(c) In order to discover what intensity of sampling would be needed, the figures for past cruises were analysed and the Coefficients of Variation assessed.

(d) The results show that a sampling method would be perfectly applicable to medium or large size cruises. A series of tests demonstrated that the errors entailed would be well within the prescribed margin.

(e) The major practical difficulty would be to assess Coefficients of Variation in advance. Various means of doing this are discussed.

(f) The adoption of such a sampling system would result in very great savings in both field and office work.

SOME NOTES ON UTILISATION OF TIMBERS IN THE SOUTH-WEST PACIFIC.

By STEWART CAMERON.

Prior to the Japanese advance South into the Pacific in early 1942 the exploitation of the milling timbers in the islands of the South-west Pacific area had been limited either to operations which, established in the more densely populated areas, cut to satisfy local demand, or to the extraction of commercially valuable woods like Laup or New Guinea walnut (*Dracontomelum mangiferum*) for which an overseas demand had arisen. In New Caledonia and in New Guinea there were several small mills of relatively modern design, whilst at Vanikoro in the Santa Cruz group, milling of *Agathis spp.* was carried on by an Australian syndicate. In many other islands, in New Britain, for example, mission stations ran small sawmills as an integral part of their organized activities to fill their housing requirements. According to the Annual Report to the League of Nations by the New Guinea Mandate Administration for the year 1st July, 1939, to 30th June, 1940, the total production in the New Guinea Territory was 3,961,884 board feet. Of this the log export in Hoppus measure amounted to 3,167,386 board feet and the export of sawn flitches to 90,990 board feet. The greater part of the sawn flitches exported and 1,911, 214 board feet of the log export consisted of *Dracontomelum mangiferum.*

As the American Forces landed in the recapture of Japanese held islands they brought with them Navy Construction Battalions and Army Engineers Units who set up portable mills, confining their cutting to accessible coastal stands, in order to produce construction and bridge timbers. In New Guinea the Australian Army started mills manned mainly by their Forestry Companies who had earlier in the war seen service in the United Kingdom and the Middle East.

Later the New Zealand Forces established two mills, one operated successively at the Matanakau River on Guadalcanal and at Lombrum Point on Los Negros Island in the Admiralty Group ; the other after cutting on Arundel Island in New Georgia and the Tenaru River area on Guadalcanal, was shipped to operate at Polmalmal near Jacquinot Bay in New Britain.

It is interesting to take note of the different methods employed by each of the three countries in the conduct of their operations.

American Mills.

Initially, the American system was to have a small portable mill of 3-5 M per day capacity attached to each Construction Unit to supply its immediate needs and to conserve the supplies of sawn and dressed oregon, redwood, ponderosa pine, etc., and plywood which were shipped from the United States for use in better class buildings of a permanent nature.

These mills in the main possessed a light carriage, often of the log-beam type, with setworks operated manually by the sawyer, a single 60 in. circular breakdown saw, a ganged three circular saw edger and a cut-off saw. Power was derived from a heavy 60-70 H.P. petrol motor for the breakdown and from lighter motors for the other individual units. In more permanent locations these basic mills were expanded and elaborated on, the more complex plants often having two carriages running back to back on parallel tracks with a log intake deck on each side of the mill and live rollers and transfers for off-bearing the timber to a green chain or sorting table of the type at Waipa State Mill. The physical labour involved in these units was never strenuous, man-handling of both logs and timber being reduced to a minimum whilst the timber turned out was always accurately dimensioned and sawn.

Inserted-tooth saws were almost invariably used in both breakdown saws and edgers. Width of kerf was of little import and the great advantage of the swaged inserted teeth lay in the fact that when cutting in shrapnel riddled timber, instead of a whole saw, if it wasn't shattered completely, having to be stripped, regulleted, sharpened and set, the comparatively unskilled job of replacing a few teeth was all that was required. In one mill, cutting in a stand near a beachhead which had been heavily shelled prior to the landing, over a period of six months the average daily toll of teeth was ten. Electro-magnetic and other detecting devices had limited use.

