tons.	Remarks.
30	Rimu— [Supposed Red Pine.] Hawke's Bay		1						178						1. Broken by a gradually increasing pressure. 2, 3, 4, 5. All broke suddenly, or at least with little warning. Neutral axis very low.
			2	·626	39·0	166·6	·64	100	170	2·0			245·48	13·622	
			3	·644	40·11	140·7	·70	100	170	2·40			242·04	13·058	
			4	·564	35·19	129·0	·78	100	152	1·80			244·38	14·213	
			5	·581	36·21	107·92	·70	75	145	2·56			235·26	12·984	
			M	·604	37·63	136·07	·705	94	163	2·19	3·11	·577	241·79	13·469	*Mean results.*
*	Rimu		1, 2, 3	·576	35·88	147·56	·654	93·5	128	1·33	2·03	·73	222·05	11·62	*Mean results* of three experiments at Sydney. Samples all 5 feet long between supports; two 1·9 in. square, and the third 1·9 in. x 3 in. deep.
31	Rimu— Flagstaff, Dunedin		1	·574	35·743	120·2	·82	100	149·0	2·5			239·96	13·592	All broke suddenly, No. 3 by a gradually increasing pressure. These specimens were cut from a plank exhibited for its beauty, so that the results are under the true strength of the wood, the plank having been cut so as to have a cross and wavy grain.
			2	·550	34·28	138·5	·80	100	112·0	1·00			212·51	10·888	
			3						109·2	0·90					
			4	·618	38·51	125·0	·60	75	95·0	1·00			184·66	7·757	
			5	·587	36·60	113·6	·44	50	75·0	0·70			168·31	6·610	
			M	·582	36·28	124·3	·66	81·2	108·04	1·25	1·89	·75	201·36	9·62	*Mean results.*
32	Red Pine— Banks' Peninsula, Canterbury		1	·771	48·41	80·0	·50	40	75	·88			146·34	4·345	This wood resembled Black Pine, in colour and general appearance, more than Red Pine. The slabs were large and very handsome, but the grain was much too cross to give good results from experiments on such small samples. They all broke nearly square across, without noise. No. 5 broken by gradually increasing pressure.
			2	·829	51·70	100	·50	50	75	·90			141·61	3·937	
			3	·721	44·94				67	·88			143·56	4·340	
			4	·711	44·31	87·5	·40	35	58	·86			134·51	3·539	
			5						55	·60					
			M	·76	47·34	89·16	·46	42	66	·84	1·84	·636	141·50	4·04	*Mean results.*
			GM	·593	36·94	143·38	·663	92·8	140·2	1·76	2·65	·662	227·14	12·089	*General mean* of all experiments on Rimu, omitting No. 32.

			GM	·630	39·25	133·8	·654	86·3	122·5	1·53	2·34	·704	208·11	10·300	*General mean* of all experiments on Rimu, including No. 32.
*	MANGI— Mangi *Tetranthera calicaris*	A small evergreen tree.	1, 2	·621	38·70	185·36	·59	109	137·8	1·27	2·15	·796	221·86	11·17	*Mean* of two experiments at Sydney. Samples and fracture good. Specimens 5 feet long and 1·9 in. square.
33	TOTARA— Totara *Podocarpus totara* Hawke's Bay	40 to 60 feet in height, 4 to 10 feet in diameter; wood very durable, and adapted for every kind of carpenter work. It is considered to drive better (for piles) than perhaps any other New Zealand wood. Red Totara is highly esteemed in the North Island. It is extensively used in Wellington for house-building and for wharf piles. In Auckland the Harbour Master considers it proof against marine worms, if driven as soon as felled. The bark is used for roofing.	1						170·0	3·00					Nos. 1 and 6 were broken by gradually increasing pressure. All the samples showed great flexibility combined with considerable strength; but when they broke it was completely, and without any warning.
			2	·539	33·60	140·2	·56	75	150	2·58			248·43	15·03	
			3	·550	34·28	96·2	·76	75	148	3·28			244·28	14·39	
			4	·550	34·28	107·4	·59	60	140	2·60			237·59	13·61	
			5	·551	34·37	112·0	·68	75	140	3·00			237·30	13·56	
			6						140	2·40					
			M	·548	34·13	113·95	·65	71	148	2·81	4·32	·480	241·90	14·148	*Mean results.*
34	Totara— Wellington		1	·547	34·11	155·2	·44	75	150	1·38			246·57	14·69	
			2	·532	33·13	250	·30	75	145	1·96			246·54	14·89	
			3	·534	33·26	96·1	·52	50	125	2·06			227·95	12·72	
			M	·538	33·83	163·8	·42	66	140	1·80	4·3	·471	240·35	14·083	*Mean results.*
35	Totara— Banks' Peninsula, Canterbury		1	·569	35·46	102·0	·72	75	125	2·20			220·76	11·55	
			2	·559	34·77	103·5	·70	75	122	2·70			220·24	11·61	
			3	·561	34·97	80·6	·90	75	120	3·36			218·24	11·39	
			4	·633	39·43	96·87	·80	75	120	2·36			205·11	9·45	
			5						120	2·40					
			M	·565	36·16	95·74	·78	75	121·4	2·60	3·34	·618	216·09	11·00	*Mean results.*
*	Totara		1, 2, 3	·587	36·58	138·12	·71	98	118·7	1·13	1·60	·826	207·01	10·51	*Mean results* of three experiments at Sydney. Specimens all 5 feet long between supports; two 1·9 in. square, the third 1·9 in. broad x 3 in. deep.
	Totara		GM	·559	35·17	124·61	·65	77	133·6	2·27	3·50	·576	226·71	12·455	*General mean* of all experiments on Totara.
*	HINAU (POKAKO)— (Hector) Hinau *Elæocarpus dentatus*	Small tree, the wood a yellowish brown colour, and close grained. The bark is used for tanning, and yields a permanent dye.	1, 2	·562	35·03	200·7	·47	94	125	1·28	2·71	·754	220·10	11·766	*Mean* of two experiments at Sydney. Specimens 1·9 inch square and 5 feet long between supports. Captain Ward remarks that this wood has very little power of resisting compression, and that it "bent like a rope round the point where the strain was applied," from which I would rather infer that it has great power of *elongation*, there being nothing in that inconsistent with ability to resist compression.

