MANUAL OF REFORESTATION AND EROSION CONTROL FOR THE PHILIPPINES

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MANUAL OF REFORESTATION AND EROSION CONTROL FOR THE PHILIPPINES

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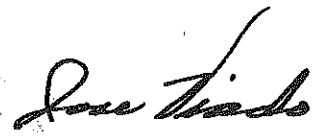
Foreword

Centuries of misuse for lack of knowledge on the proper conservation of our forest resources has led to the denudation of over five million hectares of our forest lands causing severe erosions. These are mostly located in critical watershed areas of our principal rivers, thus, making reforestation and erosion control of utmost importance.

The training in reforestation and erosion control in our country is therefore, timely and relevant to the current national development program launched under the leadership of President Ferdinand E. Marcos. This program has become a major project of our government and it has to succeed if we want to achieve national progress.

This MANUAL ON REFORESTATION AND EROSION CONTROL for the Philippines, the first of its kind ever published, will serve as a guide and a valuable reference for foresters and for those engaged in reforestation and erosion control in the country. It is the product of the joint efforts and cooperation between the Philippine counterparts and the German consultants sent by the German Agency for Technical Cooperation (GTZ):

The book itself, is by no means complete but definitely is an answer to the lack of reference books well adopted to Philippine conditions and serves as a monument to the most productive relationship between the German Agency for Technical Cooperation (GTZ) and the government of the Republic of the Philippines through its Bureau of Forest Development.



JOSE VIADO
Acting Director
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PREFACE OF THE AUTHORS

The layout of this book originates from lectures held by the authors during a six years training programme at the PHILIPPINE-GERMAN TRAINING CENTER FOR REFORESTATION AND EROSION CONTROL at Baguio City sponsored under the Technical Assistance Programme of the Federal Republic of Germany.

The training programme had been designed as a refresher course for the field personnel of the BUREAU OF FOREST DEVELOPMENT, mainly on the ranger level, and emphasis was more on the practical side.

Special effort was made to adapt useful procedures developed in temperate countries to tropical and especially Philippine conditions. As a result we feel, that the procedures described in this book may also be of interest to foresters of other tropical countries with related problems.

The authors have to acknowledge gratefully the cooperation of Mr. Herminio Boado who typed the final draft of this book in a non-stop effort and the patience of Mr. Conrado Consul and Mr. Julius Unciano in the preparation of the numerous illustrations.

THE AUTHORS

P A R T I

INTRODUCTION TO PHILIPPINE FORESTRY

TH. HOENNINGER

Chapter 1:

GEOGRAPHICAL SITUATION

1.1 General Remarks

The entire Pacific Basin from Kamchatka south to Japan, Taiwan, the Philippines, Indonesia and on through New Zealand owes much of its development to a vast and exceedingly complex series of stress lines, along which faulting, folding, and volcanic and earthquake activity have taken place.

The most important fault line lies across North Central Luzon. It crosses the Bicol Peninsula, continues southward through the mountains of Eastern Mindanao. A belt paralleling this fault line is marked by many of the highest elevations in the Philippines as well as by numerous active volcanoes. A less pronounced fault line runs from SW to NE connecting Borneo and SW Luzon through the 400 km long island of Palawan. Still another reaches from Northeast Borneo through the Sulu Islands into the tail-like Zamboanga Peninsula.

Much of the present day pattern of island distribution and of local mountain building has resulted from the fact, that the Philippines is situated in a zone of convergence of several Pacific mountain building zones. Pronounced recent movement along these lines is demonstrated by the limestone consisting of coral, which is now lying at considerable elevations on numerous islands in such diverse locations as Palawan, Mindanao, Cebu and Northern Luzon.

The archipelago consists of 7,100 islands, of which only 2,773 have names. The northernmost point, Y'Ann Isle is situated

125 km from Taiwan, the southernmost point, Saluag Island is only 55 km from Borneo. The total land area of the Philippines is 300,000 square kilometers. The irregular coastline stretches 17,400 km, twice as long as the coastline of the United States of America.

Luzon, the largest island, is larger than Portugal. Mindanao, the second largest island, is larger than Austria, and Samar, the third largest island, exceeds the size of Cyprus.

The highest mountain of the Philippines is Mt. Apo (2955 m) in Mindanao. The lowest spot in the world is the "Philippine Depth", situated east of Mindanao. It is 11,500 meters deep, and the Mt. Everest, the highest Mountain of the world, could easily be submerged in it.

1.2 Luzon

The mountain ranges of Central and Northern Luzon form the outline of an upright "Y" with an outlier parallel to the main arm of the Y on the west coast, the Zambales Mountains. Along the east coast the mountains border directly the Pacific Ocean and leave only small patches of level land consisting mostly of Tertiary and Quarternary sediments. The mountains collectively known as Sierra Madre extend with only one break (southwest of Baler) from the Quezon Memorial park in the south to Cape Engaño in the extreme northeast.

Situated parallel to the west coast of northern Luzon are the mountains of the Cordillera Central, while their western outliers are known as the Ilocos Mountains. The Cordillera like the Sierra Madre has a core composed mainly of basic rock types of the Mesozoic period. However, a significant portion of the middle section consists of Tertiary volcanic formations.

North of Luzon are the Babuyan and Batanes Islands. Here a complex mixture of volcanic activity and reef building has created an environment as forbiding and fascinating as any in the Archipelago.

In the Zambales Mountains, the central and northern portions are composed of complex Mesozoic formations, while the southern and highest portions consist of Tertiary volcanic material. In addition to acting as a transportation barrier, these mountains lie directly athwart the southwest monsoon and intercept considerable rainfall. Consequently there are heavy dipterocarp forests on the windward slopes and more open forests on the lee slopes.

Plains of Central and Northern Luzon. The Central Plain of Luzon east of the Zambales Mountains extends unbroken from Laguna de Bay to the Lingayen Gulf. It has once been occupied by the sea, and is now covered by marine sediments. The surface cover consists mainly of volcanic tuff. From this flat of Quarternary deposits extinct volcanoes rise abruptly resembling inselbergs. Mount Arayat is the highest and rises in a beautifully symmetrical cone. A second large plain is found between the Sierra Madre and the Cordillera Central, the Cagayan Valley. Its rolling surface suggests that erosion played a part in its origin.

Southern Luzon is composed of a complex series of peninsulas marked by many fault lines and numerous exposures of ultrabasic basement rocks. Between the six still active and numerous dormant volcanoes are spread broad areas of almost level Tertiary and Quarternary volcanic deposits which have resulted in very fertile soils. In this region Mt. Mayon is probably the most symmetrical and beautiful volcano in the world.

1.3 Visayan Islands.

The southeast trend of the Bicol Peninsula continues throughout the islands of Samar and Leyte. The other large islands, however, like Cebu, Negros, Panay and Palawan show trend lines towards the southwest.

Mindoros backbone is a broad anticlinal ridge of Mesozoic rock with mountains rising up to 2500 meters. Samar shows a mature hilly landscape with little really flat land on the

hill tops or the valley bottoms. Leyte is separated from Samar by the narrow San Juanico Strait and bisected by the main Philippine fault line. Cebu has large areas of steep slopes and severe erosion, yet it is one of the most densely populated islands. Massive beds of Tertiary limestone are exposed at the surface and many features of a carst topography, such as sink holes and underground stream channels, are present. Negros, the fourth largest island, is dominated by four volcanic mountains. From their eruptions fertile plains have built up. In Bohol Tertiary and Quarternary limestone and coral with carst features abound. Underground drainage give the island a much more arid appearance than the rainfall data would suggest. In Panay the folded mountains of Mesozoic basement rock along the boundary of Antique act as an effective wooded barrier for rainfall and transportation to the well populated agricultural plain in the east.

The elongated island of Palawan is forming a bridge between the Philippine Archipelago and Borneo. That a land connection between the two islands has existed in the past is indicated by the fact, that flora, fauna and fossil remains from Palawan are more closely related to those from Borneo than to those from other islands in the Philippines.

1.4 Mindanao and Sulu Islands.

Mindanao, the second largest island of the Philippines shows the greatest variety of physiographic development. In this island one can find high, rugged, faulted mountains, almost isolated volcanic peaks, high rolling plateaus, and broad, level, swampy plains.

The mountains of Mindanao can conveniently be grouped into five ranges, which enclose nine active volcanoes. Paralleling the remote and forbidding east coast from Surigao del Norte to Cape Augustin is one range of mountains. A second range extends in north-south direction west of the Agusan River from the Camiguin Island volcano to Tinaca Point with two other active volcanoes, one of them Mt. Apo. A third

range of complex mountains with six active volcanoes is found southeast of the Lanao Lake. Finally a fourth range of volcanic mountains runs parallel to the coast of South Cotabato.

Another important geographical feature of Mindanao is the series of upland plateaus in Bukidnon and Lanao del Sur. These plateaus are composed of basaltic lava flows interbedded with ash and volcanic tuff. Near their edges at several points spectacular waterfalls (Maria Christina, Abad Santos) drop the the narrow coastal plain.

Mindanao has two large plains situated in the valleys of the Agusan River and the Mindanao River in Cotabato Province. The latter is in full agricultural development and may compete with Central Luzon.

The Basilan and Sulu Islands extend over 300 kilometers and form a natural series of stepping stones between Borneo and Mindanao. Probably during the Pleistocene these islands, too, formed a land bridge across which man as well as animals and plants moved to the Philippines. The hilly interior portions of these islands are mainly of volcanic origin, the coastal areas composed of uplifted coral limestone.

This brief account of the geographical situation of the Philippines has been adapted from the works of CHOINSKI (1967), FISHER (1967), ROBEQUAIN (1964) and ZAIDE (1970).

Chapter 2:

PHILIPPINE SOILS

2.1 General remarks

Soil formation results from the action of climate, natural vegetation and soil organisms upon a diversity of parent materials. Where land has been stable over long geological periods, the soils tend to lose the character of their parent material and assume the characteristics of their environment. Where soils are youthful, as in the case of most Philippine soils, they tend to show strong influences of their geological parentage. Therefore the parent material may serve as a basis for soil classification, until more complete and detailed information becomes available (Table 1).

Parent material	Area	Percent of total area
Alluvial deposits	4.5 mil. ha	15
Shale and sandstone	4.4 mil. ha	15
Volcanic tuff	0.6 mil. ha	2
Andesite, basalt, agglomerates	6.2 mil. ha	21
Limestone	3.8 mil. ha	13
Complex	4.1 mil. ha	14
Rough mountain soils	5.6 mil. ha	19
Unsurveyed	0.4 mil. ha	1

Table 1: Parent material of Philippine soils)Source: BUREAU OF SOILS, MANILA)

2.2 Alluvial deposits

All the fertile plains in the Philippines consist of alluvial deposits and are heavily populated. The f i n e textured alluvial soils like clay loams and clay are generally utilized for irrigated rice. The main areas are situated in Central Luzon, the Cagayan Valley and the flats of the Mindanao River.

Alluvial soils of c o a r s e texture are used for sugarcane, maize, abacca, coconut and tobacco. These soils have a very good permeability, but are usually of low fertility because of rapid leaching. This type of soil is found in Tarlac and Pampanga, Negros and Cotabato.

There are also limited areas with alkaline soils usually with a poor drainage. In Cotabato cotton and sorghum is grown on these soils.

2.3 Soils originating from shales and sandstone

In the Philippines soils originating from shales are more common than those from sandstone. Their color usually is black or dark brown and in most cases they have to be classified as clays. When wet these soils are plastic or sticky, in dry condition they become hard and crack.

The profile depth depends largely on the hardiness of the parent material. The surface often shows a rolling relief. The permeability is generally low, and there is usually a high rate of run-off resulting in heavy erosion where the soil is not covered by forests. Heavy clay soils of this type originating from shales and related material are found to a limited extend in the Sierra Madre, Catanduanes, Southern Negros, South Cotabato and Surigao.

As a general rule these soils are less fertile than those originating from limestone.

2.4 Volcanic tuff

This parent material is the product of geologically recent eruptions of volcanoes. It is found in the provinces surrounding Manila, in Albay and to a limited extend in Occidental Negros. Soils developed from volcanic tuff have a rather fine texture and a highly plastic consistency. The color varies from gray to brown or black depending on the type of soil minerals and the content of organic matter. On alkaline sites of this type, the plants often show symptoms of chlorosis, probably caused by unavailability or limited solubility of iron and magnesium.