Wherever possible these mills were used to cut small to medium diameter trees of clear form, similar to the pole type rimu of the South Island West Coast, from stands on coastal benches and river flats. Petrol driven chain-saws were used not only for cross-cutting the logs on bush and mill skids but also in actual felling. Tractor logging was universal and the latest types of arch choker equipment were to be seen.

Logging on Arundel Island, New Georgia.

Australian Mills.

The Australian Army mills by comparison were extremely primitive. For labour, extensive use was made of New Guinea native boys under the control of ANGAU (The Australian New Guinea Administration Unit) in both bush and mill. Felling was all axe-work, the natives erecting scaffolding-like stages of saplings about the heavily buttressed trees and then gnawing around the tree beaver-wise and trusting to providence that it would fall in the direction opposite to that in which they ran as it started to sway on the under-cut stump. After the tree was on the ground the local equivalent of the traditional cry "Timber!" would resound through the bush. Under supervision, they did all the roping and breaking out for the tractors and also the loading and unloading of logging trucks. In the sawmills they did the bobbing in the mill skids, assisted on the breakdown benches, on the flitch skids and in the yard. Also they bore off the slabs and with wheelbarrows wheeled away the sawdust from pits beneath the sawbenches.

Labour saving machinery was at a premium always. Slow, heavy flat top carriages with no setworks, cutting through twin circulars, merely slabbed the logs which ranged from 18 to 60 ins. diameter and sent down flitches which, judging by N.Z. standards, were enormous, to a big 48 in.—54 in. saw breast-bench with a lever operated roller feed. Two tailers-out were employed, big timbers 12 in. x 12 in., 16 in. x 8 in. etc. being cut on this bench and the remaining offcuts sent across to a small "mosquito" breast bench with no trucks and only a small central live feed roller, the flitches being returned on dead rollers. Such a phenomenon as "double-flitching," commonly practised throughout New Zealand, was unheard of. Four men were needed for this "mosquito" bench, one heading in, another to lift the front end of the flitch into the saw and two to tail out. All saws except the lower breakdown which had four minute jets of water playing on to one side were run dry and hot in packing, for there seemed to be a prevalent idea that running a saw wet was a dangerous practice. No fence, either of the Trewhella type or the usual N.Z. pin type was used nor were any fins erected to prevent flitches being returned over the top of the saw to the danger of the sawyer. Another item surprisingly absent was the timber jack of the Price type so universally employed in New Zealand, crowbars being the order of the day on the skids and breakdown benches. However, considering the type of milling equipment they had, the Australian men did wonders insofar as output and quality of sawn timber was concerned.

In the bush, tractors were used either ground skidding or with pneumatic-tyred log carts on a pattern heavier than the Hyster D4 model and made in Australia.

New Zealand Mills.

The New Zealand mills, the initial one on Guadalcanal which was erected of improvised materials under fire being an exception,

were of a type to be found throughout New Zealand among the 8-10,000 feet b.m. per day class of bush mill. Bullock type so called "Pacific" benches with manual setworks and dogging equipment were used with twin circulars, the conventional breast-bench with live feed and return rollers and a water race to convey sawdust away. The main power unit was in one mill a Caterpillar D8 tractor with a rear power-take-off and in the other a 6 cylinder marine type Diesel with separate petrol motors for the breast-bench and the slab conveyor.

In the bush, tractors were used for the entire haul either to mill or truck loading bank, except in one operation where they fleeted the logs to a diesel powered hauler. The bush work, even discounting the oppressive humidity and heat, the ubiquitous and troublesome insect life, the stinking, often thigh-deep, mud and the restraining activities of "Wait-a-while," a hooked plant which shames New Zealand Bush Lawyer's puny efforts, was in the main much more arduous than in the New Zealand native bush. Heavily buttressed trees necessitating three and four jiggerboards, rotten limbs which tended to fall disconcertingly, and torrential rain which made all axe work, especially from jigger-boards, perhaps 15 or 20 feet up, extremely dangerous, all contributed their share.