APPENDIX C.—TABLE OF WOODS—*continued.*

No.	Name, &c.	Dimensions and Uses.	No.	S.G.	W lbs.	E $\frac{W'}{\delta}$	δ ins.	W' lbs.	S lbs.	δ' ins.	$\frac{\delta'}{\delta}$	$\frac{W'}{S}$	λ feet.	W'' tons.	Remarks.
36	Moko— Moko *Aristotelia racemosa* Vicinity of Dunedin	A small, handsome tree, 6 to 20 feet high. Wood white and soft, and might be applied to the same uses as Lime tree in Britain. From some specimens finely marked veneers can be cut.	1						150	3·9					Very flexible wood. All broke somewhat suddenly. This wood appears to resist compression well, but breaks short under tension. 1 and 4 were broken by a gradually increasing pressure. E and δ for No. 6 not noted.
			2	·530	33·04	83·30	·90	75	124	3·2			227·77	12·741	
			3	·553	34·47	86·77	·60	50	123·7	3·18			222·74	11·930	
			4						122	3·60					
			5	·507	31·62	107·47	·74	75	120	3·40			229·07	13·175	
			6	·541	33·74				120	2·80			221·75	11·950	
			7	·566	35·25	93·75	·64	50	99	2·5			197·04	9·230	
			M	·593	33·62	93·07	·72	62	122	3·22	4·47	·508	219·67	11·805	*Mean results.*
37	Wawaku— (Supposed Kawaka) *Libocedrus doniana* Wellington	60 to 100 feet high, 2 to 4 feet diameter. Wood close grained and durable, and said to be excellent for planks and spars.	1	·637	39·69	136·7	·64	75	120	3·7	5·78	·625	229·38	9·364	Exceedingly flexible. Bent from the upper edge, with great buckling of the fibres under compression.
	Kohe Kohe— *Dysoxylum spectabile*	40 to 50 feet high. Tough, but splits freely.	1, 2	·678	42·25	208·61	·44	92	117·4	·99	2·25	·783	195·96	8·339	*Mean* of two experiments at Sydney Mint. Dimensions, 1·9 in. square and 5 ft. long between supports. Specimens said to have been worm-eaten.
*	Taraire— *Nesodaphne taraire*	60 to 80 feet high. Wood white, splits freely, but not much valued.	1, 2	·888	55·34	205·04	·47	99·6	112·3	·67	1·42	·895	167·49	5·322	*Mean* of two experiments at Sydney. Dimensions same as last. One sample broke at a flaw.
38	Kahikatea— White Pine *Podocarpus dacrydioides* Wellington	Trees gregarious. 150 feet high, 4 feet diameter. Wood white or yellowish white, not durable. Would answer for building small boats, and is used for common cheap work and for ordinary building purposes. Sometimes used by cabinet-makers as a contrast to darker woods, selected pieces being very handsome, and having a sparkling appearance when polished.	1	·536	33·40	167	·44	75	155	2·0			253·29	15·671	All broke suddenly.
			2	·557	34·74	147	·34	50	150	2·0			244·30	14·295	
			3	·463	28·86	167·4	·48	75	125	2·96			244·69	15·734	
			4	·468	29·17	139·0	·36	50	115	2·40			233·47	14·248	
			M	·506	31·54	155·1	·405	62	136	2·34	5·77	·456	243·94	14·987	*Mean results.*
39	White Pine— Banks's Peninsula, Canterbury		1						125	2·40					Nos. 1 and 5 broken by a gradually increasing pressure. Nos. 2 and 6, elasticity early damaged; δ not noted. All broke suddenly, No. 4 being the most fibrous specimen.
			2	·464	28·94				95	2·40			213·02	11·907	
			3	·459	28·63	83	·60	50	90	2·20			208·47	11·467	
			4	·474	29·54	78	·64	50	90	1·84			203·10	10·930	
			5						90	1·20					
			6	·470	29·33				55				161·05	6·763	
			M	·467	29·11	80·5	·62	50	90·8	2·01	3·24	·550	221·41	10·276	*Mean results.*

•	KAHIKA— (Supposed White Pine)		1	·502	31·28	108·54	·528	57·3	77·5	Not obsd		·739	185·07	8·645	*Results* of an experiment at Sydney. Sample, 1·9 in. square and 5 ft. long between supports.
	White Pine		M	·488	30·43	127·1	·484	57·9	106	2·10	4·46	·546	227·38	11·966	*General mean* of all experiments on White Pine.
40	WHAU— Native Cork Wood *Entelea arborescens* Auckland	A small tree, with remarkably light wood. In transverse section it appears as if it were formed of exceedingly thin tubes of woody fibre, the interstices (sometimes ½ inch wide, or even more) being filled with cellular tissue. When cut plank-wise, and carefully smoothed with glass-paper, it presents all the appearance of a solid wood. It is used by the Natives for fishing-floats, but would be well adapted for life-belts, fenders for life-boats, and similar purposes, if painted or prevented from becoming water-logged by occasional drying. It would answer for many purposes where little strength is required and great lightness is an advantage, as, for instance, for rollers for the protection of plans and photographs, &c., when transmitted by post.	1	·189	11·76	41·03	·34	13	32	4·00	11·8	·406	193·98	15·493	These results are given more from their curiosity than from their usefulness. δ′ is only approximate, as the specimen continued slowly yielding with the least weight, but never actually gave way. The specific gravity of the specimen tested was rather above the average of all which were weighed. The mean weight per cubic foot was 10·39 lbs., but one specimen weighed only 8·29 lbs., or a little more than half the weight of cork.

WOODS FROM NEW SOUTH WALES.

NOTES.—The experiments made at Dunedin are distinguished by consecutive numbers as before.

The results marked with a † are reduced from a "Report of further Experiments conducted at the Sydney Branch of the Royal Mint, to determine the Strength and Elasticity of Colonial Timber," by E. W. Ward, Esq., Deputy-Master, 1860–61.

Those marked with †† are reduced from the results of the experiments conducted at the Paris Exhibition of 1855, by Captain Fowke, R.E.

No.	NAME, &c.	DIMENSIONS AND USES.	No.	S.G.	W lbs.	$\frac{E}{W'/\delta}$	δ ins.	W′ lbs.	S lbs.	δ′ ins.	$\frac{\delta'}{\delta}$	$\frac{W'}{S}$	λ feet.	W″ tons.	REMARKS.
††	IRON BARK	Has a high reputation for strength and durability. Diameter, 3 to 6 feet; height, 100 to 150 feet.	1, 2, 3, 4	1·032	64·315	317·2			339				269·93	12·825	*Mean of results* of experiments at Paris in 1855, conducted by Capt. Fowke, R.E. The Paris experiments were all made on samples 2 inches square and 1 foot between supports; any which did not agree with those standard dimensions being reduced thereto by calculation.
41	BARREMMA— Iron Bark *Eucalyptus sp.* Jervis Bay	Attains a diameter of 4½ to 5 feet, but that chiefly used does not exceed 4 feet diameter, as the heart of the tree generally decays before it attains that size.	1	1·238	77·14	319·6	·74	225	335	2·0			248·64	9·937	1. Very fine specimen; broken slowly; fibres much compressed on under side. 2. Very tough and hard. 3. Similar to the other.
			2	1·238	77·14	269·7	·54	150	325	2·40			241·33	9·361	
			3	1·251	77·97	317·3	·68	200	325	1·80			240·04	9·212	
		Thrives well on stiff clay soil. Is chiefly used for railway works, shipbuilding, &c., &c.	M	1·242	77·41	302·2	·65	185	328·3	2·07	3·18	·557	243·34	9·503	*Mean results.*
†	IRON BARK— Berrima } Albury }	Timber hard, close-grained, and of great strength and durability. Is valuable for shipbuilding, engineering works, &c. It is, however, readily attacked by the white ant. [I understand that the teredo attacks it freely at Newcastle, N.S.W.—J.M.B.]	1, 2, 3, 4, 5, 6	1·156	72·04	281·11	·63	177	222·5	1·18	1·88	·785	206·63	7·102	*Mean* of six experiments at Sydney: three on specimens from Berrima, and three on specimens from Albury. All the experiments at Sydney Mint were made on samples 2 inches square and 4 feet long between supports.

