THE ESTABLISHMENT OF A PINE PLANTATION IN WESTERN AUSTRALIA

A comparison of methods used in the Hills and Coastal Plains.

A dissertation submitted for the degree of Bachelor of Science in Forestry at the University of Western Australia.

Submitted by D.J. Keene - 1965.

CONTENTS

INTRODUCTION

The demand for timber, and other products derived from wood has shown and will continue to show a marked increase. In Australia, the native hardwoods have relatively slow growth rates. Although it will be possible to improve the future yield from our existing forests by improved management and silvicultural techniques, the long rotation needed to produce a commercial log does little to alleviate an anticipated shortage in the future. In an attempt to ensure that a "timber famine" does not occur, and also to reduce the amount of softwoods at present imported into Australia, extensive areas of pine plantations have been planted in this country.

The first large scale plantations were established in South Australia, and at present all states have embarked on a programme of softwood plantations. In Western Australia the earliest plantings took place at Hamel and Ludlow at the beginning of the century. Only moderate success was experienced, but since that time improved selection of species and strains and better establishment techniques have led to the development of successful stands of Pinus pinaster (on the coastal sand) and Pinus radiata (On the better soils in "hills plantations").

The author has been stationed both at Nannup (a hills plantation) and at Wanneroo (where pines have been established on the sandy coastal plains). This dissertation will attempt a comparison between methods of conversion of areas from their native states to re-afforestation with exotic softwoods, both in the better class soils and on the poor sandy soils of the Swan Coastal Plain.

Section II SOIL SURVEY

(i) GENERAL

As the cost of establishing a plantation is very high, it is imperative that only areas of land of undoubted suitability be developed. To avoid planting on unsuitable sites (with consequent risk of failures), the first step in pine establishment is a soil survey of the area.

The soil associations occurring in the hills plantations vary greatly, both among themselves and from the soils occurring on the coastal plains. This complexity of distribution of soils in the hills region makes detailed soil surveys a necessity. A number of broad divisions, based on the nature of the parent material from which the soil was derived, are recognised and used as mapping units. This will be discussed more fully later.

By contrast, the soils of the coastal plain do not display the same diversity. They are sands of varying ages of aeolian origin. A soil survey on the coastal plains in consequence may be more extensive in character. The division between yellow and grey sands, and the depth to limestone in the profile are delineated, while topography plays a larger part in determining the boundary of plantable soil.

This latter factor is especially important on the grey sand dunes.

It can be said that generally a soil surveyor is aiming to delineate the boundary of soil which will support a commercial crop of P.radiata in the hills region and a commercial stand of P.pinaster on the coastal plains.

(ii) PINUS RADIATA SOIL SURVEY

As mentioned in the introduction to this section the classification of forest soils which are suitable for the growth of P.radiata is based on the parent material from which the soil has been derived. The main groups which are recognised by Forests Department surveyors are:-

Granitic
Basic
Lateritic
Alluvial
Metamorphic

The last named group is prevalent in the Blackwood Valley. The soils which are included in this association are heterogeneous in colour and sharp changes frequently occur. They are often designated as "Acid Metamorphic" soils.

Soils belonging to the "granitic" group are derived from parent rock which is of an acidic nature. The colour of the soil profile is typically a yellow or grey-brown soil as opposed to the "Basic Soil" profile which is designated as a soil predominently red in the A_2 and B horizons. The basic soil is derived from parent rock with a high ferro-magnesian content, such as a dioritic rock.

A major percentage of the soils in these three groups are suitable soils for the growth of pines. Each group is sub-divided into three divisions (or phases) by the soil surveyor according to his assessment of their suitability for pine growth. These consist of: (a) obviously suitable
(b) doubtful
(c) unsuitable

The "soil line" or boundary of plantable soil marked in the field is usually located within phase (b). Within the basic soil type the boundary occurs towards the lower limit of the phase; while within the granitic soil type, the division is generally found towards the upper limit.

The lateritic soil profile is complex in that lateritisation of profiles has occurred in recent times and could be a continuing process.

The ancient laterite forming the "ironstone" capping on the ridges of the Darling Scarp is obviously unsuitable as a P.radiata soil. However the limit of the "lateritic group" is difficult to define.