Broadly, the natural forested areas were, on the smaller islands, three : Swamp near rivers and coasts ; a jungle type with no timber trees of value but consisting mainly of a riotous profusion of smaller trees and vines forming a dense light-excluding canopy at from 30 to 50 feet above the ground ; then the bush proper with a predominance of timber trees. Various admixtures of these types, e.g. jungle beneath an upper storey of high open spaced trees, occurred. During the war assessments with the aid of topographical and forest type maps compiled from aerial surveys and photographs, in conjunction with reconnaissance lines cut and cruised for the volume of individual species on each type area and topographical region have been extensively carried out, especially by the Australians in the New Guinea Mandated Territories.

The following is a list of the species met with by the writer : mainly in the New Guinea Territories of Manus, Los Negros and New Britain. It does not pretend to completeness nor claim to be representative of the full range of timbers found and milled in the South-west Pacific area. The reader wishing detail not given in this brief summary is referred to reports such as "The Forest Resources of Papua and New Guinea," made in 1925 by C. E. Lane Poole, to the handbooks based on this report issued by the United States Navy and Army for guidance of their sawmilling personnel, and to the works which are certain to arise and be printed as a result of the more intensive work done under the impetus of wartime needs by the Australian Council for Scientific and Industrial Research and various American authorities ; also by the New Zealand Forest Service in the South Pacific.

To anyone whose sole experience of forests has been the New Zealand native bush in its various latitudinal ranges and associations, the tropical jungle is bewildering in that it is at once disarmingly simple and disconcertingly complex. Of the myriad smaller shrubs, palms, ferns, grasses, lianes and epiphytes just how much is known botanically is doubtful. The strategic and commercial value of timber has naturally made millable trees the primary object of investigation and research.

Native names for trees and shrubs can vary from island group to island group and even in some cases from village to village. Those noted beside the botanical names here, are by usage now more or less trade names as are rimu and matai in New Zealand.

Pometia pinnata. (Sapindaceae). Native name in Rabaul area Taun, Tun or Tuun.

This is a very widespread timber tree common throughout the region. It has a clean sawing timber, reddish brown in colour with quite frequently a wavy grain, this latter feature tending to make it unpopular for rotary-veneer peeling. For general building purposes it is an excellent timber, working and nailing easily, glueing well and having reasonable strength and hardness (air dry density 33-40 lbs./cu. ft.). It has good bending properties but requires careful seasoning. In the ground it has a life of two or three years under tropical conditions. In a favourable habitat the tree yields a merchantable bole of 50 — 60 ft. with a girth of 6 —8 ft. On some small coral-base islands where, incidentally, *Calophyllum* spp. were predominating, *Pometia pinnata* was observed to grow to little more than a shrub. The young leaves have reddish pseudo-autumn tints which make the smaller tree very attractive in appearance.

Afzelia bijuga (Leguminosae). Rabaul—Kwila.

A bright yellow wood when freshly cut, turning on exposure to brown. Not only is it hard to saw and heavy to handle (A.D. density 50-58 lbs./cu. ft.), but being hard on planer knives owing to its interlocked grain it is a difficult timber to dress. However, for its excellent properties of strength, hardness, durability and low shrinkage, kwila is widely known and used for all general building purposes, for bridges and for decking. The Australians used it for reach poles in their logging trailers. As to its resistance to termite and toredo attack there is some controversy. In Guadalcanal the wood is much lighter in weight, often under 40 lbs./cu. ft.

Calophyllum Spp. (Guttiferae).

Calophyllum inophyllum ("Pink mahogany") is a very characteristic tree of the beaches of Malaya, the Indies, the Phillipines and New Guinea growing out at an acute angle over the sea and attaining maximum dimensions of 8 -10 ft. girth with a total height of 50 — 60 ft. As a sawlog proposition being often gnarled and otherwise malformed, it is not attractive. However, there are other *Calophyllum*

spp., some of which have a very sticky yellow bark exudation and which grow inland in the jungle as large erect trees 8—12 ft. in girth and with 60 — 80 ft. of merchantable bole. The timber saws easily, is clean to handle and though its open interlocking grain at times makes it difficult to work, it planes up to a distinct lustre and shows a very attractive figure on tangential surfaces. It is used for a wide range of light building and constructional work.

Alstonia scholaris (Apocynaceae).