In some places volcanic soils are subject to severe erosion.

2.5 Soils derived from andesite, basalts, and agglomerates

A relatively large area of soil has developed from igneous rocks of volcanic origin like basalts, andesite and agglomerates. Soils of this type are mainly found in the uplands and are in some areas still covered with forests.

Where the parent material had been very resistant to weathering, these soils tend to be quite shallow and carry only a meager vegetation. Often their fertility is low due to a low base status of the parent material or due to heavy leaching. Often these soils lack all the important plant nutrients like nitrogen, phosphorus and sometimes potassium.

Where they are deeply weathered, we generally encounter lateritic soils or latosols. Lateritic soils are characterized by leaching of silica and bases and an accumulation of iron and aluminum hydroxides in the upper horizon. If the process of laterization has progressed to a point, where the ratio between iron and aluminum hydroxides and silica oxide is greater than 2, we would speak of laterites. Soils that have not reached that point yet, but are subjected to laterization are called latosols or lateritic soils. Laterization only takes place in a hot and humid climate in soils with a pH-value below 7. In the initial stages of laterization the color of

the soil can be brownish or yellowish, but takes on a red hue later due to the presence of Fe_2O_3 hydrates.

Lateritic soils have a stable columnar or prismatic structure and have a high infiltration capacity. In contrast to their favorable physical structure however, they are deficient in most important plant nutrients, particularly phosphorus and bases. Since they typically have a low pH-value, phosphorus is hardly available, and the bases like calcium, magnesium, potassium are leached easily. For agricultural use heavy applications of lime are required on these soils.

Latosols are typical for rain forest areas. When used for shifting cultivation they lose their fertility very quickly.

2.6 Limestone soils

Soils developed from limestone are very common and they are found in areas from the northernmost part of Luzon down to the southernmost part of Mindanao. They are most prevalent, though, in the Visayan Islands. The parent material is mainly Tertiary coral. The coralline rocks appear in great masses and outcrops are very widespread. The formation generally does not show any stratification. The coral skeletons are often well preserved.

Many limestone soils are quite shallow with a soil depth of only 15 to 50 centimeters showing only an A/C profile, while the B-horizon is often absent.

Sometimes also soils of a purplish red color similar to laterites are found in thick layers on top of limestone or between rocky limestone outcrops, as can be seen near Baguio. It is difficult to understand, however, how thick layers of soil can be derived from rocks consisting of almost pure calcium carbonate. MOHR and VAN BAREN (1959) suggest, that the red soil found over limestone in many tropical countries possibly originates from windborne material and only to a small part from the underlying limestone.

The native vegetation of limestone soils in the Philippines is composed of the Molave-Narra Association as still preserved in Fuga Island, the northern part of Sierra Madre Mountain (Callao), and a few other places. Steep limestone formations with their thin soil cover are easily eroded and should be left under a forest cover.

For the assessment of soil profiles and the edaphic requirements of reforestation species consult Part 2, Chapter 2 and 3 of this book.

Chapter 3:

CLIMATIC CONDITIONS

3.1 The rainfall pattern

On a map of isohyets showing the average annual rainfall, several areas of extremely high precipitation are noticeable:

- the coast of Luzon, east of the crest of the Sierra Madre Range,
- the east coast of the island of Samar and Southern Leyte,
- the east coast of Mindoro,
- Misamis Occidental.

These areas receive heavy orographic rainfall during the winter period, when the northeast monsoon dominates. In addition to heavy orographic rainfall, the coastal region from Samar

to the North receives a good share of rainfall from typhoons.

Much of the island of Mindanao shows rainfall of over 250 centimeters annually. The high rainfall in Mindanao, other than the orographic rainfall on the east coast, is primarily due to two factors. First, this is the area over which the intertropical rain front lies for the greatest period of time. Second, Mindanao is an island large enough to give rise to convectional cells which produce local precipitation at almost all seasons of the year.

There are some places in the Philippines, that show markedly lower annual rainfall than the surrounding areas:

The Central Plain of Luzon with averages between 1500 and 2250 mm annual rainfall lies in a double rain shadow. During the southwest monsoon the Central Plain is shielded by the Zambales Mountains, which lie directly to the west of the plain. During the northeast monsoon the Central Plain is sheltered by the Sierra Madre situated to the east.

The east coast of Cebu is also protected from both monsoons. During the southwest monsoon it lies in the shadow of the highlands of Negros and the mountains of Cebu itself. During the northeast monsoon it is shielded by the highlands of Leyte. In addition the northeast monsoon winds, when they do reach Cebu, very often blow parallel to the coast; thus, they are not cooled and little rain is derived from them.

In Zamboanga City the annual rainfall averages only 1100 millimeters, because the city is somewhat shielded by the island of Basilan and also the Zamboanga Mountains.

Dadiangas (General Santos) lies in a pocket almost completely surrounded by mountains and is sheltered from prevailing winds in several directions.

3.2 Variations of rainfall.

A factor of considerable importance is the reliability of rainfall from year to year. The average deviation from normal rainfall appears to be in the order of 14 percent. This figure

is relatively low, and much lower than in other monsoon countries. The variations appear to be least in the interior of Mindanao, and relatively high in Samar, and Southern and Central Luzon.

Extreme variations from 60 to 100 percent have been observed in Baguio City, Samar and Surigao. These variations are all surplus of rainfall, not deficits and coincide with years of extraordinary typhoon activity. So areas deriving a good part of their precipitation from typhoons or from the northeast trade winds show relatively high variations from year to year. Areas deriving much of their rainfall from the southwest monsoon or from the South Pacific trades show moderate variation.

Areas particularly in the south, deriving their moisture largely from the intertropical front, also show relatively small variations in their rainfall pattern.

3.3 Climatic types.

The classification of climatic types in the Philippines is based on differences in the rainfall distribution throughout the year, the presence or absence of a dry season and of a maximum rain period due to the combined influence of topography and wind direction.

First Type: two pronounced seasons, dry season from November to April, wet during the rest of the year. The controlling factor is topography. The localities of this type are shielded from the northeast monsoon and even in good part from the trade winds by mountain ranges, but are open only to the southwest monsoon and cyclonic storms.

Second Type: No dry season with a very pronounced maximum rain period from November to January. These regions are situated along or very near the eastern coast and sheltered neither from the northeast monsoon and trade winds nor from cyclonic storms.

Third Type: seasons not very pronounced, relatively dry from November to April and wet during the rest of the year. The maximum rain periods are not very pronounced, too, with a short dry season lasting only from one to three months. These localities are only partly shielded from the northeast monsoon and subject to frequent cyclonic storms.

Fourth Type: Rainfall more or less evenly distributed throughout the year.

3.4 Temperature variations.

The Philippines extend over a latitudinal distance of over 1500 km and yet, within this broad expanse, we encounter relatively small temperature variations. Aparri in the extreme north of Luzon and Jolo in the Sulu Islands have nearly the same maximum, average and minimum temperatures.

Aparri	30.4°C max.	22.8° C min.	26.3°C average
Jolo	30.8°C max.	22.7° C min.	26.6°C average
Baguio	23.1°C max.	15.0° C min.	18.2°C average

Table 2: Maximum, minimum and average temperatures of Aparri, Jolo and Baguio.

Differences in temperatures in the Philippines are mainly due to differences in elevation, as demonstrated in Table 2. Aparri and Jolo are situated at sealevel, Baguio City at 1500 m elevation.

3.5 Typhoons or tropical cyclones (9,13,14).

Typhoons carry excetionally great amounts of moisture, are responsible for between one quarter and one third of the total Philippine rainfall, and have set world records for rainfall over short periods of time. The world's record 24-hour rainfall was recorded during a typhoon at Baguio City, between noon of July 14 and noon of July 15 in 1911, when 1170 mm of rain literally flooded the city. In addition to heavy rains, typhoons are accompanied by high winds, which over coastal areas often reach 200 km per hour and cause heavy damage to buildings, crops and forests.

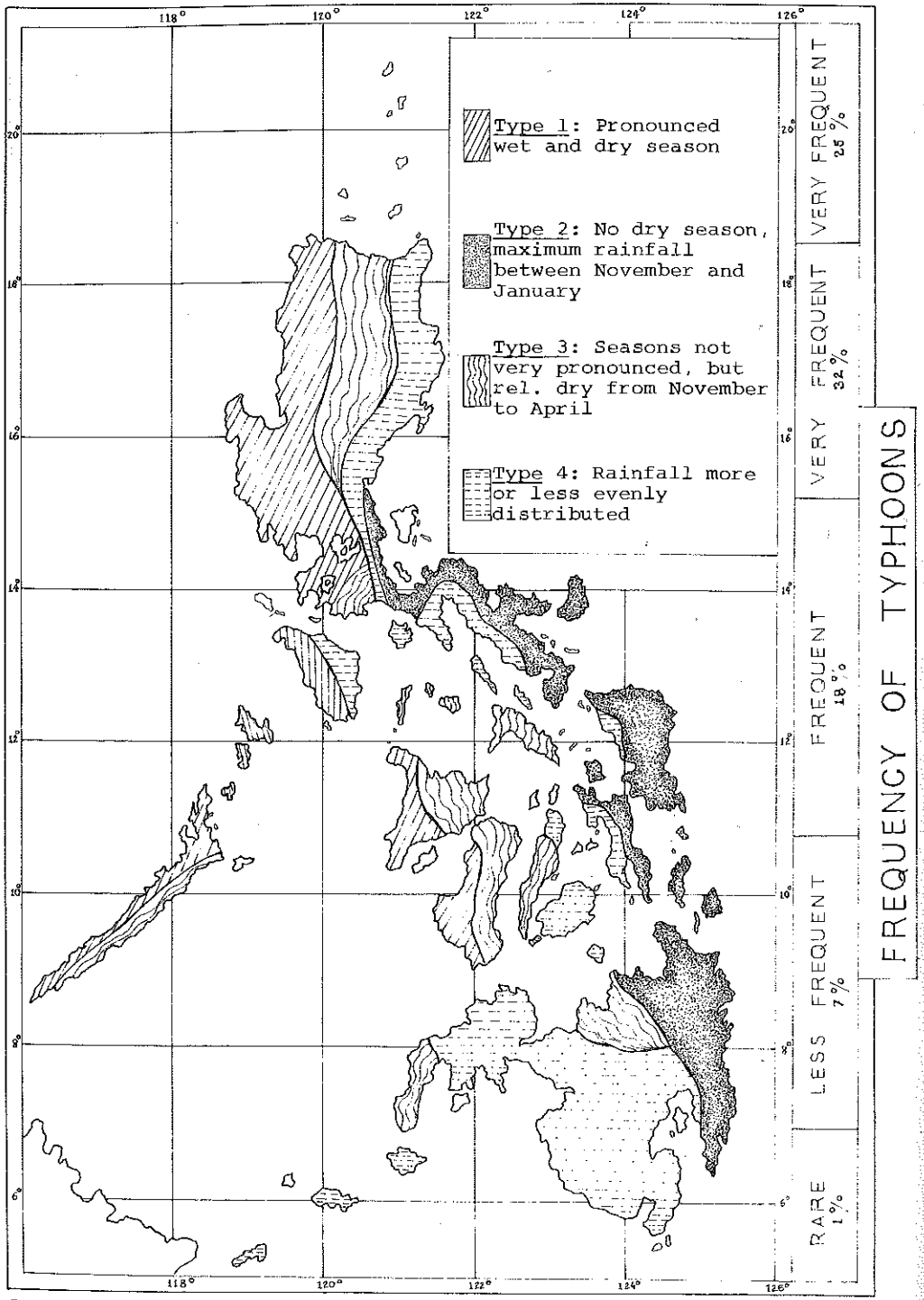

Fig. 1: CLIMATE MAP OF THE PHILIPPINES

Typhoons originate usually in the area of the Caroline or Marshall Islands. They are vast low pressure systems which in the northern hemisphere are accompanied by a counter clockwise whirl of winds gradually spiraling towards the vortex. Violent updrafts and convergence cause rapid cooling of the marine tropical air masses and heavy precipitation results. Cloud cover is normally quite dense within a 500 km radius, but the central eye or the vortex of the storm is usually marked by an area three to five kilometers in diameter where the sky is clear and where calm prevails. These storms usually move toward the west or northwest, but as they approach the continent, they generally swing to the north and eventually die out as they are forced toward the northeast in the west wind drifts.