In efforts to achieve a measure of uniformity in the selection of "what constitutes a pine soil", the value of a quantitative indicator is very high. It has been established that the level of phosphorus in the form of P_2O_5 in the top 4" of the profile has a marked correlation with the ability of the site to support a commercial crop. At present the minimum acceptable level is 250 parts per million of P_2O_5. Forests Department policy lays down that soil samples must be collected for analysis in each area, the number being determined by the complexity of the soil associations.

The procedure carried out while conducting a soil survey will be briefly outlined. The survey usually covers an area which is either within existing State Forest, or is private property which has been offered for sale. In each case a preliminary recconnaissance is made before the detailed survey proceeds. The inspection eliminates areas of obviously unsuitable soil type and is also an aid in determining the method and intensity of the detailed survey. Soil samples are sometimes also taken at this stage and the resultant P_2O_5 levels guide the surveyor in the detailed survey.

The immediate aim of the soil surveyor is to produce a report and a soil map, which demarcates the boundary of plantable soil; the position and extent of each soil type; and showing topographical features such as ridges, creeks, steep slopes and rock outcrops. To achieve this objective the soil surveyor utilises the soil groups and phases described above, and may subdivide these phases further so as to arrive at series of homogeneous soil mapping units.

A grid system of strip lines is laid out, the grid distance determined by the complexity of the soils in the area as seen from the recconnaissance. A common pattern is for a 20 chain grid of strip lines running across the topography tied to each other and to as many fixed points as possible. Inspection holes are exposed at 5 chain intervals along the strip lines. Accurate field survey work increases the usefulness of the resultant plan. While conducting the soil survey, the officer also usually makes notes on the vegetation present, with particular emphasis on merchantable timber present. The location of fences, tracks and topographical features are recorded in the field book, while if the survey covers private property, areas of cleared land and other improvements are also noted.

The soil plan is drawn up from the surveyors field book (or map) using conventional symbols - see attached example. Soil samples are best collected from the centre of each soil type and are thus taken after the field work and plan are completed. A soil surveyor must also write a report of the soil survey. It is submitted for approval with the plan and consists of notes of the area covered and soils encountered. (Forest Department Circular).

Once the completed survey and soil plan have been approved, the boundary of plantable soil is marked in the field. This is usually done by the soil surveyor. The boundary thus established is the limit of all subsequent conversion operations, although the external plantation firebreak is sometimes constructed outside the soil line. A pine working plan proposal may then be drawn up covering the suitable land.

(iii) PINUS PINASTER SOIL SURVEY

At the foot of the Darling Scarp lies the Swan Coastal Plain. This relatively flat area is comprised of five geomorphic elements, namely the Ridge Hill Shelf, Pinjarra Plains, Bassendean Dunes, Spearwood Dunes and Quindalup Dunes.

The land available for pine plantations north of Perth (the Wanneroo Division) is comprised of the Bassendean, Spearwood and Quindalup Dunes. The other elements of the Swan Coastal Plain will not be considered further, except to note that the Ridge Hill Shelf is comprised generally of residual laterite over yellow sand; while the Pinjarra Plain is composed of a complex of eight depositional soil systems of varying ages and soil types which may be broadly described as podsolic or undifferentiated alluvial soils.

Pinus pinaster has been successfully grown both on the Bassendean Dunes and Spearwood Dunes. The Bassendean Dune System, occurs to the west of the Pinjarra Plains, and is composed of dunes of silicious sands interspersed with poorly drained areas. It is considered that the Bassendean Dunes are the oldest of the dune formations and hence have become podsolised to a higher degree than the Spearwood and Quindalup series. The continued leaching has removed the carbonates from the profile and an iron podsol soil is typically found.

Often iron has been leached from the upper horizons and deposited as a layer of 'Coffee Rock' in the B horizon. This is associated with a fluctuating water table in the flatter, more poorly drained areas. In the better drained areas, iron has been leached from the profile.

The Spearwood Dune Sytem occurring to the west of the Bassendean Dunes is intermediate in age and consists typically of podsolised sands. The profile consists of deep yellow sands overlying travertine limestone. In places the sandy horizons have been eroded away leaving limestone outcrops at the surface.

The Quindalup Dunes are the youngest dunes and the carbonates are still more or less uniformly distributed throughout the profile which may be described as undifferentiated calcarious sands.