A soft, easy cutting white timber which is very light and works and carves readily. The sapwood stains and deteriorates very rapidly in a tropical climate but the heart timber is quite suitable for interior work and crating, etc. As a plywood filler, especially if chemically treated, it should have possibilities. It, along with *A. macrophylla* and *A. subsessilis* is used by the natives for carving ornamental patterns.

Cedrela toona (Meliaceae).

This timber, not abundant in any of the areas worked by the New Zealand mills, cuts well and has an extremely beautiful appearance, being red and lustrous when dressed. It is durable, light (A.D. density in New Guinea 28 lbs./cu. ft.) clean and bends well. The writer saw many small boats made of this wood and also furniture. When freshly cut or dressed it has a distinctive fragrance.

Eugenia spp. (Myrtaceae).

These trees are widely distributed, the species growing in New Guinea, the Bismarck Archipelago and the Solomons have a timber generally red brown to dark brown in colour which is hard, straight grained and has an average A.D. density of 50-55 lb./cu. ft. Both for general building and for heavy constructional work it is widely used.

Homalium pachyphyllum (Flacourtiaceae).

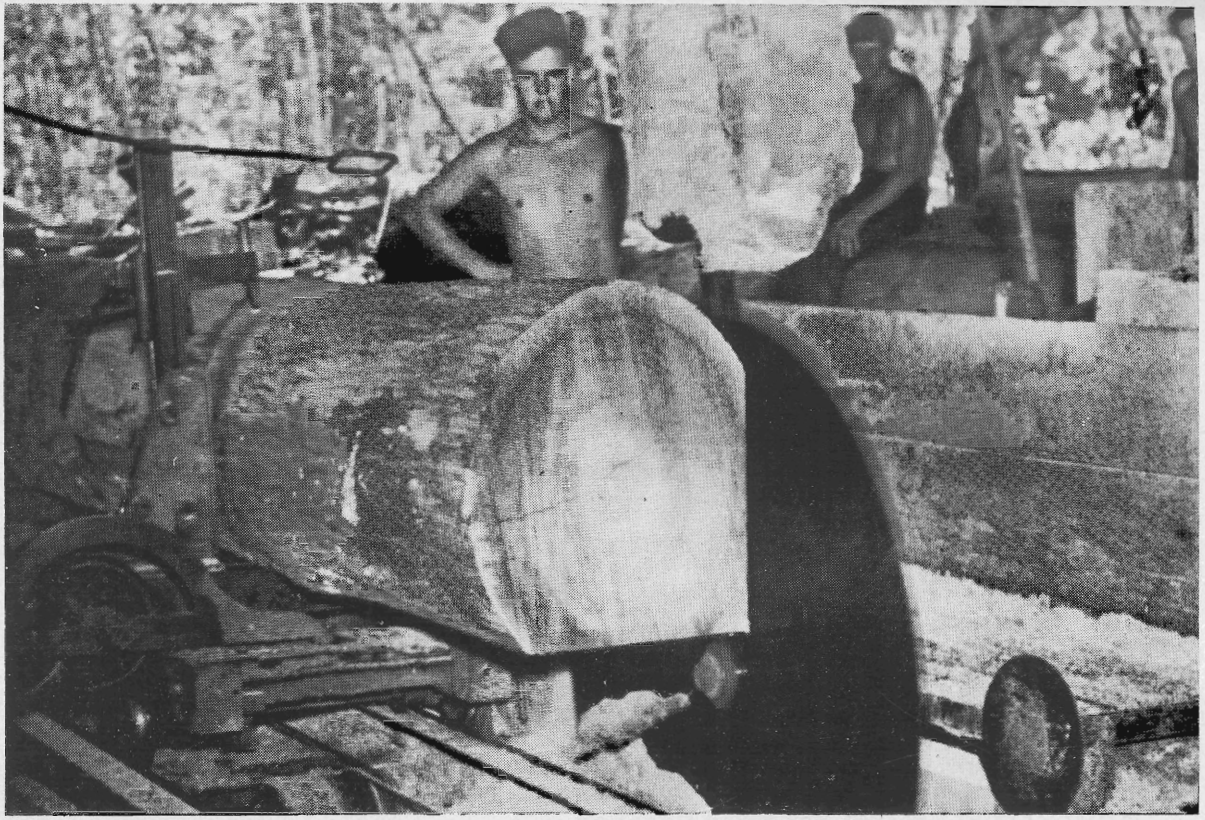
This is a heavy timber which is very hard to mill and the few trees met were instinctively avoided for that reason.