The typhoor season last in the Philippines generally from July to November, although sometimes storms occur during other months. Typhoons most often touch the Philippines between the southern tip of Samar and Northern Luzon (See map).

Chapter 4:

THE NATURAL FOREST TYPES

There are over three thousand species of trees in the Philippines that can reach diameters of 30 cm or more. However, at the present stage of utilization only about 70 species find their way to the market. Seventy five percent of the annual cut consists of dipterocarp species, commonly referred to as the lauan family or Philippine mahogany. The species that make up the bulk of the volume are white lauan, apitong, red lauan, followed by mayapis, mangasinoro, bagtikan, palosapis, almon, tanguile and yakal (3).

Based on their species composition the Philippine forests are generally classified into six types (15):

1. Dipterocarp forest,
2. Molave forest,
3. Pine forest,
4. Mangrove forest,
5. Beach forest,
6. Mossy and high mountain forest.

Most of the original forest types have been altered fundamentally through human action such as logging, grazing, shifting cultivation, or have been cleared for agricultural crops. Up to now there is no map available showing the present distribution of forest types. The following table is only an estimate of the area still occupied by each type.

Type	Area (ha)	Percent	Source
Dipterocarp forest	9,352,000	62	B.F.D., 1973
Molave forest	500,000	3	rough estimate
Pine forest	269,000	2	B.F.D., 1973
Mangrove forest	218,000	1	B.F.D., 1973
Beach forest	very small area		
Mossy & high mountain forest	1,000,000	7	rough estimate
Open grassland and other	3,765,000	25	B.F.D., 1973
Total	15,104,000		

Table 3: Area of the main forest types in the Philippines.

4.1 Dipterocarp forests.

The tropical rain forest of the Philippines is dominated by Dipterocarpaceae of the following genera: Shorea, Dipterocarpus, Hopea, Parashorea, Pentacme, Anisoptera, and Vatica. From the standpoint of the botanist the composition of these forests is complex, but from the standpoint of the lumberman it is relatively simple, because several different species are generally grouped under the same trade name.

Dipterocarp forests can occur from the coastal flats onwards up to about 800 meters elevation. They are best developed where rainfall is more or less uniform throughout the year, or where there is only a very short dry season. According to the dominating species association WHITFORD (1911) divides the dipterocarp forest into five subtypes:

a) Lauan type
b) Lauan-Hagakhak type
c) Yakal-Lauan type
d) Lauan-Apitong type
e) Tanguile-Oak type

	Lauan	Lauan-Apitong	Yakal-Lauan	Lauan-Hagakhak
Dipterocarps	252 m^3	116 m^3	80 m^3	55 m^3
Others	14	52	73	28
Total Volume per hectare	266 m^3	168 m^3	153 m^3	83 m^3

Table 4: The volume per hectare of dipterocarps and other species from sample plots in 4 subtypes of the dipterocarp forest taken by WHITFORD (1911). Note: WHITFORDs conversion factors were corrected.

a) Lauan type:

In the true lauan type the relative proportion of dipterocarps and the commercial volume is usually higher than in any other type,. It represents the most valuable commercial forest in the Philippines (see table 4).

Because of a dense canopy, the true lauan type is relatively free from undergrowth. The shade is so dense, that regeneration of light demanding species has no chance. This type reaches its best development in low elevation extending only to an altitude of about 300 to 400 meters. On favorable sites this type regenerates easily after logging. The second growth is usually dominated by white lauan and mayapis mixed in the earlier stages after logging with a large number of gubas, which are eventually shaded out.

b) Lauan-Apitong type: Where there is a pronounced dry season, the lauan type is replaced by the lauan-apitong type, which also occupies only lower elevations. The canopy of this type is more open allowing more undergrowth.

c) Yakal-lauan type finds its best development in regions where the dry season is short. Regarding the soil it prefers low coastal hills of volcanic origin. This type has a slight deciduous appearance during the driest part of the year. Another association where yakal is less dominant, however, is found along streams and the slopes of ravines.

d) Lauan-hagakhak type is restricted to areas where the water level is near the surface. In composition it differs from the previous type mainly by the presence of hagakhak (Dipterocarpus warburgii) and a much larger number of codominant species of other families. During the rainy season, the soil in large areas is too wet for the best development of many species. These factors reduce the volume of timber per hectare as compared with forest types growing in more stable areas (Table 4).

e) Tanguile-oak type covers the areas extending from the upper limits of the lauan and the lauan-apitong type to the lower limits of the pine or mossy forest types, from 400 to 500 meters above sea level up to 800 to 900 meters. The rainfall is more evenly distributed throughout the year, and the relative humidity is constantly higher than in the adjacent forests of lower altitudes. In the lower transition zone one may find scattered specimens of dipterocarps belonging to the forest types bordering below. Many of the species in this type also occur much dwarfed in the mossy forests higher up.

4.2 Molave forest.

The molave forest occurs in regions with a very distinct wet and dry season. They are typical for the limestone soils in the coastal areas, which are usually quite shallow and excessively drained. During the dry season, there is often the impression of semi-arid conditions. A number of trees in the molave association shed their leaves every year during the dry season.

Molave itself is a short boled, ragged tree, but has a very durable and valuable wood, which is in high demand. The forests are open with a few dominant trees far apart. Besides molave there are often kalantas, ipil, supa, narra, camagon, banuyo, tindalo and other valuable timber trees associated in this type.

Since the sites of these forests are easily accessible, most of the original forests have been destroyed by exploitation. A relatively well preserved molave forest can still be seen in the narrow coastal plain west of the Zambales Mountains. Other remains are said to exist still in the lime stone hills of the northern end of the Sierra Madre Range.

During the Spanish period ships built of molave maintained the historic Manila-Acapulco galleon trade for nearly two-and-a-half centuries.

4.3 Mangrove forests.

Mangrove forests occur along the tidal flats at the mouths of streams and along the shores of protected bays. The stands are composed of eight species of the bacauan family (Rhizophoraceae), which once were the principal source of tanbark, cutch and dyebark, but now mainly produce charcoal. Where utilization had been intensive, api-api (Avicennia officinalis) becomes more and more dominant, because its sprouts easily.

Further upstream, where the water is not so brakish any more, nipa palm may form extensive and dense stands, which are a major source of roofing material in coastal areas.

The mangrove forests are practically clear of undergrowth. The stilt roots are as high as 3 meters. The leaves of all species are hard and leathery. The seeds are distributed by the tides until they find a suitable lodging place. Virgin areas show surprisingly large stands of poles and trees. In thickly populated areas, the forest has degraded to such an extend that it produces now only firewood. Many mangrove swamps have been cleared for fishponds.

4.4 Beach forest.

This type is found on sandy beaches above the high tide limits where the original form of vegetation had been left undisturbed. Since these are very favorable sites for settlements and coconut plantations, little of the original beach forest is left.

Typical beach forest associations include Pandanus, large specimens of bitaog (Calophyllum inophyllum), talisay often in groups, stands of agoho on sandy flats near the mouths of rivers, duñgon-late and others.

4.5 Pine forest.

There are two species of pines found in the Philippines forming pure stands: Benguet pine (Pinus insularis) and Mindoro pine (P. merkusii). While Benguet pine forests form extensive stands in the mountains of Northern Luzon, the Mindoro pine occupies only an estimated 5-6000 ha in two isolated areas in Northern Zambales and Northern Mindoro. The altitudinal range of Benguet pine extends from about 700 m onwards to about 1800 meters. The two known Mindoro pine forests occupy an area mainly between 100 and 500 m elevation.

Because of their silvicultural characteristics (Part 2, Chapter 3 of this book) the Mindoro pine has practically no economical importance in the Philippines. The Benguet pine, however, is planted now all over the islands. The growth outside the natural range of this species is sometimes higher than in the Mountain provinces of Northern Luzon.

	Height	Diameter	Volume over 7 cm
Benguet Province	14-18 m	12-15 cm	150 m^3 per ha
Bukidnon Province	25-27 m	20-23 cm	400 m^3 per ha

Table 5: Growth of Benguet pine, age 20 years, spacing 2 x 2 m.

The natural pine stands are generally quite open and subject to frequent fires. Only along creeks one can find some broad-leaved vegetation. Where fire protection can be enforced, natural regeneration appears easily. The management of natural pine forests is described in Chapter 5.

4.6 Mossy forest.

The mossy forest is found above the tanguile-oak type. In Northern Luzon on southern slopes and dry ridges it is replaced

naturally by Benguet pine. The ecology of this forest type is characterized by a relatively low temperature, high and uniform humidity in form of rain and fog throughout the year, short duration of sunshine and strong winds.

A striking feature of the flora are the numerous epiphytes consisting of mosses, liverworts, ferns and orchids in great variety and also bottle-shaped myrmecodias. The trees are generally of medium height and short boled. Typical genera are Podocarpus, Dacrydium, Quercus, and Eugenia.

The mossy forest is of little commercial value, but important as a protection forest. A great portion of it in Northern Luzon has been cleared for vegetable farming. A relatively well preserved mossy forest can still be seen in the mountain range between Banaue and Bontoc.

Chapter 5:

MANAGEMENT OF NATURAL FORESTS

Philippine forestry has two distinct aspects namely the management of the natural forests, and reforestation and erosion control of denuded areas. Since this book is primarily devoted to the latter, management of natural forests is treated here only very briefly.

Of the different forest types of the Philippines, only the dipterocarp forest and the pine forest are under special systems of forest management based on the concept of sustained yield.

5.1 Selective logging in dipterocarp forests (12).

The main objective of the Philippine system of selective logging in the tropical rain forest is to retain an adequate number of undamaged and healthy residuals to be utilized in the next cutting cycle or later, which one tries to achieve by marking the residual stand before logging. According to the official logging instructions laid down in the HANDBOOK ON SELECTIVE LOGGING, the main phases can be described as follows:

a) Determination of marking goal. For any particular setup (area covered from one spar tree) the marking goal for residuals is either 60% of the number of healthy trees in the 20-70 cm diameter classes, or if there are more trees in and over the 80 cm diameter class than below, then 40% of all trees over 20 cm diameter. This distinction is made to allow

a reasonable number and volume of commercial trees to be retained in areas which are heavily stocked with large trees.

The marking goal is computed from a 5% sample inventory using circular 0.1 ha plots (r=18 m). In this pre-marking sample inventory all commercial trees are recorded by species and diameter class.

b) Tree marking: This involves trees to be retained as residuals, and those to be cut. Trees marked as residuals are numbered consecutively with paint and are recorded individually by number, species, diameter, height up to first branch and volume. Marking is continued until the marking goal is reached and the whole set up is covered. Residuals should not be marked

- on cableways radiating from the spar tree, which have to be kept as narrow as possible,
- on log landings which should not have more than 40 m radius for the largest setups,
- in the fall direction of trees marked for felling.

Marking for felling is carried out at the same time, and all merchantable trees over the minimum diameter limit (70 cm), that are not needed to make up the marking goal, are marked with a vertical arrow on the side of the felling direction.

c) Residual inventory after logging. This is the physical examination and count of the marked residuals left in a setup after logging. The inventory crew will go over the logged setup, examine each marked tree to judge, whether it is healthy, substandard or damaged. All unaccounted or lost trees are noted. Unmarked healthy residuals are all recorded and numbered consecutively, but they shall not be used to replace damaged marked trees.

The residual inventory has three main objectives. One is to determine the extend and cause of damage done on the residuals to make the necessary corrections. The second objective is an appraisal of residual growing stock as a basis for silvicultural treatment and management. The third objective is to provide the

necessary information to compute fees to be paid by the concessionaire for the damaged trees.

d) Timber stand improvement: After the logging operation is completed the forest is left behind with an open canopy and exposed soil, which favors the invasion of undesirable tree species and climbers suppressing seedlings, saplings and poles of desirable species.

The first silvicultural treatment is to be applied 5 to 10 years after logging. Many foresters agree, that no tending should be attempted during the first 5 years because of the difficulty of entry and the heavy growth of climbers.