APPENDIX C.—TABLE OF WOODS—*continued.*

No.	Name, &c.	Dimensions and Uses.	No.	S.G.	W lbs.	E $\frac{W'}{\delta}$	δ ins.	W' lbs.	S lbs.	δ' ins.	$\frac{\delta'}{\delta}$	$\frac{W'}{S}$	λ feet.	W'' tons.	Remarks.
	Iron Bark		GM	1·138	70·92	297·08	·64	180	282·7	1·47	2·3	·636	234·58	9·417	*General Mean* of all experiments on Iron Bark.
42	Booah— Colonial Mahogany *Eucalyptus sp.* Brisbane Water	Grows to a great size. Is often used as principal timbers in house-building, &c., as, when varnished, it matches well with cedar. Generally found in the same forest as Black Butt and Blue Gum.	1						320	1·60					1. Broken by a gradually increasing pressure. 2. Gave way slowly at first; very fibrous. 3. Broke slowly, fibre by fibre. 4. Good specimen.
			2	1·108	69·06	361·10	·66	225	300	1·20			245·04	10·202	
			3	1·111	64·26	321·80	·64	200	300	1·10			244·71	10·160	
			4	1·084	67·54	288·18	·88	225	295	1·40			245·72	10·372	
			M	1·101	68·62	323·69	·73	216	303·7	1·36	1·86	·711	245·14	10·245	*Mean results.*
†	Mahogany— Bowenfels	Strong timber; said to be durable, and very suitable for house carpentry.	1, 2, 3, 4	1·036	64·56	276·91	·57	159	206	·98	1·72	·771	210·28	7·769	Sydney experiments; *mean* of four.
††	Mahogany	Diameter, 30 to 70 inches; height, 60 to 130 feet. Much prized for strength and durability.	1, 2, 3	·952	59·33	391·23			281				255·88	12·00	Paris experiments; *mean* of three.
	Ditto		M	1·037	64·21	325·24	·64	183	262	1·17	1·82	·70	234·42	9·781	*Mean* of all experiments on Mahogany.
43	Yarr Warra— Black Butt *Eucalyptus media* Brisbane Water	Grows larger than Iron Bark, but when large the heart is generally decayed. Greatly used for almost all kinds of work; is much used for flooring boards, as it wears exceedingly well.	1						297	1·70					1. Broken by a gradually increasing pressure. 2, 3, and 4. Broke slowly and quietly; a good fibrous fracture.
			2	1·004	62·54	249·7	·68	175	285	2·04			250·99	11·245	
			3	1·009	62·88	262·73	·82	200	275	1·50			245·87	10·762	
			4	1·015	63·23	278·04	·62	175	275	1·70			245·20	10·674	
			M	1·009	62·88	263·49	·71	183	283	1·73	2·44	·646	247·35	10·894	*Mean results.*
†	Black Butt— Brisbane	Used for posts, rails, piles, &c. Supposed not to be very durable.	M	·945	58·89	316·8	·47	148	185·5	·74	1·57	·798	208·67	8·011	*Mean* of four; Sydney experiments.
††	Black Butt	One of the largest of the *Eucalypti*, producing excellent timber for house carpentry, or any purpose for which strength and durability are the chief requisites. Sometimes attains a diameter of 10 feet and upwards, but in such cases is always very hollow.	M	·891	55·53	279·82			273·2				260·79	12·884	*Mean* of eight; Paris experiments.
	Black Butt		GM	·929	57·90	293·95	·57	163	253·7	1·23	2·16	·642	244·20	11·186	*General Mean* of sixteen experiments on Black Butt.
44	Dahl Wah— Forest Oak *Casuarina suberosa* [Perhaps *C. tenuissima*.] Lake Macquarie	The best description is chiefly used for shingles, but large quantities are used for firewood and for making charcoal, though its qualities ought to command a better use.	1						325	1·60					1. Broken by a gradually increasing pressure. 2 and 3. Fracture moderately good and fibrous. 4. Sudden short fracture; very stiff specimen.
			2	1·125	70·085	273·35	·54	150	317	1·40			250·15	10·554	
			3	1·100	68·571	316·9	·70	200	275	1·20			235·46	9·452	
			4	1·045	65·142	315·7	·70	225	256	1·04			233·08	9·502	
			M	1·090	67·93	301·98	·65	192	293	1·31	2·02	·655	239·56	9·503	*Mean results.*

†	Forest Oak— *C. suberosa* Bowenfells	Timber of fine mottled silvery grain, and of great strength and durability. Chiefly used for shingles.	M	1·104	68·80	286·63	·52	150	193·5	·78	1·5	·781	196·67	6·583	*Mean* of four; Sydney experiments.
8	Forest Oak		GM	1·098	68·43	293·21	·57	168	243	1·04	1·83	·691	215·05	7·834	*General Mean* of all experiments on Forest Oak.
45	Cooranga— Blue Gum *Eucalyptus sp.* Brisbane	Grows to a large size. Valuable timber, extensively used by wheelwrights, as well as for ship and general house building purposes. Generally found in the same forests as Iron Bark and Black Butt.	1	·990	61·714	238·6	·64	150	275	2·10			245·35	11·070	1. Gave way gradually; good fracture. 2. Broke suddenly; fibres compressed or buckled considerably on under side.
			2	·993	61·857	290·3	·68	200	275	1·74			247·91	11·031	
			M	·991	61·785	264·4	·66	175	275	1·92	2·91	·636	246·63	11·050	*Mean results.*
††	Tdjetlat Barroulgoura— Blue Gum *Eucalyptus sp.* Camden	Very valuable timber, more in-locked in grain and more durable than common Blue Gum, but not obtainable of nearly such large size. One of the most durable woods known: excellent for naves and felloes of wheels, and for works under ground. Average diameter, 3 to 4 feet; average height, 80 to 100 feet.	M	·843	52·54				224	·665			242·78	11·48	Paris experiments. *Mean* of four.
†	Blue Gum— Brisbane		M	1·094	68·18	257·2	·66	169	210	1·17	1·74	·805	206·25	7·279	Sydney experiments. *Mean* of four.
46	Blue Gum		M						210						*Mean* breaking weight of twelve samples, mostly cut from the cases in which the large blocks of Newcastle coal were sent to the Exhibition.
	Blue Gum		GM	·973	60·66	259·6	·66	171	214·8	1·12	1·7		228·94	9·713	*General Mean* of twenty-two experiments on Blue Gum.
†	Spotted Gum— *Eucalyptus goniocalyx* Brisbane	25 feet average height to fork; 30 inches average diameter. Timber of great strength and durability in dry situations, but not much prized.	M	1·170	72·91	332·5	·50	166	217	1·02	2·04	·765	202·84	6·802	Sydney experiments. *Mean* of four from Brisbane.
47	Booangie— Spotted Gum *Eucalyptus sp.* Brisbane Water	Attains a very large size, sometimes as much as 8 feet diameter. Heart generally rotten. Used for bridge-building, coach-building, &c., &c. Grows well in a clay soil.	1	·985	61·371	214·03	·64	125	225	1·64			225·13	9·133	1. Hung a short time before parting. 2. Good fracture. 3. Broken by a gradually increasing pressure. 4. Broke quickly, fibrous.
			2	·990	61·714	184·64	·70	125	220	1·70			221·99	8·856	
			3						215	1·20					
			4	·974	60·685	167·06	·76	125	195	1·40			210·76	8·050	
			M	·983	61·26	188·58	·70	125	214	1·48	2·11	·584	219·29	8·68	*Mean results.*
†	Spotted Gum— Berrima	Tree with elongated trunk, averaging 40 feet to fork, and 2 feet diameter. Timber very strong, durable, and considered very suitable for ship-building, &c.	M	·942	58·71	238·31	·58	138	172	1·04	1·79	·806	200·95	7·440	Sydney experiments. *Mean* of four from Berrima.