Sarcocephalus cordatus (Rubiaceae).

A distinctive wood, bright yellow to orange yellow in colour, soft, easily worked and with a characteristic greasy surface. (A.D. density 35 lbs./per cu. ft.)

Eucalyptus naudiniana (Myrtaceae). Syn. *Euc. deglupta.*

Nowhere was this seen in the large pure stands such as Lane Poole states exist at Wide Bay on New Britain, but it was noticed scattered along river valleys. Known to the New Britain native as kamarere it grows to a big tree (80 -100 ft. high, 8 -10 ft. in



New Zealand Operated U.S. Navy Sawmill on Los Negros Island.

girth). Its regularly interlocked grain makes it hard to saw and it is heavy to handle. The sawn timber is a golden-brown to red-brown in colour and in the Rabaul area it is used much for boat planking as well as for ordinary building construction.

Casuarina spp. (Casuarinaceae). She Oak.

A very characteristic coastal feature along with *Calophyllum inophyllum*, these trees, (*C. nudiflora* and *C. equisetifolia*) with the needle-like aspect of their dark green jointed leaves provide a contrast to the usual broadleaf littoral jungle forest trees.

Xylocarpus granatum (Meliaceae).

The writer did not see other than small trees of this species. The wood is a reddish brown with a silky lustre on dressing and shows very distinct ripple marks. Besides being very suitable for furniture it is also a toredo resistant wood.

Parinarium griffithianum (Rosaceae). Busu Plum.

The timber of this tree is extremely difficult to saw and the writer on two or three occasions in different mills saw logs abandoned and hauled clear of the mill sites after the breaking down of one flitch had left the saw-teeth hopelessly pitted and blunt. It is a very hard, heavy (A.D. density 62 lbs./cu. ft.) wood with a dark reddish colour. The true heartwood is often a pure red and for certain types of interior finishing and furniture it should have a wide demand.

Pterocarpus indicus (Leguminosae).

A good milling timber of medium density (45 lb./cu. ft.) and of sufficient strength for all building purposes. The heartwood is a yellow-brown to red-brown in colour and the timber when newly cut possesses an odour similar to that of *Cedrus* spp.

Dysoxylum spp. (Meliaceae).

There are several species of *Dysoxylum* found. *D. caulostrachyum* is a timber similar to New Zealand's *D. spectabile* macroscopically and in its working characteristics. Others such as *D. pettigrewianum* are heavier (A.D. density 55-60 lbs./cu. ft.) and more difficult to work than kohekohe.

Terminalia spp. (Combretaceae).

Of this genus there are many closely related representatives throughout the various island groups. In general they cut into a medium weight timber of a reddish brown colour suitable for all light construction and building. Some species, *T. catappa* for one, have a distinct lustre on finished surfaces.

Vitex cofassus (Verbenaceae).

Occasional trees of this species were milled. From general observation and handling of the green timber the impression that it is not in any way comparable with our *Vitex lucens* was obtained.