These extremely poor soils of the Bassendean and Spearwood Dunes are deficient in many trace elements and the addition of superphosphate is essential. Thus the method of selection of suitable sites for pine establishment differs from the phosphorus determinations used in the hill plantations.

The major factor to be considered when establishing P.pinaster stands on the deep grey sands of the Bassendean Dunes is the presence or the absence of the "Coffee Rock" layer.

It has been found from numerous pine plots, and from the large scale plantation established at Gnangara that Pinus pinaster, the only pine species successfully grown on the dune sands to date, rarely flourishes on sites which do not contain a hard pan in the profile. The best results are usually obtained when the Coffee Rock is present from three feet to twelve feet below the surface. As it is only present in flat areas and not on the excessively drained sand dunes, the task of selecting suitable sites is simplified.

The use of aerial photographs and field inspections enables the flats to be delineated easily from the dunes. In the past, areas of low and medium sized dunes have been planted unsuccessfully and present practise is to leave unplanted any higher ground.

The soil surveys for potential plantations on the yellow sands of the Spearwood Dunes varies from that on the grey sands. The carbonates have not been leached from the profile completely, but remain as deposits of travertine limestone; while the iron is still spread more or less evenly through the profile. Thus the "Coffee Rock" formation typical of promising soils of the Bassendean System in absent.

Planting of P.pinaster on the Spearwood Dunes, although not as yet as extensive as those on the grey sands, have indicated that successful growth will occur if an horizon of yellow sand of at least 20 feet overlays the limestone.

The topography does not appear to be such a limiting factor for satisfactory growth in the Spearwood System. Where a difference of a matter of inches in height could cause a severe falling off in site quality in the Bassendean System, successful plantings may be obtained on undulating topography on the yellow sands. Generally the higher dunes are capped with the residual limestone, or have been denuded of some of the depth of sand, rendering them unsuitable for planting. Aerial photos are therefore again a useful adjunct in selecting suitable areas.

Thus the soil surveys which have been conducted on the coastal plains are extensive in character rather than the intensive method in the hills plantations. However numerous strip lines and test bores have been made by the Forests Department. A large series of pine pilot plots covering various topographical situations on both dune series have been established for a number of years. These provide valuable information as to the suitability of the sites.

The sandy soils of the Swan Coastal Plain are very poor in nutrients and superphosphate is a necessary addition for satisfactory growth. On the yellow sand an admixture of 10% zinc in the form of zinc oxide is added to the superphosphate, which is spread at time of planting. Experiments with trace elements have been instituted to further improve growth, but further detailed work appears necessary to achieve maximum productivity.

Section II SUBDIVISION

(i) INTRODUCTION

The normal procedure within the Forests Department of W.A. is to submit a plan of the soil survey for approval.

Once the soil survey has been approved subdivision proposals may be instituted. This entails drawing up the plans for the future plantation. Included is the broad scheme of large blocks with intervening buffer strips. Within the blocks the position of major roads, internal "feeder" roads and ultimately the position of each compartment break are determined.

Before proceeding with the details of subdivision, it is thought that a brief discussion of the merits of this breakup of the plantation area should follow. Within the native forests of the state, the forest area is broken up into blocks of some hundreds of acres, with an occasional internal track. Little thought in the past has been given to subdividing blocks into small homogeneous areas or compartments except where intensive work such as thinning has been instituted.

However access is a most important consideration in the plantation. It is necessary for:-

(a) planting
(b) subsequent tending - cultivation, sucker-bashing, pruning, etc.
(c) protection from fire
(d) access for thinning

With a large amount of finance being spent in a comparatively small area it is necessary to transport men, plants and equipment close to the site. However the provision of access is even more important as "insurance" against the outbreak of fire. The cost of construction of roads especially in the hills plantations is high. It has been found from experience that the time taken to reach an outbreak of fire in a plantation must be kept to an absoluteminimum if damage and loss are to be curtailed. If a fire does become established, the more roads and tracks which are in its path, the greater the chance of controlling it rapidly. Thus it is felt the expenditure on road construction isjustified.

(ii) HILLS PLANTATIONS

A large percentage of land available for pine planting on the rich loamy soils is situated on very steep topography. This is especially so in the Nannup Division, where the bulk of the suitable land has been repurchased from private farmers. The agriculturalists found it difficult to farm the upper slopes of the Blackwood Valley economically because of the steep rocky terrain.