APPENDIX C.—TABLE OF WOODS—*continued.*

No.	Name, &c.	Dimensions and Uses.	No.	S.G.	W̶ lbs.	E $\frac{W'}{\delta}$	δ ins.	W′ lbs.	S lbs.	δ' ins.	$\frac{\delta'}{\delta}$	$\frac{W'}{S}$	λ feet.	W″ tons.	Remarks.
	Spotted Gum		GM	1·036	64·57	149·91	·58	144	201	1·18	2·03	·716	206·64	7·546	*General Mean* of twelve experiments on Spotted Gum.
48	Dthah Dthaang— Stringy Bark *Eucalyptus sp.* George's River	The timber is not very highly prized, but the bark is turned to very many uses, such as for roofing, and as a substitute for rope. It is one of the most serviceable trees that grow for settlers and others.	1 2 3 4	 ·849 ·838 ·827	 52·94 52·26 51·57	 158·97 197·42 169·03	 ·60 ·56 ·62	 100 100 100	250 224 200 175	2·50 2·00 1·80 1·40			 241·84 230·02 216·59	 11·348 10·332 9·220	1. Broken by continued gradually increasing pressure. 2. Short fracture; broke at a flaw. 3. Hung one minute, and then broke without warning. 4. Short fracture; broke suddenly.
			M	·838	52·26	175·14	·59	100	212·2	1·93	3·27	·471	229·48	10·30	*Mean results.*
††	Bour-rougne— Stringy Bark Camden	Height, 50 to 100 feet, 2 feet to 4 feet 6 inches diameter. Much prized for flooring and general house carpentry, and of considerable strength and durability.	M	·864	53·84				181				215·65	8·947	Paris experiments. *Mean* of four from Camden.
†	Stringy Bark— From Berrima, Albury, Armidale, Mudgee	Valuable timbers, used for ordinary engineering and house-building purposes. The timber appears to be least esteemed in the Armidale district.	M	·980	61·10	201·42	·56	113	155	·91	1·162	·73	187·37	6·341	Sydney experiments. *Mean* of twelve samples from four districts.
	Stringy Bark		GM	·933	58·18	196·16	·566	110	171·6	1·16	2·05	·641	199·97	7·515	*General mean* of twenty experiments.
49	Coorong— Mountain Pine *Araucaria cunninghamii* Richmond River	Grows to a very large size on high ground. Used for packing-cases, common furniture, cheap houses, building and similar purposes.	1 2 3 4	·666 ·602 ·605	41·48 37·58 37·71	287·6 222·4 252·3	·52 ·64 ·40	150 125 100	225 195 175 175	1·40 2·00 1·36 1·10			273·82 253·70 253·27	16·434 14·822 14·746	1. Hung one minute, and then broke suddenly, without warning. 2. Broken by a gradually increasing pressure. 3. Short ragged fracture; little warning. 4. Like last.
			M	·624	38·92	254·1	·52	125	192·5	1·46	2·81	·649	260·26	15·334	*Mean results.*
	Mountain Pine— *Araucaria cunninghamii* Brisbane	Said to be of little value. Tree averages 45 feet to fork; 30 inches diameter.	M	·763	47·55	220·2	·445	98	117·25	·76	1·71	·835	184·62	6·978	Sydney experiments. *Mean* of four from Brisbane.
	Mountain Pine		GM	·703	43·85	234·7	·48	109	154·8	1·11	2·31	·698	217·03	10·582	*General Mean* of twenty experiments on Mountain Pine.

50	POLAI— Cedar— *Cedrela australis*	The Cedar attains a diameter of 10 to 13 feet, and is usually sound to the heart. It is a free working, light timber, which in the colonies takes the place of mahogany; in fact, its uses are too numerous to be mentioned. The undergrowth of Cedar scrub is of the densest character, rendering it necessary to cut tracks in it in order to be able to get back to the starting point.	1						167	2·20					1. Broken by gradually increasing pressure. 2. Broke suddenly. 3. Ditto. 4. Ditto, short across.
			2	·474	29·56	144·4	·56	75	148	2·40			263·10	17·974	
			3	·489	30·51	160·5	·46	75	147	2·00			258·06	17·020	
			4	·473	29·48	145·1	·72	100	140	2·00			256·20	17·065	
			M	·478	29·85	150·0	·58	83	150·5	2·15	3·70	·551	259·12	17·353	*Mean results.*
†	Cedar— Armidale		M	·444	28·12	122·80	·57	70	91·0	·98	1·72	·77	211·51	11·91	Sydney experiments. *Mean* of four from Armidale.
	Cedar		GM	·458	28·86	134·46	·574	74	120·75	1·565	2·72	·613	231·91	14·243	*General mean* of all experiments on Cedar.

WOODS FROM TASMANIA.

No.	NAME, &c.	DIMENSIONS AND USES.	No.	S.G.	W lbs.	E $\frac{W'}{\delta}$	δ ins.	W' lbs.	S lbs.	δ' ins.	$\frac{\delta'}{\delta}$	$\frac{W'}{S}$	λ feet.	W'' tons.	REMARKS.
50	BLUE GUM— (Believed to be Tasmanian.)		1	1·153	71·871	322·2	·38	125	317	1·06	2·79	3·94	246·93	10·153	A very fine well-seasoned sample, believed to be from Tasmania; cut from an old window-sill.
51	Blue Gum— *Eucalyptus globulus*	Diameter, 5 to 30 feet—average of those felled for use, 6 feet; height, 150 to 350 feet. Abundant in the southern and south-western parts of the island. A very superior timber, used for house-building, ship-building, &c.	1	1·047	65·30	263	·50	125	285	3·00			245·63	10·54	1. Fibrous fracture, neutral axis high. Lower fibres show signs of great compression. 2. Broke somewhat sharply, with shorter fracture than usual. 3. Gave good warning, neutral axis very high.
			2	·999	62·254	311	·46	125	273	1·80			247·43	10·954	
			3	·995	62·030	362	·50	175	250	2·30			255·53	11·704	
			M	1·014	63·19	312	·48	141	269	2·36	4·92	·524	249·53	11·066	*Mean results.*
52	Blue Gum— *E. globulus*		1	1·071	66·73	212·8	·72	150	260	2·24			232·09	9·309	1. Sudden fracture; fibrous but short. 2. After yielding a time, broke rather short. 3. Broken by a gradually increasing steady pressure. 4. Broke diagonally.
			2	1·084	67·52	364·4	·48	150	250	1·68			226·20	8·790	
			3						240	1·80					
			4	1·084	67·52	202·3	·70	125	206	2·20			205·33	7·242	
			M	1·078	67·26	259·8	·63	142	239	1·98	3·14	·594	221·21	8·447	*Mean results.*