Stand improvement operations at this stage include:

- cutting, girdling and poison-girdling of undesirable trees,
- climber cutting,
- thinning, where natural regeneration is too dense.

For more detailed information consult the HANDBOOK ON SELECTIVE LOGGING.

5.2 Management of pine forests under the Seed Tree Method.

Within the concession areas the pine forests of Northern Luzon are generally managed under the seed tree method. This involves clear-cutting the area leaving only a few seed bearers. After the new stand is established, the seed trees may be removed in a second cut or left for the next rotation.

The number of trees to be left as seed bearers should be between 16 and 20 trees per hectare as suggested by CALEDA (loc. cit. NICHOLSON, 1970). Only large, straight-boled trees with thin branches and large crowns are to be selected. Since the quality of the mother trees will be reflected in the offspring, they should be carefully selected. An even distribution of seed trees would interfere too much with logging, therefore NICHOLSON suggests to mark the seed trees in 4-5 groups of not more than 4 trees, per hectare. The dispersal-range of pines is quite wide and natural regeneration can be expected over the whole area.

After logging the success of the natural regeneration depends largely on effective fire protection. Where regeneration is inadequate, it can be supplemented by planting.

Successful regeneration of Benguet pine by the seed tree method can be observed in the Bobok Concession east of Baguio City.

Chapter 6:

REFORESTATION

The creation of the "Inspeccion General de Montes" in 1863 by the Spanish government was the formal beginning of a forest service in the Philippines. This agency undertook a study of the Philippine forest resources, and laid down the regulations for opening of virgin lands and cutting of timbers. Many comprehensive laws were subsequently passed imposing also replanting, but until the turn of the century not much had been accomplished in the implementation of these laws.

After the United States had succeeded Spain, forestry received more serious attention. The war had hardly ended in 1900, when a forestry bureau was organized under US-military government, which established the base for the forestry practices that we have today.

"Most authorities trace reforestation work to have begun in 1910 with the establishment of the Forest School at Los Baños. The original school site consisted of grass and brushland. The students cleared the ground and then planted seedlings in connection with their Silviculture Class. Practical methods of planting cogonal areas were tried, and the species suitable for planting were determined. By 1916 approximately 600 species were tried in the nursery and the plantation of the school. This first attempt for the recovery of grassland paved the way for the establishment of the Makiling Reforestation Project 1937" (CUNANAN, 1968, Reforestation Monthly).

Modest reforestation outside Los Baños began in 1916 when the government appropriated the sum of 10,000 Pesos for reforestation of badly eroded government land in Cebu, where the second reforestation project was established. In 1919 three new projects were opened, namely: (1) Arayat, (2) Ilocos, which is the forerunner of the present Caniaw Project and (3) Zambales, which is now known as Magsaysay Reforestation Project.

New funds enabled the Bureau of Forestry to open the Cinchona Plantation at Impalutao and three other projects up to 1931. The period from 1916-1936 may well be called the pilot planting period, since the trial plantations of that period laid down the foundation for more extensive reforestation in the years to come.

The years 1937 to 1941 were a period of full-scale reforestation, since periodic appropriations in substancial amounts enabled the government to open new reforestation projects. Qualified personnel were employed in conducting planting surveys to determine the areas needing immediate planting and to gather data for a long-range planting plan. A special office was created under the Director of Forestry for the "round-the-clock" inspection of all new reforestation projects. Prior to the second world war, there were 35 projects in operation, covering a total area of 535,000 hectares. The total area of the forest nurseries was 24 hectares with average annual capacity of 17 million seedlings. Before World War II 28,000 hectares were already planted.

The war brought tremendous destruction on the reforestation areas.

During the Japanese occupation, the people in the vicinities sought refuge in the reforestation projects and made clearings to produce staple crops for their subsistence. Furthermore, considerable plantations and nurseries were damaged because of military operations. Only 15 percent or 4000 hectares of the pre-war plantations survived the war.

The funding problems for reforestation of the post-war years were partly solved, when Congress passed Republic Act 115 in 1947. Through this act a separate fund was constituted into which every concessionaire had to pay the amount of ₱0.50 on each cubic meter of timber from the first and second group, and ₱0.40 on timber of the third and fourth group cut and removed from any public forest for commercial purposes.

To pursue a vigorous reforestation programme, the Reforestation Administration was created as a separate government agency under the Department of Agriculture and Natural Resources in 1960. This signalled the transfer of responsibility of reforestation of approximately 5 million hectares from the Bureau of Forestry to the new agency.

After the creation of the Reforestation Administration in 1960 replanting of denuded areas was speeded up, and the annual rate of reforestation never sank below 10,000 hectares. It even reached 35,422 hectares in 1963.

In 1973 about 182,000 hectares of plantations were maintained by the Bureau of Forest Development. There are now 91 reforestation projects, 3 cooperative nurseries and 2 experimental nurseries all over the country compared to 57 reforestation projects in 1966 when the agency was founded. Of the 91 reforestation projects 46 are in Luzon, 31 in the Visayas and 14 in Mindanao.

The declaration of martial law on September 21, 1972 has resulted in the restructing of the Philippine political system and is reflected in the reorganization of several government agencies. The Presidential Decree No. 1 and the letter of instruction No. 3 dated November 1, 1972 was issued to merge the Bureau of Forestry, the Reforestation Administration and the Parks and Wildlife Office into the new BUREAU OF FOREST DEVELOPMENT.

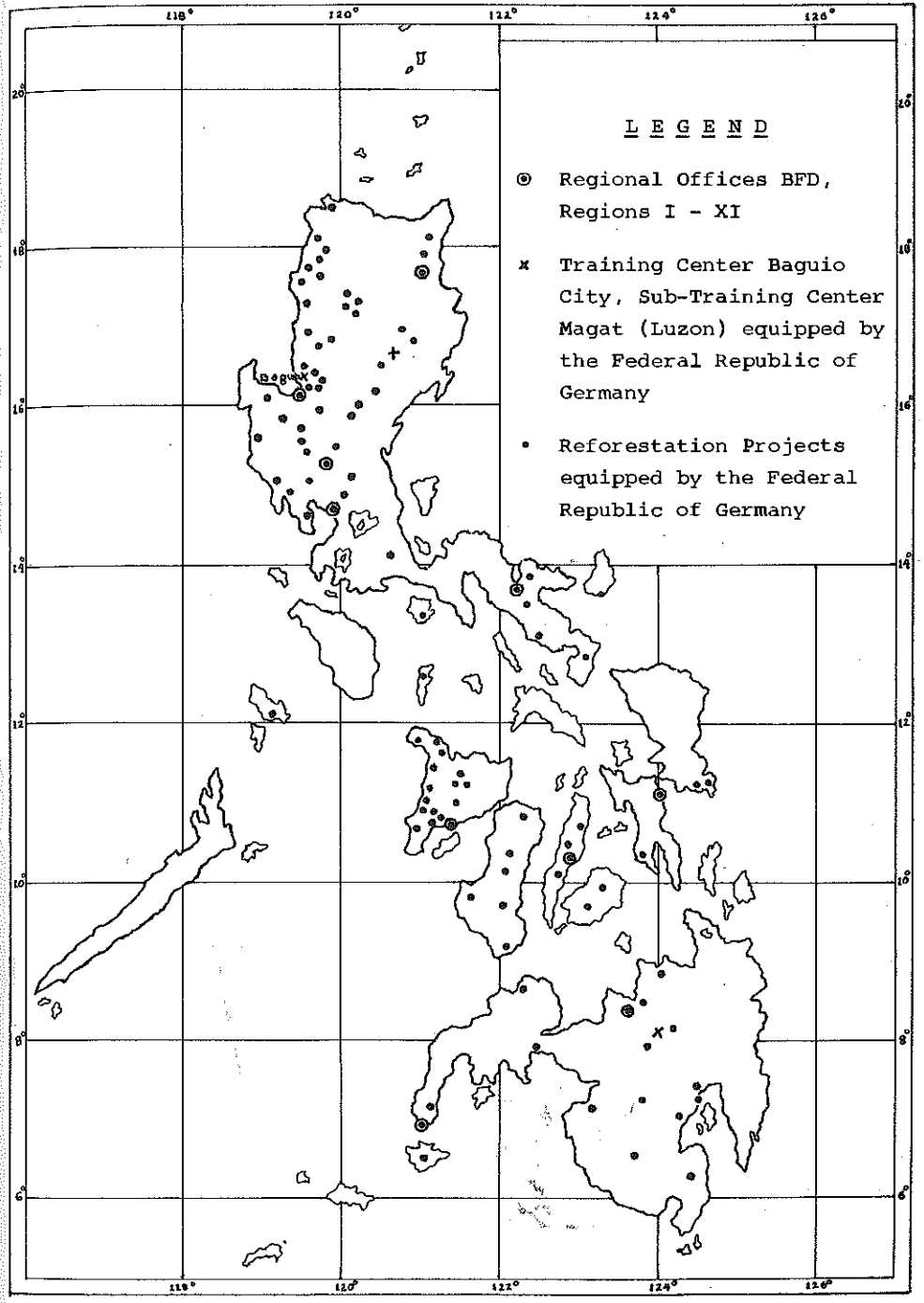

Fig. 2: Distribution of reforestation projects in the Philippines (1974).

The policy of this new office encourages tree farming and industrial plantations as well as large scale rehabilitation of denuded watersheds, which are now exclusively under the jurisdiction of the Bureau of Forest Development.-

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P A R T II

ESTABLISHMENT, MAINTENANCE AND PROTECTION OF FOREST PLANTATIONS

H.J. WEIDELT

Chapter 1:

PLANTING SURVEY, PLANTING PLAN, PLANTATION RECORDS AND MAPS

Each reforestation project requires a detailed plan, which assures the continuity of the reforestation work inspite any changes of staff. The plan has to indicate clearly the objectives of the reforestation project and how these objectives are to be achieved (67).

In the absence of systematic planting plans the results of reforestation are bound to be patchy and erratic. Any large scale reforestation programme must be based on planting surveys, planting plans, proper plantation records, and a simple and efficient reporting system.

1.1 The planting survey

The planting survey is the basis for the planting plan and is the first to be taken up, when a new reforestation project is started. Since the procedure described by TOUMEY and KORSTIAN (1967) is widely known in the Philippines, a modified version of their methods more adapted to Philippine conditions is recommended here:

The project area is crossed at several different places taking advantage of roads and trails and any views one can have from higher points. Recording of data should be as detailed as possible without using sophisticated survey instruments. Mapping is done in form of field sketches with the help of a box compass and by pacing, or even by estimates only. The field report on a planting survey should normally cover the following items:

(a) A general description of the topographical features of the project area including the main ridges, streams, rivers, roads and trails.

(b) A brief history of the area regarding past fires,kaingin, timber cutting, etc.

(c) Location and boundaries of the areas to be planted should be indicated on available base maps, or a rough field sketch must be prepared, which allows an estimate of the area. For details consult Part III.

(d) Subdivision of the area into compartments with neat boundaries following the topographical features and differences in silvicultural treatment. The compartment boundaries are marked later by border stones or posts with painted numbers,

(e) The soil conditions should be indicated by symbols for every compartment or subcompartment (deep, medium, shallow, rocky, sandy soil, marshy depression, fertile alluvial soil, major landslides, ravines, light, medium, heavy erosion, etc.),

(f) The species suggested for every compartment or subcompartment are to be marked in the field sketches.

(g) Description of existing vegetation, regeneration of desirable species, type of ground vegetation (incl. grasses, species, height),

(h) Selection of sites for nurseries and subnurseries.

No distinction is made here between intensive and extensive planting surveys, because it does not have much significance in current practices.

1.2 The planting plan

All important information obtained in the planting survey should be incorporated into a concise planting plan. This plan must include:

(a) A general description of the entire project area including location, range of altitude, topography, soil conditions,

history, present vegetation, original forest types, information on fire, kaingin, grazing, pasture leases and other hazards, landownership and possible claims.

(b) A general description of the climate, including data on the monthly distribution of rainfall of the nearest meteorological station.

(c) Objectives of the reforestation project, which may be watershed protection, erosion control, production of timber,pulpwood, fuelwood, minor forest products, etc.

(d) Subdivision of the area into compartments and subcompartments according to topography, differences in site conditions, and a different choice of species. Compartment areas range from 10 to 30 hectares, the average is about 20 hectares. Compartments usually are smaller in the mountains.