Thus there are inherent difficulties in subdivision in most hills plantations. The copy book chequer board layout of compartments is impossible to obtain. The initial breakup into blocks usually follows a topographical feature. Wide buffer strips are left unplanted between the blocks and as ridges are often capped with lateritic outcrops they are obvious choices for boundaries . Not only is the buffer on unplantable soil, but the ridge tops allow easier construction of roads of a satisfactory grade. Buffer strips are otherwise located on more rocky terrain or poor soil types. In the hills plantations with heavy and expensive clearing, buffers are left uncleared. These buffer strips which may be 20 chains or more in width are a necessary adjunct in fire control as a fire would be stopped by a clean buffer strip.

Each block is divided into a series of compartments. These compartments are theoretically of similar size of about 40 acres, but in practise range in sizes up to 100 acres or more. It is thought that it is more important to have a trafficable boundary (at least to tractors) round the compartments, than to arbitarily mark off say 40 acre sections.

All roading and compartment breaks are roughly mapped out in the field, and submitted as a pine working plan proposal before any clearing is done. After the site has been prepared for planting, any compartmentbreaks which have not been made roads, are pegged in the field together with the extraction tracks, selected for easier access through each compartment.

The roads through the plantation are more than the normal forest tracks. Costing up to £400 per mile to construct with heavy earthmoving equipment each road has to be carefully selected and pegged on a grade line. This price does not include gravelling. The maximum permissable grade on these major access routes has been fixed at 1:10. Typically a major road is selected approximately following the boundary of plantable soil; which is frequently on the upper slopes. Other major roads follow the valley floor, and along the contour of the mid slopes.

The network of major roads is usually completed by the construction of a major road from the valley floor to the ridge top.

A further difficulty with roading in the steep topography (the natural angle of repose appears to be approximately 1:3) is the problem of drainage. Surface run off on the freshly cleared hillsides causes serious erosion until the pines become established and unless adequate provision is made for the drainage to the roads, land slips and scouring of the shoulders is a problem.

The subdivision is completed by leaving unplanted a net work of compartment breaks which are usually on a steeper grade than major access ways. Made roads are not constructed here, but the breaks are kept clean by spraying with weedicide.

(iii) COASTAL PLANTATIONS

Subdivision of the flat topography of the Swan Coastal Plain does not present the same difficulty or expense as that in the Hills Plantation. In fact at Gnangara the "text book" design of compartment layout may be followed.

After the unplanted dunes have been demarcated the area to be planted is measured up and break positions arbitarily determined to give approximately equal area compartments. In the past large continuous areas have been planted with pines and few buffer areas were left. ~~As well as allowing potentially increase fire danger, areas were planted which yielded poor results.~~ A programme of "conversion to buffers" has recently been undertaken to split up the plantation into smaller management units. Strips of poor quality or failed pine have been fallen or burnt. Present policy is to separate areas of about 1000 acres by strips of natural banksia vegetation of 10 to 20 chains in width. In some cases the buffer zone has been fallen and is now kept regularly burnt.

Each block is subdivided into compartments with unplanted breaks between each. Unplanted extraction rows are left at 2 chain intervals and "cross tracks" are put in by ploughing out the young pines at intervals at right angles to the extraction rows. This leaves the plantation broken up into an orderly pattern of small divided areas, which facilitates extraction of thinnings and as a fire control precaution.

The only expensive facet in the provision of access in the sandy coastal plantations is the provision of surfacing material for the main extraction routes. Gravel deposits are absent in the district and use is made of crushed limestone rubble, or diatomitic earth to provide a firm foundation on the sandy soil.

Section III GROUND PREPARATION

(i) GENERAL

This section will cover the stages of development of an area from undeveloped land to its readiness for planting. The process usually takes about three years and consists of pushing down, burning and ploughing. The effectiveness of the preparation of the site for planting has a large bearing on the success of establishment. This applies especially on the coastal plains, where the slower growing Pinus pinaster requires a langer period to dominate the site and suppress competition. Proteateous shrubs always compete vigerously with the young pines necessitating re-cultivation between the rows. The problem is accentuated if the ground preparation is not thorough, and growth may be seriously retarded in the initial years.