APPENDIX C.—TABLE OF WOODS—*continued.*

No.	Name, &c.	Dimensions and Uses.	No.	S.G.	W lbs.	E $\frac{W'}{\delta}$	δ ins.	W′ lbs.	S lbs.	δ' ins.	$\frac{\delta'}{\delta}$	$\frac{W'}{S}$	λ feet.	W″ tons.	Remarks.
53	Curled Blue Gum		1						140	1·62					Broken by a gradually increasing pressure.
			2	1·012	63·08				112	2·80			156·67	3·620	All the samples of Curled Blue Gum broke nearly square across, though tried in all positions of the grain. Obviously the "curl" extends over a considerable thickness, and larger samples would probably give much higher results, as the timber looks well in large pieces.
			3	·996	62·09				80	1·50			133·46	2·648	
			4	·992	61·80				78				132·09	3·130	
			5	·952	59·30				69	1·80			126·83	2·447	
			M	·988	61·57				95·8	1·93			137·26	2·961	*Mean results.*
			GM	1·061	66·17	291·1	·53	139	260	2·01	3·8	·534	237·02	9·813	*General Mean* of eight experiments on Blue Gum, excluding No. 53.
	Curled Blue Gum		GM	1·035	64·5				196·8	1·98			200·74	8·230	*General Mean* of thirteen experiments on Blue Gum, including No. 53.
54	Iron Wood—*Notelaria ligustrina*	Diameter, 9 to 18 inches; not rare; used for mallets, sheaves of blocks, turnery, &c.	1	1·089	67·88	243·1	·52	125	295	2·40			245·10	10·293	1. Broke quickly, with fibrous fracture. 2. After hanging one minute, splintered up slowly.
			2	·998	62·27	209·1	·60	100	225	2·70			230·53	9·508	
			M	1·043	65·07	226·1	·56	112	260	2·55	4·55	·430	237·81	9·900	*Mean results.*
55	Prickly Box—*Bursaria spinosa, var.*	Diameter, 8 to 12 inches; height, 15 to 25 feet. Used for sheaves of blocks, and general turnery.	1	·968	60·34	252·5	·64	150	250	2·00			239·32	10·408	1. Broke slowly, with a short fracture. 2. Resists compression well; broke gently; more fibrous than last.
			2	·877	54·66	166·7	·58	100	225	2·56			238·55	10·867	
			M	·922	57·5	209·6	·61	125	237·5	2·28	3·70	·526	238·93	10·637	*Mean results.*
56	Blackwood—*Acacia melanoxylon*	Diameter, 1½ to 4 feet—average, about 2¼ feet; height, 60 to 130 feet. Makes excellent naves and spokes for wheel work, cask staves, &c.	1						260	2·00					1. Broken by a gradually increasing pressure. 2. Hung one minute, and then gave way slowly. 3. Fibres parted by jerks, one after another. 4. Broke suddenly at last.
			2	·924	51·57	222	·70	150	250	1·90			258·97	13·174	
			3	·754	46·97	220	·58	125	245	2·10			268·53	14·853	
			4	·721	44·92	260·1	·60	150	235	2·20			280·15	16·533	
			M	·800	47·82	234	·63	142	247·5	2·05	3·25	·574	269·22	14·187	*Mean results.*
57	Blackwood—(Figured variety.)	In constant use for cabinet and fancy work.	1	·781	48·69	233·3	·64	150	250	2·00			266·60	14·362	1. Broke very suddenly. 2. Broken by a gradually increasing pressure. 3. Broke very suddenly.
			2						230	2·60					
			3	·674	42·00	201·1	·64	125	225	2·60			272·13	16·132	

			4	·679	42·31	207·6	·80	150	200	1·80			255·62	14·180	4. Broke with a loud noise, suddenly. 5. Similar to last, but more fibrous.
			5	·730	45·47	197·7	·64	125	200	1·70			246·58	12·730	
			M	·716	44·62	209·9	·68	137	221	2·14	3·15	·620	260·23	14·351	*Mean results.*
			GM	·752	45·99	218·8	·66	139	232·8	2·10	3·18	·597	264·08	14·281	*General Mean* of nine experiments on Blackwood.
58	Stringy Bark— *Eucalyptus gigantea*	Diameter, 4 to 24 feet—average of those cut, about 5½ feet; height, 150 to 300 feet. Abundant everywhere upon hilly ground. Used for same purposes as Blue Gum.	1	·966	60·214	231	·70	150	224	2·10			226·77	9·360	1. Broke slowly, fibres on under side much compressed. 2. Ditto. 3. Broken by gradually increasing pressure. 4. Ditto.
			2	·933	58·157	245·5	·70	150	223	2·20			230·29	9·808	
			3						200	2·00					
			4	1·021	63·643	241·4	·58	125	175	1·24			194·97	6·727	
			M	·973	60·67	239·3	·66	142	205·5	1·88	2·85	·691	217·34	8·632	*Mean results.*
59	Pinkwood— *Beyeria viscosa*	Diameter, 6 to 10 inches; height, 15 to 25 feet. Used for sheaves of blocks, turnery, &c.	1	·704	43·88	178·4	·56	100	195	2·20	3·93	·513	247·84	13·090	
60	Native Box— *Bursaria spinosa*	Turnery, &c.	1	·843	52·46	209·2	·50	100	198	2·00			228·42	10·171	1. Sudden short fracture. 2. Similar to last, but better.
			2	·900	56·10	191·5	·54	100	180	2·30			210·61	8·360	
			M	·871	54·28	200·3	·52	100	189	2·15	4·13	·529	219·51	9·265	*Mean results.*
61	Myrtle— *Fagus cunninghamii*	Diameter, 2 to 9 feet—average, about 3½ feet; height, 60 to 180 feet. Abundant in western parts of the island, growing in forests to a great size in humid situations. Used for house fittings, ornamental cabinet and fancy work.	1	·921	57·40	238·4	·64	150	275	2·00			257·35	12·341	1. Moderately fibrous fracture. 2. Broke very suddenly; resists compression well. 3. Short fracture. 4. Broken by gradually increasing pressure. 5. Broke quietly, through a curl or wave of the grain, nearly short across.
			2	·776	48·34	230	·44	100	200	1·80			239·15	11·613	
			3	·844	52·60	119·0	·42	50	175	1·60			214·46	8·953	
			4						140	1·40					
			5	·908	56·57	116·0	·40	50	115	1·60			167·63	5·276	
			M	·862	53·73	175·8	·47	87	181	1·73	3·68	·480	219·65	9·545	*Mean results.*
62	Native Laurel— *Anopterus glandulosus*	Diameter, 6 to 10 inches; height, 15 to 22 feet. Tolerably abundant in some sub-alpine localities. Used for cabinet and fancy work.	1	·770	48·80	153·3	·70	100	150	1·30			207·84	8·803	1. Hung upwards of one minute, when the outer part flew off. 2. Diagonal fracture. 3. Ditto.
			2	·742	46·28	108·0	·68	75	145	1·80			208·10	8·987	
			3	·737	45·94	94·3	·80	75	125	1·78			193·94	7·834	
			M	·750	47·0	118·5	·73	83	140	1·63	2·23	·593	203·29	8·541	*Mean results.*
63	Huon Pine— *Dacrydium franklinii*	Diameter, 3 to 8 feet—average, 4½ feet; height, 50 to 120 feet. Very durable. Used for boat-building, flooring, house fittings, &c.	1						163	2·20					1. Broken by gradually increasing pressure. 2. Very sudden short fracture. 3. Ditto. 4. After one minute, broke suddenly; no warning. 5. Very sudden short fracture.
			2	·512	31·88	99·80	·46	50	143	2·20			249·00	15·489	
			3	·539	33·60	96·88	·80	75	136	2·20			236·54	13·627	
			4	·512	31·88	99·98	·40	50	125	1·76			233·80	13·549	
			5	·582	36·26	87·80	·80	75	120	1·82			213·90	10·727	
			M	·536	33·4	96·11	·61	62	137·4	2·07	3·34	·451	233·06	13·098	*Mean results.*

APPENDIX C.