The subdivision into compartments is absolutely necessary for control and reference purposes.

(e) A tabular compilation of all compartments and subcompartments with designation (numbers for compartments, small letters for subcompartments), area, species, spacing, quantity of seed or seedlings required.

(f) Necessary improvements of the road and trail systems.

(g) Nursery plan for main and subnurseries, which includes the location, the area, and the number of seedlings to be raised each year.

(h) A discussion of the area not recommended for planting with supporting reasons (too wet, dense brush, already adequately stocked, needed for other purposes, etc.)

(i) Maintenance of the plantations during the first 5 years, including weeding, tending, fertilizer application, fire lines.

(j) A time schedule, according to which the different compartments are to be planted stating priority areas within the project.

(k) Equipment and supplies required.

(l) A detailed estimate of the expenditure for each year.

(m) Appendix of maps.

The planting plan should cover at least a period of 5 years and must be prepared sufficiently ahead to allow enough time for seed collection and raising of nursery stock.

If a number of years has passed since the time of the planting survey, a brief inspection of the area should be made to consider any changes which might have occured.

Planting plans for different projects can be summarized into a more general plan for a region. The regional plan should have a list of priority projects.

1.3 Plantation records

A pre-requisite of good management is that proper records on all plantations or compartments are maintained in every reforestation project.

For each plantation (compartment or subcompartment) a special registration sheet is maintained, on which all important events and data are recorded. This register has to be updated constantly.

According to FAO recommendation (28) the plantation register or plantation index card should contain the following information:

- Designation of plantation, compartment or subcompartment,
- Area
- Species and seed source,
- Spacing
- Date of planting, estimated number of seedlings, size and quality of planting stock,
- Date of replanting, number of seedlings, size and quality of planting stock,
- Events and date of occurance, such as fire, insect attack, tending operations, inventories, survival counts, thinnings, etc.

Compartment: 9		Itogon Reforestation Project	
Species: Benguet pine		Origin: Bobok Concession	
Area: 18 hectares		Spacing: 2 by 2 meters	
Planted: October 1969, 45 000 seedlings, bare root, 12 cm.			
Replanted: July 1970, 30 000 seedlings, potted, 18 cm.			
July 1971, 7 000 seedlings, potted, 27 cm.			
Events in the plantation:			
March 1970:	5 hectares burnt	May 1971:	Survival 78 %
May 1970:	Survival 33 %	July 1971:	Replanted
July 1970:	Replanted	Nov. 1971:	Ring weeding
October 70:	Ring weeding	May 1972:	Survival 84%

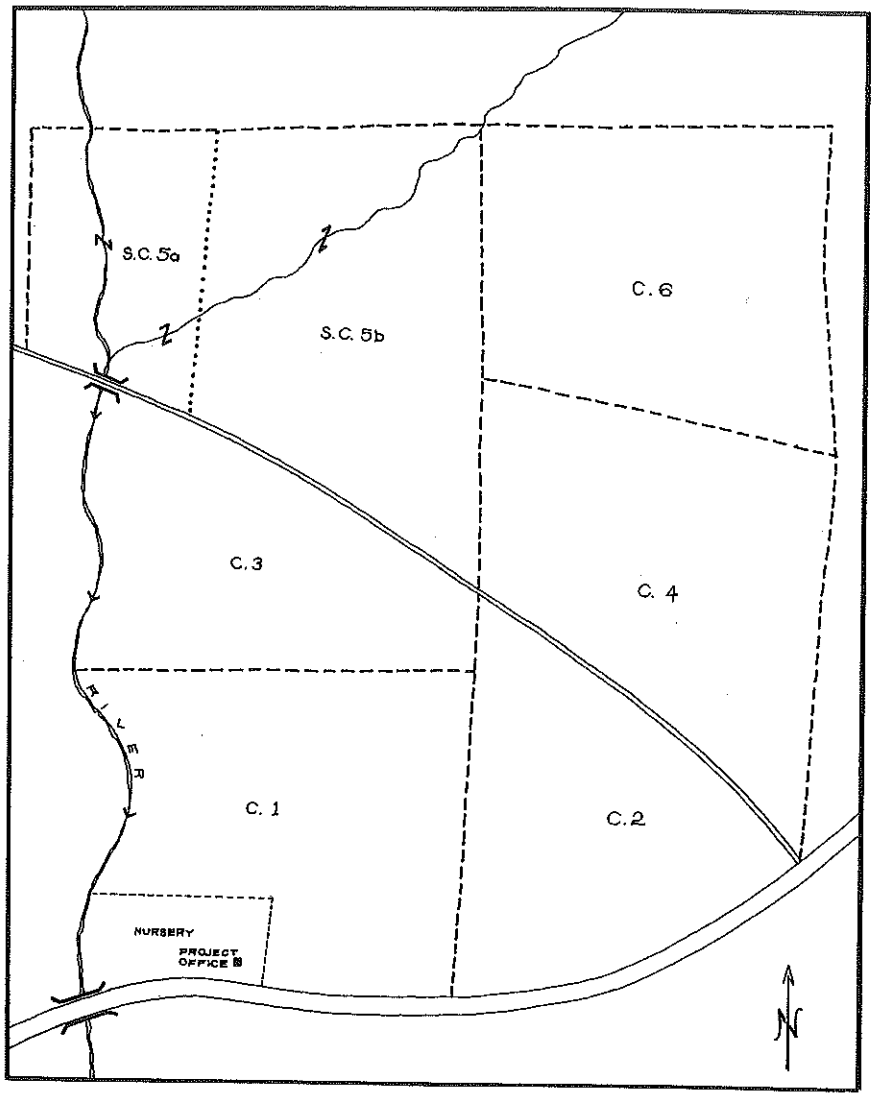
Table 1: Plantation index card.

1.4 Plantation maps

In every reforestation project there should be base maps available of the entire project area, preferably at a scale of 1 : 10,000. Maps at a scale of 1 : 20,000 would show the plantation areas too small. If the map supplied by the Central Office in Manila is too small, a special request must be made for enlargement. Base maps contain only the important geographical features like roads, rivers, creeks, buildings and settlements, and other important landmarks as tie points. Most important is that all aboundaries of compartments and subcompartments are printed on the maps for control and reference purposes. Without the subdivision of the project area into compartments no efficient control is possible. All reporting has to be done by compartments, so that any figure reported can be easily checked in the field later.

Progress of reforestation is indicated by using a different color for every species. In a more advanced stage the different age classes (class I: 1-10 years, class II: 11-20 years, etc.) can be shown by different shades of the same color. For the main reforestation species the same colors should be used throughout the country.

A number of such base maps should be available in every reforestation project to be able to record different features



Legend: Scale 1:10,000

Highway ____ Compartment boundary (trails)

Dry weather road .....Subcompartment boundary

Geographical feature, which is not a compartment boundary

Fig. 1: Project map (base map)

of the project, whenever required, as for example the extent of fires, distribution of species, progress of planting work, future plantation areas by years, priority areas, extent of erosion, etc.

Most important is the map showing the extent of plantations. This map must be updated every year at the end of the planting season, and a copy is submitted to the Central Office in Manila to update the master copy. Without any maps of the project area a proper management is not possible.

Chapter 2:

ECOLOGICAL ASPECTS FOR THE CHOICE OF TREE SPECIES

The main ecological factors, which decide whether a species will be able to succeed on a site, are climate and soil conditions.

2.1 Climatic factors

If we would consider the climatic factors influencing tree growth on a worldwide basis, we would have to deal with a great number of climatic features such as among others the

occurrence of frost and snow, variations of relative humidity, daily and seasonal temperature variations, etc. But here we have to consider only the Philippines and can limit ourselves to only those basic climatical features, which show significant variations within the country, and allow us a more simple and practical approach.

a) Rainfall:

- The total annual rainfall helps us to classify a site by one figure only in dry (below 50 inches), moist (50 - 100 inches), and humid (over 100 inches). The disadvantage is, that this does not say much about the moisture conditions throughout the year, because the rainfall can be very unevenly distributed.

- The monthly distribution of rainfall gives us an indication of the length of the wet and dry season, and therefore has more significance than the total annual rainfall. An attempt of a classification and a suggestion of suitable tree species is made below:

(A) Dry season less than 4 months *): Anthocephalus chinensis, Eucalyptus deglupta, Albizzia falcata, Octomelis sumatrana, Hevea brasiliensis,

(B) Dry season 4 to 6 months *): Swietenia macrophylla, Tectona grandis, Pterocarpus indicus, Pterocarpus vidalianus, Gmelina arborea, Toona calantas, Leucaena leucocephala

In higher elevations:

Pinus insularis, Eucalyptus spp., Alnus maritima,

(C) Dry season 6 months or more *): Vitex parviflora, Gliricidia sepium, Psidium guava, Anacardium occidentale,

*) A month is considered as dry, when the rainfall is below 50 mm

- Rainfall types according to the official classification of the Philippines do not lend themselves easily for classification of forest sites, because in the rainfall types II, III and IV (see Part I) rainfall can be expected in practically every month of the year, and the same group of species (group (A) above) can be planted in all three climatic types. All species requiring a seasonal wet and dry climate would have to be listed summarily under type I rainfall (groups (B) and (C) above).

It should be noted, however, that the classification attempted above is only a broad guideline for the choice of tree species, which may have to be modified locally because of changes in soil conditions, adverse exposure, changes in altitude, and other factors.

b) Temperature:

Inspite of the wide extent of the country the change of latitude does not have so much influence on the temperature to affect the choice of tree species significantly. Temperature variations from one place to the other in the Philippines are mainly due to changes in altitude (21).

The commonly accepted gradient is $0.5^{\circ}C$ per 100 meter rise in elevation. For example the difference in elevation between Baguio and Binga is about 1000 meters, we therefore can expect, that the temperature in Binga is $\frac{1000 \times 0.5}{100} = 5^{\circ}$ C above the temperature prevailing in Baguio.

This difference of 5° C has already a great effect on the growth of tree species. While in Binga teak, narra, molave, kalantas and other lowland species can still be grown and bear seeds, they would usually not thrive in Baguio. 600 to 700 meters above sealevel seems to be the upper limit for most lowland tree species in Luzon.

2.2 The edaphic factors:

The most important soil characteristics influencing tree growth are the depth of the soil, the humus content, the permeability, the moisture regime, the content of rocky material, the nature of the subsoil, the availability of nutrients and the pH-value. Assessment of these characteristics is generally part of the planting survey and can -except the last two items- be determined by inspection of a soil profile. But even without making a chemical analysis we can draw some conclusions about the availability of nutrients and even the pH-value from the ground vegetation, the presence of humus, the thickness of the A-horizon, the soil structure and the color.

If the special technical terms for a soil description are not known, a free description of what is actually seen should be made. A simple guide for a profile assessment is given below:

(a) General information: Location of the profile,
topography of the profile site,
geological information, if available,
climatic conditions,
vegetative cover, dominant species,
local soil names, if any.

(b) Estimate of the soil fertility is generally not difficult by considering the natural vegetation found at the profile site. For site classification purposes it is recommended to develop a system of indicator plants, which are characteristic for special soil conditions.

(c) Depth of soil:

less than 30 cm.	- shallow
30 to 100 cm.	- medium
100 to 200 cm.	- deep
over 200 cm.	- very deep

(d) Moisture at time of profile description:

dry: color becomes darker, when water is added,

fresh: color does not change, when water is added,

moist: if sample is pressed by hand, water will show,

wet: if sample is pressed by hand, water will run out.

(e) Usual height of water table taking into account the weather conditions.

(f) Drainage: Terms generally used in profile description are

excessive (in sandy soils),

free (for "normal" soils),

imperfect (often in slightly compacted soils with a high clay fraction)

impeded (often in lower horizons of clay soils, where the soil is compacted, and in profiles situated in a depression)

(g) Separation of the profile into horizons:

O-horizon: undecomposed or semi-decomposed litter,

A-horizon: characterized by the presence of soil humus. The color is generally darker than the underlying B-horizon ("topsoil").

B-horizon: The horizon of mineral soil between the A-horizon and the underlying parent material ("subsoil").

C-horizon: The parent material, mostly undecomposed rocks and other material, where the soil forming process has not yet started.