(ii) HILLS PLANTATIONS

The native vegetation on the fertile soils consists of a dry sclerophyll forest of jarrah (E. marginata) and marri (E. calophylla) as the major species. Since jarrah is a valuable commercial species all millable timber, together with poles and piles, and any other utilizable material is removed as a first stage of clearing.

Often the site forms part of a permit area, and the permit holder has the right to remove all merchantable timber from the area to be cleared. The only restrictions which are usually placed on falling is that operations must remain within the demarcated boundary of plantable soil; and trees are left standing on the route of proposed roads. This latter provision facilitates road construction by reducing the number of stumps to be removed. Once these trees have been pushed over, any mill logs are then recovered as a salvage operation.

In the Nannup Hills Plantations where much of the proposed plantation area has been repurchased on the open market, the salvage of this merchantable timber, helps to offset the purchase price of the land.

After the removal of useful timber, remaining uncommercial species and useless trees are removed. As large areas, beyond the scope of Departmental equipment, are involved, contracts are often let to private concerns. The contract usually calls for pushing down the trees only. It is present policy for a "broadcast" burn to be carried out, which necessitates leaving the fallen trees scattered over the area, instead of "windrowing" (stacking the logs in parallel heaps).

The cleared area is left for approximately three years to thoroughly dry out before the burn is put through. With the heavy timber involved a number of large partly burnt logs are left after the passage of the fire. These logs are pushed together and burnt. The use of the windrow technique would largely eliminate this restacking with consequent reduction in the hand labour required in picking up. However it is argued that a broadcast burn is more effective in removing undergrowth which would compete later with the young pines. The accumulation of ash beds is also less with a broadcast burn, while a fault of the windrowing technique is that the nutritious topsoil often becomes scraped into heaps with the logs.

The ground to be planted is ploughed in the autumn before planting. Ploughing is considered necessary especially on former pastures where grass competition is often detrimental to the growth of the young pines. In the steep topography of the Blackwood Valley a complete ploughing is difficult to achieve. However, all but the most inaccessible areas are ploughed, the Connor - Shea plough drawn by a small crawler type tractor being the basic unit used. The area is now prepared for planting.

(iii) COASTAL PLANTATIONS

A low woodland composed primarily of banksias (Banksia grandis) interspersed with coastal blackbutt (E. todtiana) is the typical vegetation type found on the sandy coastal plain. The swampy areas of the grey sand dune areas are usually covered with paper bark (Melaleuca Sp.) and blackboys (Xanthorrea Australis). Stunted Jarrah and Marri also occur, while Tuart (E. gomphocephala) occurs on the limestone soils. There are few mill logs on the area, and clearing costs are very low compared with those of radiata areas.

In the past the method of clearing has been by "logging", which consists of pulling a long pole behind a bulldozer. This method was reasonably successful but a subsequent treatment of "scrub rolling" prior to the burn was essential. The latter operation crushed understory vegetation and protruding limbs and branches using a large hollow steel roller, which facilitated a hotter fire.

Recently however, the pushing down has been let out on contract. The contractors using two large bulldozers equivalent in size to a Caterpillar D8, model, linked together by about 100 yards of heavy gauge chain. The tractors travel abreast approximately three chains apart; this distance varying with the size of trees to be removed. The heavy chain uproots each tree crushing it as the chain is dragged alongthe ground.

The undergrowth is also pounded flat by the chain, eliminating need for subsequent scrub rolling. The cost of this operation is of the order of 10/- to 15/- per acre.

Ploughing is carried out mainly by using a large Chamberlain agricultural type plough, while a Connor - Shea plough is used on areas of dense undergrowth such as blackboy flats. As mentioned previously, ploughing is essential to combat the competition from native shrubs.

Section IV PLANTING PROCEDURE

(1) GENERAL

The procedure for planting pines varies little between P.radiata and P.pinaster areas of the state. In each case one year old pine seedlings raised in Forest Department Nurseries are used. Planting cannot commence until the opening seasonal rains have been received. This usually occurs early in June. The planting takes approximately 2 months to complete, dependant on the acreage to be planted.

Certain precautions have to be taken to ensure maximum survival rates. The most important is that the roots of the pine seedling must not be exposed to the air more than necessary and allowed to dry out. To this end, the time taken between lifting and planting is kept to a mimimum; the plants are kept covered and sheltered from the wind and sun. In the heavy radiata soils care must be taken in planting to avoid air pockets at the base of the pine roots. Especially during "notch" planting by hand air pockets are left, causing the young pine roots to dry out and die. Bags used for transporting pines must be kept wet. Planting is carried out only on suitable days and dry and windy days are avoided.