No. 2.—ABSTRACT TABLE showing the "Mean Results" for all the Woods experimented on, as well as the Values of a few of the Strongest and Weakest Woods experimented on at Paris in 1855, and of a few of the best-known British and other Woods, from Barlow's Standard Work on "Materials and Construction," (London, edit. of 1851). The whole arranged in the order of the values of S.

No.	NAME, &c.	WHERE GROWN.	S.G.	W lbs.	E $\frac{W'}{\delta}$	δ ins.	W' lbs.	S lbs.	δ' ins.	$\frac{\delta'}{\delta}$	$\frac{W'}{S}$	λ feet.	W″ tons.	REMARKS.
1	IRON WOOD, or RED WOOD *Erythroxylon areolatum*	Jamaica. (A small tree, but 5 or 6 ins. diameter.)	·987	61·511				468·6				324·54	18·959	The strongest woods tested at Paris, 1855.
2	BOX OF ILLAWARRA *Eucalyptus* sp.	New South Wales. (A large tree.)	1·17	72·915				432·2				286·25	13·547	Paris experiments, 1855.
3	BLACK HEART EBONY *Brya ebenus*	Jamaica	1·193	74·349				424·5				280·94	10·504	Ditto.
4	GREEN HEART *Nectandra rodiæi*	British Guiana. (Squares to 18 to 24″, and 60 to 70 ft. long.)	1·052	65·56				381·66				283·68	14·031	Ditto, from Masarima River.
5	BLACK MAIRE	North Island, N.Z.	1·159	72·29	273·0	·73	193	314·2	2·02	2·77	·614	244·90	10·014	New Zealand experiments, 1865.
6	IRON BARK	New South Wales	1·138	70·92	297·08	·64	180	282·7	1·47	2·3	·636	234·58	9·417	Paris, New South Wales, and New Zealand Experiments.
7	NATIVE MAHOGANY	Ditto	1·037	64·21	325·24	·64	183	262	1·17	1·82	·70	234·42	9·781	Ditto.
8	BLUE GUM	Tasmania	1·061	66·17	291·1	·53	139	260	2·01	3·8	·534	237·02	9·813	New Zealand Experiments, omitting the results of the curled variety, which are much too low.
9	IRON WOOD	Ditto	1·043	65·07	226·1	·56	112	260	2·55	4·55	·430	237·81	9·900	Ditto.
10	BLACK BUTT	New South Wales	·929	57·90	293·95	·57	163	253·7	1·23	2·16	·642	244·20	11·186	Paris, New South Wales, and New Zealand Experiments.
11	TITOKI	New Zealand	·916	57·10	229	·51	116	248	2·73	5·35	·468	245·03	11·22	New Zealand Experiments.
12	BLACK MAPAU	Ditto	·965	60·14	215·2	·58	125	243	2·13	3·67	·514	231·76	9·872	Ditto.
13	FOREST OAK	New South Wales	1·098	68·43	293·21	·57	168	243	1·04	1·83	·691	215·05	7·834	N.S.W. and N.Z. Experiments.
14	MANUKA	New Zealand	·943	59·0	239·5	·49	115	239	2·05	4·43	·482	234·52	10·224	Ditto.
15	PRICKLY BOX	Tasmania	·922	57·5	209·6	·61	125	237·5	2·28	3·70	·526	238·93	10·637	New Zealand Experiments.
16	BLACK WOOD	Ditto	·752	45·99	218·8	·66	139	232·8	2·10	3·18	·597	264·08	14·281	Ditto.
17	GREEN HEART	British Guiana	1·00	62·32	192·16			229·9				225·83	9·12	From Barlow's Work. Wood came from Berbice.
18	BLUE GUM	New South Wales	·973	60·66	259·6	·66	171	214·8	1·12	1·7		228·94	9·713	Paris, New South Wales, and New Zealand Experiments.
19	KOWAI	New Zealand	·884	55·11	198·05	·584	98	207·5	2·62	4·82	·487	227·97	10·236	New Zealand Experiments.
20	TAWA	Ditto	·761	47·45	203·47	·68	142·4	205·5	1·65	2·49	·711	240·39	12·204	N.Z. and N.S.W. Experiments.
21	STRINGY BARK	Tasmania	·973	60·67	239·3	·66	142	205·5	1·88	2·85	·691	217·34	8·632	New Zealand Experiments.
22	TEAK	?	·745	46·43	349·3	·188	65·67	205·17	·705	3·75	·32	247·16	12·656	From Barlow's work.