If within the A,B, and C horizon significant differences in color, texture, etc. occur, a further subdivision in line with the conventional symbols used in soil science should be attempted. Each horizon is described separately indicating its depth. Example:

0 - 15 cm.	A-horizon: ...
15 - 120 cm.	B-horizon: ...
below 120 cm.	C-horizon: ...

The following items (h-n) must be described for each horizon separately:

(h) Color: The description should be as specific as possible, for example: dark reddish brown, light yellowish brown, mottled grey and red brown, etc. . Compare also the color with the horizon below and above: lighter or darker.

(i) Texture class: refers to the distribution of fine and coarse particles in the soil. The main texture classes can be easily determined by field characteristics (33):

Sand: A wet sample does not stain the hands,

Loamy sand: slightly sticky, but does not allow to be formed into a stick of cigarette thickness,

Sandy loam: makes a sound, when rubbed between the fingers close to the ear. Allows to be formed into a stick of cigarette size.

Loam: Allows to be formed into a doll with arms and legs. Rubbing between the fingers makes a very light sound only.

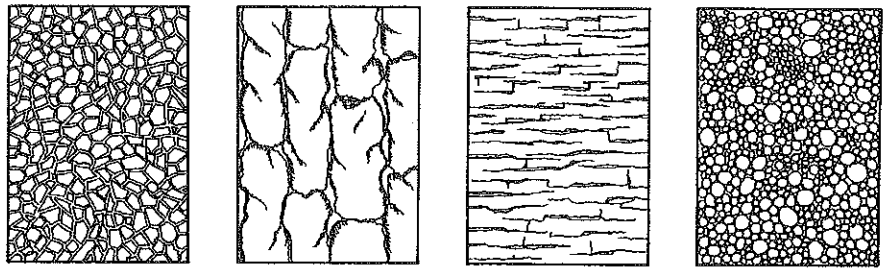
Clay loam: Sample allows to be formed into a fragile string. No sound when rubbed between fingers.

Clay: highly plastic and slippery when handled. Allows to be formed into a thin string.

(j) Skeleton percent: Estimate of the proportion of coarse particles (over 2 mm) in the soil. Also a description of their nature is required:"approximately 20% skeleton consisting of platelike stones with an average size of 2 - 3 cm."

(k) Soil structure: Sometimes more clearly pronounced in old profiles or road cuts, in a fresh profile the structure becomes more obvious, when

a shovel of soil is thrown on the ground and the soil breaks up into aggregates. Descriptive terms commonly used are plate-like, prismatic, blocky (very common), granular or crumb structure (A-horizon), or "no visible structure".



Blocky | Prismatic | Plate like | Granular or crumb structure

Fig. 2: Types of soil structures.

(l) Compaction: terms commonly used in soil profile description are: for dry soils: loose, friable, firm, very firm, cemented, for moist soils: sticky, non-sticky, plastic.

(m) Root penetration: use a free description:"many fine roots, isolated strong roots, horizon well penetrated by roots" etc.

(n) Presence of soil fauna: earth worms, termites, ants, mice or others.

To assess these soil characteristics a profile pit of about 1.5 m depth is dug on a representative site avoiding places, which are not really characteristic of the area like ridges, small depressions, vicinity of creeks and rivers etc.. Sometimes road cuts provide a very large and deep soil profile that one can save the labor for digging a pit.

On table 1 (next page) some tree species had been suggested for some typical soil types. This brief outline, however can provide only some basic ideas when selecting a tree species and does not eliminate the necessity to conduct trial plantations, whenever a new species is introduced to a region.

Elevation	S O I L	DRY SEASON LESS THAN 4 M.	DRY SEASON 4-6 MONTHS	DRY SEASON MORE THAN 6 M.
up to elevations of 600-700m above sealevel	dry rocky ridges		alibangbang, guava molave, akleng parang	alibangbang, guava molave, akleng parang
	rocky soil with high skeleton content	Gmelina arborea, bagras, Moluccan sau, ipil-ipil,	casoi, guava, molave, akleng parang, ipil-ipil kalantas,	molave, casoi, guava, akleng parang,
	very shallow soils		akleng parang	akleng parang
	sandy soils near seashore	agoho, bitaog, talissai, aroma	agoho, bitaog, talissai aroma, kamachile	agoho, kamachile,
	red and brown soils originating from limestone		kalantas, narra, molave Gmelina arborea, ipil-ipil	molave, kakawate
	deep and well drained lowland soils	kaatoan bangkal, bagras Moluccan sau, Para rubber Gmelina arborea	teak, narra, mahogany, Gmelina arborea, lumbang ipil-ipil, Honduras pine	kalantas, molave, Eucalyptus citriodora (?)
	fresh alluvial soils near creeks and rivers		Gmelina arborea, narra and many others	forest species and fruit trees
	soils with impeded drainage	Eucalyptus robusta,	banaba, Eucalyptus robusta, Casuarina glauca	banaba, Eucalyptus robusta, Casuarina glauca
above 600m	grassland soils under cogon	Benguet pine, Eucalyptus spp., Alnus maritima	Benguet pine, Alnus, Eucalyptus saligna, E. grandis,	Benguet pine, Eucalyptus camaldulensis
	mountain forest soils of good quality	Cryptomeria japonica, try also Cunninghamia konishii and Chamaecyparis formosensis		

Table 2: SUGGESTED TREE SPECIES FOR SOME TYPICAL SITE CONDITIONS

Chapter 3:

ECOLOGICAL NOTES ON SOME REFORESTATION SPECIES IN THE PHILIPPINES

1) Acacia farnesiana. Aroma

This large spiny shrub is native to South America, but now widely distributed throughout the tropics. The tree is very common along the West coast of Luzon and Mindoro and many other places. It was seen growing very well on coastal sands and may have good prospects for degraded and sandy sites in low elevation and for erosion control purposes. Due to its long spines it is not very attractive as fuelwood or fodder, which is a big advantage in some places.

2) Agathis philippinensis. Almaciga

Almaciga is a large tree with a wide distribution throughout the Philippines on moist, but well drained mountain slopes at elevations from about 300 to 1500 meters. It is not allowed to cut almaciga, because it yields a valuable resin known as copal.

Because of short viability the propagation by seed is difficult. The usual method of propagation is by wildlings, which can be found in great numbers under the mother trees, after the ground vegetation has been cleared. The young seedlings benefit from a light shade and are well suited for underplanting or enrichment planting. Almaciga requires a moist, well drained site with a humid atmosphere (forest environment) with only a short dry season, and does not seem to be suited for open grassland.

3) Albizzia falcata. Moluccan sau

A fast growing tree from the Indo-Malayan region. It grows well up to elevations of about 600 meters in Luzon, in Mindanao it can be grown also at higher elevations as in Cinchona Reforestation Project, Bukidnon. Albizzia falcata does best on a variety of soils, but best growth rates are obtained on good forest soils.

The tree is liable to wind damage and therefore should not be planted in the typhoon belt, where the branches are easily stripped off by strong winds. Albizzia falcata performs a useful function as a nurse crop, wherever light shade is required to raise more delicate species by underplanting.

Large commercial plantations of this species can be seen at the concession of the Nasipit Lumber Company in Agusan, Mindanao, where a mean annual increment of about 30 cu. m per ha is obtained an average sites and over 50 cu. m on good sites. Local yield tables are available.

4) Albizzia lebbekoides. Kariskis

A small tree with a wide distribution throughout the Philippines. Suitable for planting on dry and rocky sites.

5) Albizzia procera. Akleng-parang

This tree is common in regions with a pronounced dry season, namely the Ilocos Provinces, and is often encountered in open secondary forest. Since the tree is able to grow on very shallow soil, it may be a very useful species for difficult sites. The wood, although of small dimension, can be used for many purposes.

6) Aleurites spp.

Aleurites trisperma (bagilumbang) is indigenous only to the Philippines, while A. moluccana (lumbang) has a very wide natural distribution and had been established in plantations throughout the country. In the Nasipit Lumber Concession lumbang is planted at a commercial scale in combination with cattle ranching. The climatic and soil requirements of both species are not very specific.

A third species, Aleurites fordii, which yields the tung oil, has been recently introduced in the Philippines (Magat Reforestation Project) and is supposed to grow well on dry sites.

7) Alnus maritima (?). Japanese Alder

This medium sized tree is suitable for elevations above 600 meters. It grows well on landslides and degraded soils and therefore performs a useful function in erosion control as long as the site is not too dry.

8) Anthocephalus chinensis (syn. A. cadamba). Kaatoan Bangkal

A fast growing pioneer tree of the rainforest area, which sometimes appears in masses where the soil had been disturbed by construction of logging roads.

The ecological requirements of this species are uniform rainfall, moist and well drained forest soils and full light. Planting therefore is only recommended in type II rainfall areas without a pronounced dry season. Plantations in the drier parts of Luzon have all failed, while on favorable sites in Mindanao a mean annual increment of 50 cu m /hectare and more had been recorded.

9) Bauhinia malabarica. Alibangbang

This and other species of the genus have only value as ornamentals and can be tried in groups for beautification on dry ridges and other dry and rocky sites.

10) Calophyllum inophyllum. Bitaog

Common throughout the western Pacific region near seashores. The species is suitable for planting on coastal sands, but due to the slow growth Casuarina equisetifolia is generally preferred. Other species of this genus thrive also in inland plantations in drier places.

11) Casuarina spp. Agoho

Two species of this genus, Casuarina equisetifolia and C. rumphiana are native in the Philippines, while a third species C. montana was introduced from Australia.

- Casuarina equisetifolia: a pioneer on fresh deposits along rivers and along the sea coast. The species is recommended for planting on coastal sands and degraded sites in the lowland.

- Casuarina rumphiana: native in the moist mountain forests of the Philippines at elevations around 1000 meters. It is a beautiful tree, but apparently not often cultivated.

- Casuarina montana (syn. C. junghuniana): Most of the agoho planted at higher elevations seems to be C. montana (?). The species is very hard to distinguish from C. equisetifolia. Because of the ecological differences, however, the distinction of the two species is important:

	C. montana	C. equisetifolia
Twigs ("needles")	8-10 teeth at each node	5-8, mostly 7 teeth at each node
Fruits ("cones")	more truncate, smaller 5-6 whorls of fruit cells 8-10 cells in a whorl	more elliptic, larger 7-8 cells in a whorl

12) Cryptomeria japonica. Japanese Cypress

Some old specimens are found around Baguio as ornamentals, but they do not look very vigorous. Cryptomeria likes a deep, moist and well drained soil and is suitable only for higher elevations. A plantation established at Mt. Data at about 2500 m was growing well until burnt 1973. Seedlings showed slow progress during the first two years in the field, but then put on rapid growth. In the mountainous parts of Agusan young plantations showed extremely fast growth. The question of the proper provenance is very important for Cryptomeria japonica. In neighboring Taiwan the YOSHINO provenance from Central Japan gave best results. Provenance tests for the Philippines are recommended.

13) Dipterocarps.

Most species of this very large and important family regenerate naturally easily on undisturbed or slightly disturbed forest soils. Their artificial regeneration, however, is difficult. The seed years are irregular and the seed has only a very short viability.

Plantations have been established successfully by underplanting with wildlings of white lauan and bagtikan (Malaybalay Reforestation Project, Mindanao), because all dipterocarps require shade in their early juvenile stage. Most attempts of planting them in open plantations have failed.

If dipterocarps are considered for planting at all, trials should be conducted on forest soils under shade in regions with more or less evenly distributed rainfall. For details on planting dipterocarp wildlings and enrichment planting with dipterocarps see Chapter 11 and 16.

14) Endospermum peltatum. Gubas

The frequency of this medium to large tree increases in overlogged dipterocarp forest, where gubas can be considered a secondary species. Since it is in high demand for matchsticks and matchboxes, it is already planted in some places. The tree seems to be best suited for fresh forest soils in areas with more or less evenly distributed rainfall. The seeds require a special treatment to break or avoid dormancy (PCAR, 1975).

15) Eucalyptus camaldulensis.

This species is widely distributed all over Australia, including some areas with very low rainfall. Plantations of E. camaldulensis have been established successfully under various climatic conditions in many tropical and subtropical countries.