(ii) PINUS RADIATA PLANTING

Planting is carried out both by hand and with machines. Machine planting is generally favoured as approximately three times the output can be achieved above the hand planting rate. However, when comparing rates it must be considered that machines are used on the better areas while hand planters must contend with less favourable sites. The use of machines has increased greatly in recent years due to technical advances. The cost of operations is reduced, while the standard of planting, (and subsequent survival) can be maintained so long as strict supervision of operations takes place.

The planting machine used is a Lowther machine which is designed to be mounted by three point linkage and pulled by a Ferguson tractor. The unit is easily manoeverable and can be lifted clear of the ground to avoid rocks and other obstructions. It can be used on moderately steep slopes. Operated by a tractor driver and a planter, the planting machine is used on the easier topography where long runs can be obtained.

Hand planters, usually formed into small gangs of two planters and one plant carrier, are utilised on the steeper slopes and rocky areas inaccessible to the planting machine.

(iii) PINUS PINASTER PLANTING

The flat coastal plains provide an ideal medium for the use of mechanised means of pine planting. A Lowther four wheeled trailing type machine was originally used. This type has been modified at Gnangara to run on two wheels and has an hydraulically controlled share and coulter unit. These machines may be mounted in pairs to the draw-bar of a Chamberlain tractor, or drawn singly behind a smaller tractor (e.g. Ferguson 35). The single machines are used on stumpy areas where greater manoeverability is required.

On the level ground, runs over one mile may be achieved without turning, which improves efficiency. Hand planting is very seldom necessary and is carried out by the same procedure as for P.radiata.

Prior to planting in the sandy soils, a process of "furrow lining" is usually carried out. This consists of marking out the planting lines with furrows about 6 inches deep. The furrow lining implements are mounted in pairs at a distance apart equal to that of a pair of planting machines. The furrows usually are made at right angles to the original ploughing and serve a dual purpose besides guiding the planting machine.

Firstly the furrows accumulate rainfall into the line where the pines will be planted. This is important in the sandy soils where water is not held in the profile over the summer months. The channels give a greater amount of water along the planting lines than would normally be received. Scrub competition has already been described as being severe. The process of furrow lining aids in the elimination of competition alongside the young trees, especially in the first year after planting. As subsequent recultivation is unable to remove scrub in the planting lines, this is of special significance.

Pine survival counts are taken and refilling carried out the following year if necessary. Counts are also carried out in P.radiata planting.

CONCLUSION

The steps in the conversion of an area from native forest to an exotic pine plantation have been detailed. Any differences in procedure between the development of a coastal area and a "hills" area have been noted.

Large amounts of money are expended annually in Western Australia on the plantations. This expenditure is thought justified since the natural hardwoods can no longer supply the timber requirements of the state. Considering the great fire danger involved in rearing a commercial crop to maturity a purely business approach may perhaps condemn such large scale planting. This applies especially to the coastal plain where the slower growing Pinus pinaster takes longer to reach the rotation age. If interest was charged on the capital outlay the time taken to recoup the establishment cost must be minimised. Taken from a national viewpoint however, the value of this contribution to the timber supplies of the country should not be under-estimated.