No Araucariaceae either *Agathis* spp. or *Araucaria* spp. were, so far as is known, cut by any New Zealand mill operating in the Pacific. However, the Australian mills operating in the higher altitude regions in North-eastern New Guinea cut large quantities of Hoop Pine, this loosely applied name covering both *A. cunninghamii* and *A. klinkii*. Another loosely applied term was "mangrove." To the bushman and sawmiller anything growing in a swamp, tidal or otherwise, and having a heavily buttressed stump on elevated roots, be it *Terminalia*, *Rhizophora* or *Avicennia* was a "mangrove." A species of the Verbenaceae family similar to, if not identical with the local New Zealand *A. officinalis* was to be found in many brackish mudflats along with larger trees. There was another timber of which a few logs were cut and which was often called "balsa" but was undoubtedly a member of the Bombacaceae, *Bombax malabaricum*. It is very light and the sight of one man walking about easily with a length of say 8 x 6 ins. timber balanced on his shoulder is, if nothing else, apt to amuse onlookers. Another very light timber is *Elaeocarpus novoguineensis* which naturally falls very short of hinau in strength and durability : the same comparison applies to the only *Litsea* sp. seen and mangeao, although the rough sawn timber in respect to colour and appearance was deceptively similar. A tree called by the New Guinea natives kasikasi the writer at the time took to be a *Metrosideros* species from its habit and the appearance and properties of the timber from the few small trees felled, but it appears to be another genus of Myrtaceae, *Xanthostemon*. *Sideroxylon* spp. (*S. novoguineensis* and others) resembling tawapou were seen in New Britain where there also existed a member of the Cunoniaceae family, *Weinmannia ledermannii*.

Future Commercial Utilization.

As to possible post-war exploitation of these timbers for purposes other than local construction, there is at the present time much surmise in interested quarters. That questions of national policy are involved in many cases tends to obscure much. However, it must always be realized by any operator or syndicate whether subsidized or not, that the Pacific Islands are by no means a sawmiller's Eldorado where vast virgin forests of "mahoganies" and "teaks" await harvest. With the possible exception of the New Georgia group and New Guinea with its Bismarck Archipelago the writer saw no really extensive stands of accessible milling timber. To show further that a large capital investment would be necessary to work any stand of timber in peace time, some of the problems which would have to be faced are briefly outlined.

Nothing but the heaviest, strongest and most durable of modern equipment is worth considering. Tractors for use in heavy logging must be at least equal in specifications to the Caterpillar D8, Allis Chalmers HD14 or International TD18 models, using where topography allows, heavy duty logging arches. Wear and tear on tracks and track assemblies when subject to the abrasive action of coral sand is exceedingly heavy. Wire ropes too, apart from mere mechanical abrasion and attrition are corroded far beyond the normal. Trucks, whether for logging or transport of sawn timber, must be heavy duty models of the multi-axle all-wheel-drive type perferably equipped with a front-end winch. The ordinary commercial chassis is only a liability. Under conditions of torrential rainfall, especially in areas where good roading coral or metal is not readily obtainable, road construction is costly and maintenance never-ceasing.

In the sawmill itself everything must be of the best quality, heavy enough to handle the great diversity of logs yet must incorporate as many labour-saving devices as possible to offset the adverse working conditions common to tropical climates. A good natural fall through the mill together with adequate heavy-duty live rollers is desirable. Wear and tear on saws, belting and all accessories exceeds that under New Zealand conditions. Power plant should preferably be diesel, though in suitable locations if a permanent mill was contemplated a hydro-electric plant similar to that installed at Bruce Bay in South Westland could possibly be used. Actually, beyond the possible corrosive effect of local waters on boiler tubes and the arduous task of slab-firing in temperatures of up to 100°F. there is no reason a steam plant should not be used to advantage both in the mill and in log hauling.

A well equipped workshop with heavy-duty lathes, presses and welding apparatus would be a primary essential, for in peace-time there would be no nearby Army Ordnance Depot to take heavy emergency repair jobs to, whilst a comprehensive stock of spares for all tractors, trucks and power units would have to be carried and maintained. The supply of fuel, machinery spares and food is, of course, bound up in the general question of transport to a market.

Whether timber was to be shipped to its market in log form for peelers, squared baulks, finished sawn timber or sheets of sliced veneer, transport would be expensive. Ships such as L.S.T.'s, though admirable in certain respect, are, in their present form, slow, expensive to operate and require ramps to be built if loading and unloading are to be conducted with facility. Air transport, again expensive, may not be prohibitively so within a few years when its overwhelming advantages are considered.

The seasoning of the sawn timber presents in itself a problem requiring much technical and practical consideration. Fungous attack on block stacked sawn timber is phenomenally rapid when judged by the standards of our temperate conditions. Insect infestation is equally so. Chemical treatment could be devised to combat

both these problems; perhaps in conjunction with some form of artificial drying and sealed packaging of the finished product even the difficult one of reconciling the differences in relative humidity between mill and market, could be successfully combatted, as could the end-checking of logs intended for rotary-veneer peeling.