23	Towai (Black Birch)	New Zealand	·78	48·62	219·5	·503	108·8	202·5	2·32	4·32	·56	239·20	11·936	N.S.W. and N.Z. Experiments.
24	Spotted Gum	New South Wales	1·036	64·57	149·91	·58	144	201	1·18	2·03	·716	206·64	7·546	Ditto.
25	Miro	New Zealand	·787	49·07	230·24	·603	133	197·2	1·54	2·51	·675	238·20	11·777	Ditto.
26	Blue Gum*	Tasmania	1·035	64·5				196·8	1·98			200·74	8·230	New Zealand Experiments, including the results of the curled variety.
27	Rata (Iron Wood)	New Zealand	1·045	65·13	244·2	·51	93	196	2·08	4·18	·50	202·68	7·274	N.S.W. and N.Z. Experiments.
28	Pink Wood	Tasmania	·784	43·88	178·4	·56	100	195	2·20	3·93	·513	247·84	13·090	New Zealand Experiments.
29	Red Mapau	New Zealand	·991	61·82	169·88	·57	92	192·4	2·07	3·63	·504	199·6	7·184	N.S.W. and N.Z. Experiments.
30	Matai (Black Pine)	Ditto	·658	40·74	156·22	·67	103	190	2·08	3·10	·542	245·51	13·257	Ditto.
31	Native Box	Tasmania	·871	54·28	200·3	·52	100	189	2·15	4·13	·529	219·51	9·265	New Zealand Experiments.
32	Native Myrtle	Ditto	·862	53·73	175·8	·47	87	181	1·73	3·68	·480	219·65	9·545	Ditto.
33	Maire	New Zealand	·790	49·24	177·2	·64	106	179·7	1·82	2·84	·590	224·63	10·331	Ditto.
34	Oak	Britain	·752	46·87	111·31			178·66				229·56	10·868	From Barlow's Work. Mean of two best samples which had been years in store.
35	White Mapau	New Zealand	·822	51·24	166·86	·54	80	177·6	3·25	6·0	·450	210·53	8·780	New Zealand Experiments.
36	Stringy Bark	New South Wales	·933	58·18	196·16	·566	110	171·6	1·16	2·05	·641	199·97	7·515	Paris, New South Wales, and New Zealand Experiments.
37	Ash	Britain	·741	46·195	180·07			169·2				225·02	10·517	From Barlow's Work.
38	Kauri	New Zealand	·623	38·96	181·27	·56	97	165·5	1·78	3·18	·586	241·91	13·552	New South Wales and New Zealand Experiments, omitting the results of the "waved" variety, which is only an ornamental wood.
39	Rewa Rewa	Ditto	·785	48·92	195·25	·49	93	161	1·45	2·90	·580	214·43	9·205	N.S.W. and N.Z. Experiments.
40	Red Birch	Ditto	·626	38·99	116	·65	73·6	158·2	2·55	3·92	·465	233·4	12·37	New Zealand Experiments.
41	Mountain Pine	New South Wales	·703	43·85	234·7	·48	109	154·8	1·11	2·31	·698	217·03	10·582	N.S.W. and N.Z. Experiments.
42	Memel Deal	Russia	·59	36·77	116			144·25				232·88	12·625	From Barlow's Work.
43	Rimu (Red Pine)	New Zealand	·563	36·94	143·38	·663	92·8	140·2	1·76	2·65	·662	227·14	12·089	New South Wales and New Zealand Experiments, omitting the results of the experiments on the wood from Banks' Peninsula, which was very cross-grained and merely ornamental
44	Native Laurel	Tasmania	·750	47·0	118·5	·73	83	140	1·63	2·23	·593	203·29	8·541	New Zealand Experiments.
45	Mangi	New Zealand	·621	38·70	185·36	·59	109	137·8	1·27	2·15	·796	221·86	11·17	New South Wales Experiments.
46	Huon Pine	Tasmania	·536	33·4	96·11	·61	62	137·4	2·07	3·34	·451	233·06	13·098	New Zealand Experiments.
47	Totara	New Zealand	·559	35·17	124·61	·65	77	133·6	2·27	3·50	·576	226·71	12·455	N.S.W. and N.Z. Experiments.
48	Kauri*	Ditto	·638	38·96				130·88	1·54			192·62	10·624	New South Wales and New Zealand Experiments, including the cross-grained specimens.
49	Beech	Britain	·696	43·37	195·83	·168	32·8	129·66	·936	5·57	·253	203·3	8·839	From Barlow's Work.
50	Oak	Ditto	·898	55·96	127·01			128·55				178·20	5·993	Ditto. Mean of all the tabulated experiments on Oak.
51	Hinau	New Zealand	·562	35·03	200·7	·47	94	125	1·28	2·71	·754	220·10	11·766	New South Wales Experiments.

APPENDIX C.—TABLE OF WOODS—*continued.*

No.	Name, &c.	Where Grown.	S.G.	W lbs.	E $\frac{W'}{\delta}$	δ ins.	W′ lbs.	S lbs.	δ' ins.	$\frac{\delta'}{\delta}$	$\frac{W'}{S}$	λ feet.	W″ tons.	Remarks.
52	Rimu*	New Zealand	·630	39·25	133·8	·654	86·3	122·5	1·53	2·34	·704	208·11	10·300	New South Wales and New Zealand Experiments, including the cross-grained specimens.
53	Moko	Ditto	·593	33·62	93·07	·72	62	122	3·22	4·47	·508	219·67	11·805	New Zealand Experiments.
54	Cedar	New South Wales	·458	28·86	134·46	·574	74	120·75	1·565	2·72	·613	231·91	14·243	N.S.W. and N.Z. Experiments.
55	Kawaka	New Zealand	·637	39·69	136·7	·64	75	120	3·7	5·78	·625	229·38	9·364	New Zealand Experiments.
56	Kohe Kohe	Ditto	·678	42·25	208·61	·44	92	117·4	0·99	2·25	·783	195·96	8·339	New South Wales Experiments.
57	Bitter Wood *Quassia excelsa*	Jamaica. (Valuable for house work, as it is never infested with insects.)	·555	34·59				117				216·24	11·225	Paris Experiments.
58	Taraire	New Zealand	·888	55·34	205·04	·47	99·6	112·3	·67	1·42	·895	167·49	5·322	New South Wales Experiments.
59	White Pine (Kahikatea)	Ditto	·488	30·43	127·1	·484	57·9	106	2·16	4·46	·546	227·38	11·966	N.S.W. and N.Z. Experiments.
60	Cedar *Cedrela odorata*	Jamaica. (Large tree, much esteemed for cabinet and house work.)	·576	35·898				99·94				196·18	9·068	Paris Experiments.
61	Riga Fir	Russia	·745	46·46	167·77	·169	27·8	89·96	1·15	6·80	·308	163·59	5·543	From Barlow's Work.
62	Elm	Britain	·549	34·21	82·22			87·92				188·48	8·575	Ditto.
63	Yacca *Podocarpus yacca*	Jamaica. (Used for ornamental cabinetwork.)	·626	39·01				68·9				154·46	5·518	The weakest wood tested at Paris.
64	Whau (Corkwood)	New Zealand	·189	11·76	41·03	·34	13	32·0	4·00	11·8	·406	193·98	15·493	New Zealand Experiments.

* Nos. 26, 48, and 52 ought not to be taken as the values of the respective woods, as the results are rendered too low by the low values of the cross-grained varieties. Nos. 8, 38, and 43 are more fair averages respectively.

REPORT

ON

EXPERIMENTS MADE AT THE ROYAL MINT, SYDNEY, ON NEW ZEALAND WOODS.

By E. W. Ward, Captain, Royal Engineers.

The following woods from New Zealand have been tested as to their capability of bearing pressure applied to the centre while supported at the two extremities:—

Native Name.	Scientific Name.
No. 1. Kauri,	*Dammara australis.*
2. Totara,	*Podocarpus.*
3. Rata,	*Metrosideros robusta.*
4. Rimu,	*Dacridium cupressinum.*
5. Hinau,	*Dicera dentata.*
6. Miro,	*Podocarpus ferruginea.*
7. Manuka, or Tea Tree,	*Leptospermum scoparium.*
8. Mangaia,	
9. Rewa Rewa,	*Knightia excelsa.*
10. Kohe Kohe,	*Laurus kohe koke.*
11. Mapau,	*Suttonia australis.*
12. Tawa,	*Nesodaphne tawa.*
13. Tawiri,	
14. Kahika	*Podocarpus excelsa.*
15. Towhai,	*Leiospermum.*
16. Matai,	*Dacrydium.*

The above woods were sent from New Zealand, having been selected and forwarded to this colony, at the request of the Governor-General, for the purpose of experiment. Of the first four on the list, three specimens were sent; of the last three, one specimen; and of the remainder, two.

The first experiment was made with a view of obtaining a rough approximation to the value of each description of wood. The second was conducted with more care. Those woods of which specimens could not be obtained of greater scantling than 1 9-10ths inches square were subjected in the first place to a strain of 3 cwt., applied at the centre point. After an hour, the weight was removed and the effect of the pressure on the elasticity (if any) was noted. To those woods which the first trial had indicated to be superior, an additional 28lbs. was now applied, and to the remainder, 56 lbs. At the end of the second hour the examination was repeated and was followed by a similar addition of weight, and so on till the piece was broken.

To the specimens of larger scantling, viz., 1 9-10ths by 3 inches, 8 cwt. was applied in the first place, and 56 lbs. added at the end of each hour.