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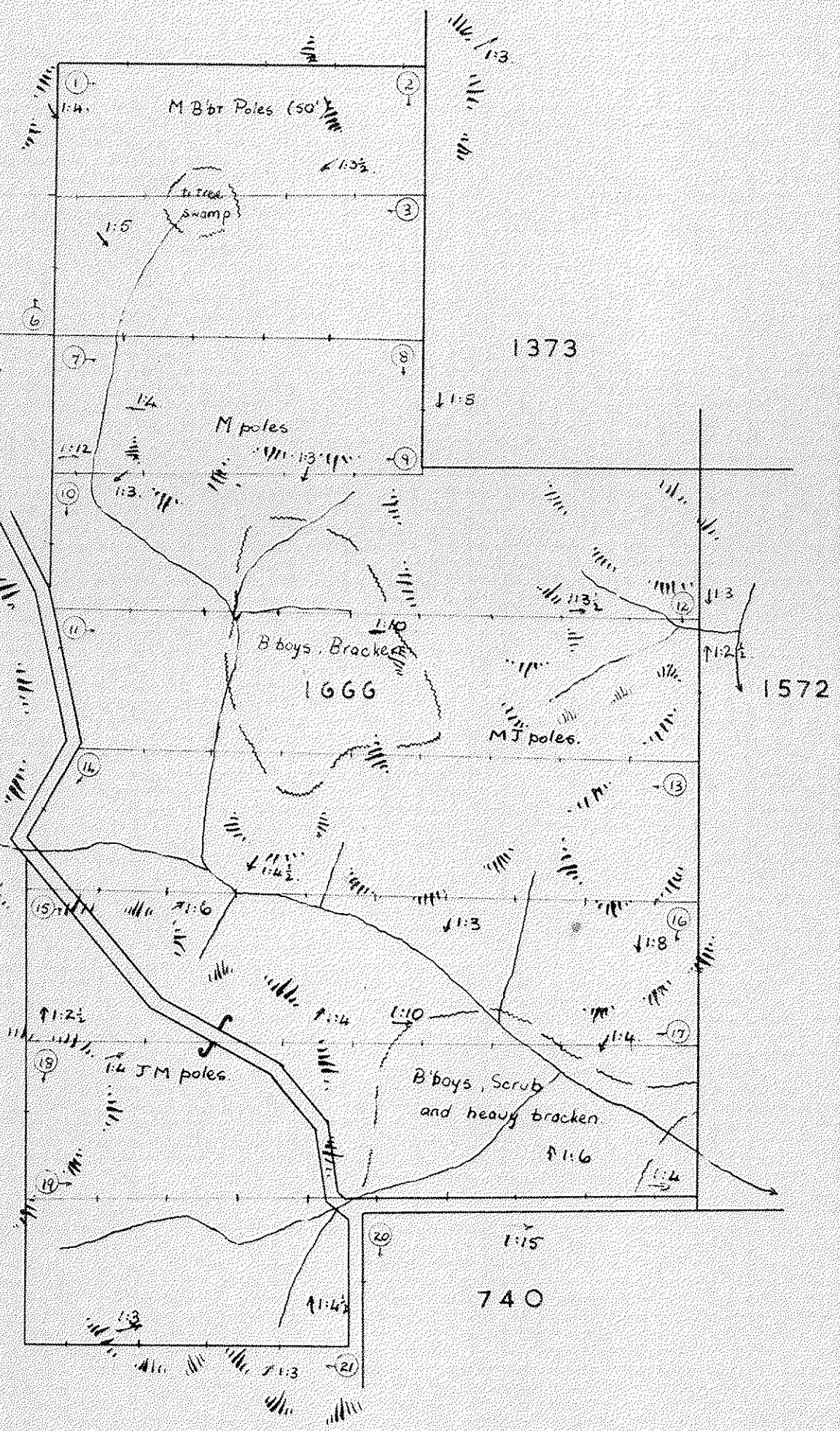
ADFO Keene

SOIL SURVEY -

PL

VEGETATION PLAN



LEGEND

- BASIC (RED)
- GRANITIC (BLUE)
- LATERITIC (YELLOW)
- UNSUITABLE (BASIC OR GRANITIC)
- DOUBTFUL
- SUITABLE (NO ADDITIONAL SYMBOLS OVER HACHURING)
- 4 AUGER HOLE
- 7 PIT
- STRIPLINE — SHOWING INSPECTION POINTS
- TIE POINT
- FN 79 3 REFERENCE TREE
- TYPE BOUNDARY
- PHASE BOUNDARY
- PROPOSED LIMIT OF PLANTABLE SOILS
- STRIPLINE REFERENCE NUMBER
- VEGETATION CHANGES

FOR CONVENTIONAL SIGNS USED ON TOPOGRAPHICAL SHEETS SEE P.35 PAMPHLET No. 10.

FOR A.P.I. CONVENTIONAL SIGNS SEE LEGEND ON EACH SHEET

SCALE: 10 CHAINS = 1 INCH

FIELD WORK ADFO D.J. KEENE

DATE 9th JAN., 1964.

BLOCK	1666
ACIDIC	183ac.
BASIC	159ac.
TOTAL	342ac.