Then there is the question of labour supply. Many of the better type of native from New Guinea, Papua and the Gazelle Peninsula around Rabaul have been employed in mills and bush before the war and during it have worked with the Australian Army, so that they are skilled in many branches of sawmilling and logging. There is a definite limit to their capabilities though, and if they are to work at all, they must be well housed, given proper food and cared for medically. Discipline and contentment must be maintained in their camps and on the job; their own conventions, codes of moral and social behaviour, conditions of family life and religious beliefs must all receive respect and consideration. They may not be worked in heavy rain nor allowed to wear clothes. Their standard of physical strength though it is, in proportion to stature, remarkable at times, is not enduring and except in rare instances they cannot be trusted to operate machinery without constant supervision. Thus a nucleus of skilled, physically fit, white labour is essential.

To induce men to work in tropical sawmills on remote islands requires the assurance of high wages, good housing and food, skilled medical care and labour saving plant.

Though administration of atebrine has reduced the malarial menace, control of the anopheline mosquito to be effective is expensive. Apart from the common ailments such as malaria, hookworm, dysentery, elephantaisis, tropical ulcers, dhobies itch, dengue, etc., sawmilling presents its own problems. The slightest cut from a saw, spragged wire rope or splinter may turn septic if not healed immediately, whilst the sap of all timbers combined with excessive perspiration produces skin irritations of many persistent varieties. The sap of certain trees even causes severe burns and blindness, whilst the writer knew of several cases of men allergic to the sawdust of particular woods to such an extent that contact with it produced weals and blisters on their skin.

Long hours cannot be worked. Five hours a day is the maximum that any white man can maintain doing heavy work such as felling or benching for any extended period and still remain fit. Camp conditions must be good and entertainment facilities such as radio, library and sports gear adequate if the men are not be become prey to ennui and general tropical lassitude. Food, much of which has to consist of special tropical preparations, must be balanced, well cooked and attractive, refrigeration facilities being indispensable. These are only a few of the problems contingent upon the employment of labour, both native and white, but even their solution involves a constant expenditure chargeable to the timber produced.

Of course, should the demand provide the incentive for sufficiently intensive research, there is the possibility that chemical and mechanical utilization of the "minor" forest products could be in itself an industry to which production of sawn timber would be merely an accessory. It is beyond the scope of this short article to predict either the shortage of hardwoods, the enhanced value of these by-products and the economical setup which would render any expensive outlay in converting the tropical jungle to the needs of temperate zone dwellers justifiable, or the extent by which white settlement may with the aid of modern science have advanced in regions at present not considered "white man's country," and thus created a local demand for wood products. Similarly, whether, aided by the rapid growth conditions prevailing, the practice of true forestry in the management either of the best stands of the existing indigenous bush or of artificially established forests of the more valuable species, will prove possible is a question which only the future can determine.

DEVELOPMENT OF SOUTHERN PINES IN AUCKLAND CONSERVANCY.

By A. D. McKINNON.

Definition.

The term "southern pine" as used in this article includes the following species :—

Pinus caribaea, More.	Slash pine.
P. echinata, Mill.	Shortleaf pine.
P. palustris, Mill.	Longleaf pine.
P. taeda, Linn.	Loblolly pine.

Location.

Artificially established southern pine stands extend over a latitudinal range of approximately 2° from Lat. 35° 14′ S. to Lat. 37° 19′ S. Situated in the North Auckland Pensinsula in four exotic forests, Waitangi, Waipoua, Puhipuhi, and Riverhead, and in South Auckland at Maramarua, Kauaeranga and Tairua Forests, with a small outlier at Great Barrier Forest, upwards of 80% of the planted area is to be found at Waipoua and Tairua Forests.

Area and Age Classes

Southern pine plantings cover approximately 5,000 acres of which 72% comprise pure stands, 6% mixtures of southern pines, while the remainder 22% consists of mixtures with other species. Only 10%