An arrangement was made by which the amount of deflection produced by the weight applied was multiplied on a dial. By this means, a difference in deflection of 1-20th of an inch, or a deterioration of the elasticity to the same amount, was rendered apparent.

Attempts were made by various means to determine in each case the position of the neutral axis, but without any reliable result being obtained. In the majority of cases the neutral axis appeared to be somewhat below the centre line, and within a confined limit as to weight applied, to be stationary. In some woods, however, the neutral axis was situated far above the centre. No. 5 of the table, for instance, bent like a rope round the point when the strain was applied, the fibres on the convex side elongating with readiness. In every case, the addition of weight beyond a certain point altered sensibly the position of this axis. On the whole, the results obtained were so anomalous as to induce me to abandon, for the present, the investigation of this portion of the subject.

Of the woods tried, I consider there are but six (Nos. 3, 6, 7, 8, 9, 12 of the accompanying table) which the experiments have shown to be eligible for the purpose of resisting cross strains. As I am unacquainted with New Zealand woods, it is possible that even some of those which these experiments have shown to possess the necessary quality, may not be procurable in size or quantity sufficient for building purposes. Though those woods only which I have mentioned appear, as far as I have been able to test them, to be suitable for resisting cross strains, it is possible that some of the others may possess the property of resisting compression as well as tension in the direction of their fibres. They may, for instance, prove serviceable as piles, struts, or tie beams: they may be able to resist the action of moisture and even of sea water. To ascertain the latter point, I have caused to be placed in a perforated case specimens of the woods numbered 3, 4, 5, 6, 7, 8, 9, 12, 13, 15, and have had them sunk in the harbour near Fort Macquarrie.

The value of S, that is, the constant representing the strain any particular wood can bear without fracture, is calculated for each specimen. As a means for comparison it may be stated that the value of S in the following known woods has been stated by Barlow to be as follows:—

Superior English Oak	S = 2037 to 2261
Ash	2037
Elm	1031 to 1206
Birch	1820 to 2037

I have not considered it necessary to calculate in any case the value of E, that is, the constant representing the elasticity of the wood; but the results given in the accompanying table are sufficient for this purpose, should the elasticity of any particular specimen be required.

To decide with confidence on the value of those New Zealand woods which have exhibited desirable properties, further trials would be necessary. At present I would suggest that other specimens of Nos. 3, 6, 7, 8, 9, 12 of the table, say four of each kind, in length not under 5 feet 6 inches and 3 inches by 2 inches scantling, be obtained and be submitted to further tests.

E. W. Ward,
Capt., R. Engineers.

Sydney, 1856.

RESULTS of Trials, at the Royal Mint, Sydney, of Specimens of New Zealand Woods, selected for the purpose.

No. of Experiment.	Name of Wood.	Dimensions in Inches.			Specific Gravity.	Weight which destroyed Elasticity.	Deflection by this Weight.	Breaking Weight.	Ultimate Deflection.	$S=\frac{lw.}{4\,ad^2}$	Remarks.
		Length.	Breadth.	Depth.							
						cwt.	inches.	cwt.	inches.		
1	Kauri	60	1·9	1·9	0	5	2·2	7	4·3	1715	Fibre very brittle; breaks without warning.
	Dammara australis	60	1·9	1·9	777	3	1·8	4½	3·0	1102	One of the specimens flew into five pieces.
		60	1·9	3·0	571	13	1·3	15	2·0	1470	
					674 mean.					1429 mean.	
2	Totara	60	1·9	1·9	634	5	2·3	6½	3·5	1592	Grain of wood short and coarse; wood breaks
	Podocarpus	60	1·9	1·9	0	5	2·5	5¾	3·4	1409	without warning. The specimens tried
		60	1·9	3·0	540	11	1·4	12½	2·7	1274	were fair of their kind.
					587 mean.					1425 mean.	
3	Rata	60	1·9	1·9	1106	4½	1·3	6	1·8	1470	Specimens 1 and 2 were cross-grained, and
	Metrosideros robusta	60	1·9	1·9	0	4	3	7	3·2	1715	broke short. No. 3 was a very good spe-
		60	1·9	3·0	1050	15	·75	26	2·0	2548	cimen; the fracture good.
					1078 mean.					1911 mean.	
4	Rimu	60	1·9	1·9	572	5	2·5	6½	4·4	1592	Broke very short. No grain.
	Dacrydium cupressinum	60	1·9	1·9	0	3½	2·2	5½	4·9	1347	
		60	1·9	3·0	579	13	1·1	17	2·4	1666	
					576 mean.					1535 mean.	
5	Hinau	60	1·9	1·9	562	4½	1·6	6	4·2	1470	Both specimens good of the sort. The wood
	Dicera dentata	60	1·9	1·9	0	4¾	1·5	6¼	4·2	1531	has very little power of resisting compres-
										1500 mean.	sion; and being light, is probably not durable.
6	Miro	60	1·9	1·9	957	6½	1·6	7½	1·9	1837	This is apparently a very good wood. The
	Podocarpus ferruginea	60	1·9	1·9	0	9	2·1	12¼	3·8	3001	first specimen broke at a knot; the second
										2419 mean.	was a very clean specimen. Fibre of wood good.

7	MANUKA *Leptospermum scoparium*	60 60	1·9 1·9	1·9 1·0	906 0	7 7¼	1·6 2·15	11½ 9¼	5·0 3·4	2817 2266 2542 mean.	Both specimens were clean and good. Fibre of wood good; gave good warning before breaking.
8	MANGIAU	60 60	1·9 1·9	1·9 1·9	621 0	6 4¾	2·2 1·7	7 6½	5·3 3·1	1715 1592 1604 mean.	Specimen good; fibre and fracture good.
9	REWA REWA *Knightia excelsa*	60 60	1·9 1·9	1·9 1·9	788 0	6½ 4½	1·5 1·4	9½ 7½	4·1 3·0	2327 1837 2082 mean.	Good specimen; fibre and fracture also good. Gave fair warning.
10	KOHE KOHE *Laurus kohe kohe*	60 60	1·9 1·9	1·9 1·9	678 0	4½ 4½	1·4 1·5	5½ 6	3·5 3	1347 1470 1408 mean.	One of these specimens was warped, and both worm-eaten; grain tolerably fair.
11	MAPAU *Suttonia australis*	60 60	1·9 1·9	1·9 1·9	923 0	6 4½	1·8 2	8 5½	3 3	1960 1347 1654 mean.	The second specimen was not a good one; the first was warped, but otherwise good.
12	TAWA *Nesodaphne tawa*	60 60	1·9 1·9	1·9 1·9	685 0	7½ 4½	2·5 1·1	8¼ 5	3·4 1·3	2021 1225 1623 mean.	The second piece was worm-eaten; the first was a fair specimen.
13	TAWIRI	60 60	1·9 1·9	1·9 1·9	888 0	3½ 5	0 1·6	5 6	0 2·2	1225 1470 1347 mean.	In the first trial, wood broke suddenly at a knot; second specimen cross-grained.
14	KAHIKA *Podocarpus excelsa*	60	1·9	3·0	502	7	1·1	9½	0	930	Broke very short, without warning.
15	TOWHAI *Leiospermum*	60	1·9	3·0	869	14	·9	15	3·2	1470	
16	MATAI *Dacrydium*	60	1·9	3·0	653	16	1·6	17	1·7	1666	Specimen and fibre both good.

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