Trial plantations at elevations above 600 meters in Luzon were quite successful. At lower elevations trial plantations of this species had been a total failure in some places and a success in others. Therefore small trial plantings are recommended before starting any larger plantation in lower elevation. It should be noted here, that most Eucalyptus species are very sensitive to weed competition, and may require a careful site preparation. This may be one of the reasons for failure in some places.

A provenance test with 50 Australian provenances of this species was conducted by the Training Center in 1972 at the Binga plantation site. The result so far has been, that

only some provenances from the most northern parts of Australia (North of 18°) gave promising results at the difficult site at Binga and seem to be well suited for dry mountain areas where the choice of species is very limited.

16) Eucalyptus citriodora.

In its natural habitat this species occurs from sealevel up to 600 meters under rainfall from 600 to 1000 mm. The tree is very adaptable in respect of soil and rainfall conditions.

In the Philippines it should be given a trial on drier sites at lower elevations.

17) Eucalyptus deglupta. Bagras.

This is the only eucalypt indigenous to the Philippines. It requires a moist and well drained soil and is not a species for dry sites or areas with a very pronounced dry season, though the species appears to be quite adaptable. On favorable sites the increment can be extremely high and a mean annual increment of over 50 cu m can be obtained.

Large commercial plantations of this species can be seen in Surigao del Sur, Mindanao,where also natural stands of this species are found.

18) Eucalyptus robusta. "Swamp mahogany".

This species grew well in trial plantations in Bukidnon and the Cagayan Valley (46). As the Australian name suggests, it prefers marshy sites and heavy soils. It can be grown also on light soils, as long as they are not too dry. On dry sites the tip may die back, when the trees reach pole size.

Eucalyptus robusta does best under uniform rainfall, even in lower elevations.

19) Eucalyptus saligna.

A very fast growing tree, which should be tried on moist sites in Mountain Province and higher elevations in Mindanao. The species is not suitable for dry and rocky sites.

Very sensitive to weed competition. Some specimen trees can be seen around Baguio as ornamentals.

20) Eucalyptus grandis.

The tree is very similar to Eucalyptus saligna and also requires a moist and well drained soil at elevations above 600 meters. It is not suitable for dry sites. Very sensitive to weedcompetition. There may be natural hybrids with the former species.

21) Gliricidia sepium. Madre de Cacao, Kakawati.

This species was introduced from Central America and is very common in the Philippine lowlands up to about 600 meters elevation. It can be easily established on dry and poor sites by cuttings, and therefore is very useful for erosion control at lower elevations. It is also a good nurse crop capable of improving the soil conditions because of the high nitrogen content of its leaves (49).

22) Gmelina arborea. "Melina", Yemane (Mindanao).

A species with roughly the same natural distribution as teak stretching from India to Indochina.

Gmelina has grown well in the Philippines under a variety of site conditions, and has become the favorite of many foresters. Due to its good early growth it can generally cope with the weeds with little or no assistance. The tree is quite adaptable to different rainfall conditions and can be planted in all four rainfall types of the Philippines. However, regarding soil conditions, the species is quite demanding. According to LAMB (1968) Gmelina not only requires good drainage, but also a high base status. Ample available nitrogen is probably essential for vigorous growth of Gmelina.

On difficult sites the tree is shortlived, sometimes dying without apparent cause already at the age of about 10 years. In a trial plantation in Binga the trees grew well during the first 2 years but then height growth stopped almost

completely. On favorable sites the tree lives up to 40 years and can attain diameters of 60 to 80 cm (41).

23) Leucaena leucocephala. (Syn. L. glauca) Ipil-ipil.
An introduced tree from Mexico and Central America, which is already naturalized in the Philippines.

Once established the tree grows and regenerates easily at elevations below 600 meters and occasionally is seen above 1000 meters. It prefers the moist and more fertile lower slopes and does not like acid soils. Regarding rainfall ipil-ipil is quite adaptable, but does not do well on very dry sites with southern exposure.

Leucaena can be grown from seed or cuttings and coppices well, therefore it may be a useful species for erosion control at lower elevations. In Laguna Province it is managed under a coppice system to provide fuelwood for the Greater Manila Area. On Java/Indonesia it is a very important nurse crop in all taungya plantations, where it is sown in lines between teak and other species. The young trees are lopped frequently to provide mulch for improving the soil conditions.

In a test with 104 strains of Leucaena leucocephala conducted at the Hawaii Agricultural Experiment Station a strain from Mexico had been outgrowing all other strains (9) and had been introduced to the Philippines recently as "giant ipil-ipil".

24) Mangifera indica. Mango
This very common fruit tree grows easily and fruits at elevations up to about 600 meters in Luzon on a variety of soils and succeeds also on rather dry sites. Planted on favorable sites around forest plantations the wide crowned mango trees will shade out grasses and provide an effective fire break.

25) Pinus caribaea var. hondurensis.
This is one of the few pine species besides P. merkusii and perhaps P. oocarpa, which can be grown successfully at lower elevations in the tropics. In a 7 years trial plantation north of Baguio the species was outgrowing the native P. insularis.

26) Pinus insularis (syn. P. khasya). Benguet Pine

This species is indigenous to the mountains of North Luzon and should be used for all grassland sites at elevations above 800 meters. At lower elevations the trees tend to exhibit a very poor shape and slow growth. The poor shape at lower elevations could possibly partly be attributed to increased shoot borer attack.

At Malaybalay Reforestation Project, Mindanao, an old plantation of very tall and straight pines can be seen at 600 meters elevation, but up to 1970 these trees produced little or no viable seed.

27) Pinus merkusii. Mindoro Pine

The tree occurs naturally in the Philippines in two small isolated areas in NW Mindoro and the Zambales Mountains. Very little planting has been done with this species in the Philippines so far, because the seed is difficult to get, it has a short viability and the seedlings are delicate and slow growing.

An additional disadvantage of the Philippine provenances of this species is, that they have a "grass stage", which does not occur in the provenances of North Sumatra and increases the weeding costs considerably.

For lower elevations it may be worthwhile to try the Atjeh strain from North Sumatra.

28) Pinus oocarpa.

Seedlings planted near Baguio have shown growth rates similar to the indigenous Pinus insularis.

WORMALD (1969) recommends trial planting with P. oocarpa v. ochoteranai at elevations below 1000 meters.

29) Pithecolobium dulce. Kamachile

A medium sized tree from tropical America, now widely distributed and naturalized in the Philippines. The species is

able to grow on dry sites and coastal sands, suitable for erosion control in low elevations, source of tannin.

30) Psidium guaba. Guava

Besides bearing edible fruits guavas are very hardy, deep rooted, and drought resistant, they can be planted on extreme sites on southern slopes and rocky ridges, where almost nothing else would grow. Once fully established, they cannot be eradicated easily and survive grass fires.

31) Pterocarpus indicus. Narra

Most of the original narra forests near the coasts are already destroyed by kaingin, cleared for agriculture, or altered by heavy timber cutting. According to WHITFORD (1911) narra is found throughout the Philippines, principally in regions where the dry season is not pronounced, nearly always occupying places on flat coastal plains behind mangrove swamps or very scattered along streams in the low hills near the coast. Very rich narra stands were also found in the Cagayan Valley.

Though the tree appears to be quite adaptable to dry sites, it may not reach the quality here required for sawn timber due to excessive forking and, as a result, short boles.

32) Pterocarpus vidalianus. Prickly Narra

The Philippine national tree. It is distinguished from P. indicus mainly by the prickly fruit, the site requirements are the same as for Pterocarpus indicus.

33) Samanea saman. Raintree, Monkey Pod, "Acacia"

This tree has been introduced probably by the Spaniards from Central America. It is frequently encountered in towns and along roads at elevations below 600 meters. The wood is in high demand for the wood carving industry.

Site requirements are not very specific, but the tree seems to be most suited for moist, but free draining sites in the lowlands with a pronounced dry season.

34) Sesbania grandiflora. Katurai

This very useful small tree occurs naturally throughout the Indo-Malayan region up to Northern Australia. It is cultivated now in most tropical countries. The flowers can be eaten as a vegetable, the leaves serve as fodder for milk cattle, an extract of the barks is prepared as a medicine against bowel complaints, the wood is used as fuel.

In the lowland of the Philippines and Java the tree is a common sight in moist places along rice fields and near homes. It is also found sometimes as a pioneer in abandoned kaingins.

35) Swietenia macrophylla. Large Leaf Mahogany

This species has proved to be one of the most successful trees for reforestation in the Philippines as long as it was not attacked by the shoot borer. It thrives under rainfall from 1500 to 5000 mm. and a dry season up to 5 months. In a moist climate the trees are taller and growing faster, but the quality of the dry area mahogany is superior. Mahogany is essentially a tree of lower elevations and should not be planted above 600 meters in Luzon.

In respect of soil requirements the species is quite adaptable and on rather shallow as well as deep alluvial soils.

Shoot borer attack (Hypsipyla robusta) is often serious especially on good sites and can perhaps be reduced by growing mahogany in mixtures or under a light shelter of Albizzia falcata to avoid the formation of long sapy shoots, which are of special attraction to the insect (6). Where shoot borer attack cannot be controlled other species must be chosen.

36) Swietenia mahogani. Small Leaf Mahogany

This species is able to grow on drier sites than Swietenia macrophylla, but the growth rate is slower.

37) Tectona grandis. Teak

Teak has been widely planted on grassland sites throughout the country. The great advantage of this species is, that it can be easily raised in the nursery, easily established in the field by stumps and sprouts after grass fires.

However, the rate of growth and the form of the trees are generally very poor in most plantations. It is not clear, whether this is a question of the site (degraded grassland!) or of unsuitable seed origin. Provenance tests with good Thai and Indian provenances including the famous Nilambur Teak from South India or Malabar provenances are suggested.

The value of teak in plantations with purely protective functions in dry areas is doubtful, since teak is deciduous and may take a very long time to suppress the grasses to a degree, where groundfires cannot do any harm (67).

Teak is a very demanding species and should be confined to rich, well drained soils, which are often really agricultural soils and should not be planted on dry rocky slopes.

38) Toona calantas. Kalantas

This species is found scattered throughout the Philippines on a variety of sites: along small streams in the molave forest, on flood plains in the lauan-hagachac forest (66), on dry slopes in the Ilocos Region, in the rain forest of Palawan, the Visayas and Mindanao. This wide distribution shows, that the species must be quite adaptable to different soil and rainfall conditions. At the Caniaw Reforestation Project in Ilocos Sur it is planted at a large scale on dry rocky slopes. On moist and fertile sites the plantations are liable to shoot borer attack like most Meliaceae. Preventive measures are described in Chapter 23.

Since the species yields a useful timber, is easy to raise and can be planted bare root, it should be given more attention.

39) Vitex parviflora. Molave

Usually a small to medium sized tree of very ragged shape and a crooked and fluted bole, but of very high value, because of its resistant timber. According to WHITFORD (1911) the tree was once widely distributed throughout the islands, especially on low coastal hills, usually on limestone, but may also occur on vulcanic rocks and other sites.

It is suitable for very dry and rocky sites with southern exposure, but due to its slow growth it had been rarely planted at a larger scale.

Chapter 4:

THE OBJECTIVES OF REFORESTATION AND THE CHOICE OF TREE SPECIES

When selecting a tree species for a planting project, we must in the first place always consider the species which grow best under the given ecological limitations. The second consideration then is which of the possible species serves best the purpose of the plantation and gives us the maximum benefit. Since the ecological aspects have already dealt with in the two previous chapters, the purpose of tree planting will be analysed here more in detail.

Objectives for planting trees can be one or several of the following:

1) Production of sawnwood, veneer and plywood,
2) Production of pulpwood,
3) Production of fuelwood,
4) Production of poles and piles for local consumption,
5) Production of "minor forest products" like rubber, fibers, tannin, resin, fruits, etc.
6) Erosion control,
7) Protection and improvements of watersheds,
8) Shelterbelts,
9) Beautification.

When making our choice, we should try to find a species, which serves not only one, but several of the above listed objectives to cope with the multiple-use functions of the forest.

4.1 Production of sawnwood

When the main objective of a plantation will be to produce sawnwood, we have to consider, that the trees we plant today, will be harvested only after 30 to 100 years. The problem for the forester is to predict, what will be required by the market a long time ahead. Inspite of all future technical developments, increased competition from other materials, and a noticible trend towards composite wood products, foresters generally are convinced, that there will always be a demand for good quality sawnwood. CHAMPION and BRASNET (1958) recommend general utility timbers as a safer investment in the long run than special purpose timbers with increased competition from other materials.

Another point, which has a bearing on the choice of tree species, is the necessity to concentrate on relatively few species, after the stage of species trials has passed. The trade and the wood based industries always want large quantities of the same product. Small quantities even of a very

useful species, to which the trade is not yet accustomed, from an isolated plantation may be very difficult to sell in most cases. The tropics are very rich in timber trees, and there is the danger for the enthusiastic forester to plant too many species. Of course also the other extreme of large monocultures with all the risks involved has to be avoided. If the existing species satisfy the demand, there will be no need to introduce unpredictable exotics. In the Philippines so far the species, which make up the bulk of industrial plantations, can be counted almost on one hand.

If a new species is to be introduced to a region, trial plantations have to be established, which should cover at least 1/3 or better ½ of the proposed rotation, before one can embark in any lager operation. Observations in the nursery and early plantation stage are not enough.

Under Philippine conditions the following species may be considered for sawnwood production in plantations:

Swietenia macrophylla	Gmelina arborea
Tectona grandis	Albizzia falcata
Pinus insularis	Eucalyptus deglupta

Pterocarpus indicus and P. vidalianus

Plantations of these species may become more and more important for the sawnwood supply in future, as the remaining dipterocarp forests will be depleted.

4.2 Production of pulpwood.

The present annual paper consumption of the Philippines is about 0.4 million tons. The increase in consumption during the last decade has been about 7% annually, and the consumption had doubled since 1961 (1).

The consumption of paper is intimately linked to the standard of living or the per capita income. The higher the standard of living and the educational level, the more the people consume paper and paper products. There is more demand for books, newspapers, magazines, writing paper. The increased consumption of goods leads to a higher consumption of wrapping

and packing materials. With the rising standard of living combined with a high population growth of 3.4% annually, we can predict a sharp increase in paper consumption, and therefore increased need for pulpwood plantations. Still quite a large proportion of the pulp and paper needed is imported, but these imports are regressive. Imported is also still a large portion of the long fiber pulp, which is blended with short fibers to produce strong paper grades or kraft paper.

In the Philippines out of 3800 woody species about 200 are suitable for pulp (1) especially

- Benguet pine (Pinus insularis)
- Moluccan sau (Albizzia falcata)
- Kaatoan bangkal (Antocephalus chinensis)
- Bagras (Eucalyptus deglupta)
- Yemane (Gmelina arborea)

Besides these species, which are already planted at a large scale for pulpwood, the Forest Products Research Institute at Los Baños recommends also a long list of others (52). Some of these, which have a potential for plantations, are African tulip (Spathodea campanulata), Binuang (Octomelis sumatrana), gubas (Endospermum peltatum) and luctub (Duabanga moluccana).

In a recent work ESCOLANO et al. (1974) have investigated kraft pulping of a number of non-commercial hardwoods, some of which like Toog showed fiber length over 1.6 mm, but may present silvicultural difficulties for mass production.

In a pulpwood plantation, considerations about stem form, branchiness and taper play only a secondary role. The main aim is to produce quantity measured by volume and weight, because about 4-6 tons of wood are required to produce one ton of pulp. The following aspects therefore have to be considered already in the planning stage:

- Since a pulp mill requires very large quantities of wood for economical operation, dry areas where trees are growing slow are unsuitable for pulpwood production. Water must be available in large quantity, because about 40 cu. m. of water are needed for one ton of pulp.

- Pulpwood is bulky, the value per unit is not as high as logs. Therefore pulpwood cannot be produced in remote areas. The plantations have to be situated as close to the pulp mill or a motorable road as possible and must be concentrated to reduce transportation cost. Small, widely scattered plantations are a great handicap for the development of any wood based industries (26).
- The species usually planted for pulpwood are fast growing. The pulp mill therefore has to be planned simultaneously with the planting programme. After 8 to 10 years we can expect the first pulpwood to be harvested and there must be a mill to utilize it.
- The number of species planted in a pulpwood plantation project should be limited, because pulping of a heterogeneous mixture of hardwoods is still difficult. From the silvicultural point of view, however, the project is more safely founded, when several species are planted, and large monocultures are avoided. Usually a compromise has to be made between the silvicultural aspects on one side and technical and economical on the other, which could result, for example, in a block mixture of different species and age classes.

4.3 Production of fuelwood.

In the Philippines fuelwood still continues to be important for the lower income groups, especially in the rural areas. The fuelwood demand of the Greater Manila area is met by the ipil-ipil plantations of Laguna. In Central Luzon heavily pollarded rain trees and katurais provide fuelwood in purely agricultural areas without remains of forest. According to estimates about one half of the worlds wood conumption of 2.5 billion cu.m. is still consumed as fuelwood. With the present energy crises the demand for fuelwood is likely to increase.

As pointed out by CHAMPION et BRASNET (1958) wood as a fuel has the great advantage over all other sources of energy, except hydro-electric, that, properly managed it is permanently self-renewing, and can be produced almost everywhere

where land and moisture is available. The great disadvantage, however, is that fuelwood is quite bulky in respect to its calorific value, and costs for transport and handling are therefore relatively high. In most cases it would not be economical to transport felling waste from the logging areas to the centers of consumption. Where it can be expected, that a demand for fuelwood is likely to continue, special plantations of easy growing species managed under a coppice system may be the best solution.

When selecting the species one should take into account the calorific value as well as silvicultural factors. One should not only select a species, that grows fast, but also one which regenerates easily naturally by seeds or coppice. Most fuelwood plantations in the tropics have been established with legumes. For the Philippines ipil-ipil, kakawate or Cassia siamea appear to be most suitable. Species, which have to be replanted after each cutting cycle are unsuitable for fuelwood plantations, except, if they are especially adapted to a site, where nothing else would grow.

In the Philippines the most common species for fuelwood plantations is ipil-ipil. Most of the ipil-ipil sold in Manila comes from the Los Baños area, where extensive plantations of this species can be seen. The rotation there is only 2-5 years. Land reasonably stocked with ipil-ipil produces about 4000 bundles per hectare per rotation(30), which would be equivalent to about 6-10 cu. m. staked per year. The "giant ipil-ipil" probably would produce much more.

4.4 Poles and piles for local consumption.

Foresters should always bear in mind the needs of the local people to assure their cooperation. In rural areas there is usually quite a high demand for piles and poles for simple construction and fences. The lower the income in a certain part, the more the people use roundwood and less sawnwood. With rising income the roundwood consumption will fall and is replaced more and more by sawnwood.

In forest areas there will be no need for making special plantations to satisfy this demand for poles and small wood. The always present secondary forest will provide enough material. Where we have closely spaced plantations for timber production, the thinnings can often be sold to meet the demand for poles (16).

If permanent difficulties in the supply exist for an area, bamboo plantations would be highly appreciated by the local population, since bamboos rank among the most useful and versatile forest products. Due to its ease in working and its availability bamboo is used in the Philippines for almost every purpose wood is used in temperate countries (30). Bamboo is used for house construction in many areas, serves as water container, or pots for raising tree seedlings, split boho is woven into a coarse matting called "sawale" used for walls and partitions in houses, or it can be used for fish traps or fences. During the Vietnam War deadly traps were constructed only of bamboo and vines to be triggered off by unwary soldiers, the "balatec" made of bamboo is still in use to trap wild boar in some places.

Bamboo also can be a source for long fiber pulp like in Sulawesi (Indonesia). The technical difficulty to a certain extent still is the high silica content which destroys the knives of the pulping machines.

Of the 17 erect species of bamboo found in the Philippines, the three species most widely used are (30):

- Kawayan (Bambusa spinosa): This spiny variety is the most commonly used bamboo in the Philippines due to its strength and durability. It is thick walled with internodes of 40 to 60 cm and can attain a height of 25 m and a culm diameter of 20 cm. Kawayan had been introduced to the Philippines a long time ago, possibly from Indonesia.
- Kawayan-kiling (Bambusa vulgaris): This species occurs now all over the tropics and is considered a pantropical species. It is difficult to decide, where it is native and where it was introduced by man. The height is less than Bambusa spinosa, and the culms have a thinner diameter and thinner walls. Where it occurs, it is extensively utilized.

- Boho (Schizostachyum lumampao): This thinn-walled species is widely distributed in lower hill forests and covers extensives areas in the foothills of the Mountain Provinces in Luzon.

It is easily understood, that a properly managed bamboo grove near a village would be of great value to the community. Larger bamboo plantations could be the basis of raw material for a number of industries.

Propagation of bamboo is done by root cuttings or root suckers, with some species also stem cuttings are successful. Seed years occur only at long intervals, after which all the bamboo over a wide area dies. If there is a seed year, this opportunity for mass propagation should be utilized to raise potted bamboo seedlings. For further information on bamboos consult McCLURE (1966).

4.5 Production of "minor" forest products.

The number of trees in the Philippines, which yield other products than wood, is very vast. But here we want to deal only with some species, which are c u l t i v a t e d for their special products. These products are often termed "minor" forest products (10), although they can be very important for the local economy, and their value per unit of area may in some cases even exceed the value of wood production. Some examples for forest trees, which are cultivated in the Philippines for other products than wood, include

- Para Rubber (Hevea brasiliensis). The largest commercial plantations in the Philippines are found in Mindanao and Basilan Island. Commercial firms plant now only high yielding varieties, which have to be grafted. Their yield is several times higher than that of the wild tree.
- Cinchona spp. yield the alkaloids quinine, cinchonine and quinidine. A bitter extract of the bark is also used for the manufacture of tonic water. Cinchona species are native to Peru and Ecuador and have since long been used for the cure of malaria. For cultivation they require a humid mountain climate.

A 225 hectare plantation was started already in 1929 near Malaybalay in Bukidnon at an elevation of about 1500 meters, known today as the Cinchona Reforestation Project.

- Lumbang (Aleurites moluccana). The kernels yield the lumbang oil, which is used to make paint, varnish, linoleum and wood preservatives.
- Almaciga (Agathis philippinensis, syn. A. alba). A large tree with broad needles belonging to the Araucariaceae. It produces a resin known as Manila Copal in the international trade. The best quality copal comes from Palawan and Quezon Province. Almaciga is widely distributed in the humid hill forests of the Philippines. Artificial regeneration of this species is mainly by wildlings, because the seeds have a very short viability.
- Pili (Canarium ovatum). This tree yields two valuable products: the famous pili nut and the Manila elemi, a resin used for the manufacture of varnish. The pili nut is a delicacy known especially from the Bicol Region, where the tree is cultivated. Canarium ovatum belongs to the Burseraceae and attains a height of about 35 meters and a diameter up to one meter.
- Buri Palm (Corypha elata). The largest of all Philippine palms. It yields the buntal fiber used for the manufacture of fine hats in Central Luzon. The fiber is extracted from the petiole of the immature leaf. The sap is used to make tuba, an alcoholic drink. The trunk contains starch, which can be extracted. The leaves are used extensively for making baskets and mats. The buri palm occurs all over the Philippines and is cultivated locally. After flowering the palm dies.

Besides these few examples of minor forest products given above, there is also a vast number of edible fruit-bearing species worth cultivating on favorable micro sites along creeks within forest plantations and along trails. A comprehensive annotated list of edible fruit-bearing tree species had been compiled by Prof. Jacalne (1960). Fruits gathered from plantation areas may improve the diet of the local population and stimulate their interest in protecting the plantation from fire.

4.6 Planting for erosion control.

For erosion control not only trees but also shrubs, grasses and other plants, which can provide vegetative cover, can be used. Very often the native flora of the project area contains very useful species for erosion control, which should be given a test, even if these species are considered weeds and have never been propagated before. The requirements for suitable species are

- the species must be able to succeed on degraded sites,
- it should have a deep and wide spread root system,
- it should be able to improve the soil conditions by producing plenty of litter, or should be able to fix atmospheric nitrogen in symbiosis with nitrogen fixing bacteria,
- for many methods of erosion control (brush covers, etc.) only species, which sprout from cuttings can be employed,
- the species must be able to withstand draught followed sometimes by superabundance of water,
- a rapid development is desirable to achieve the protection quickly,
- the species should gave some economical returns like lumber, fuelwood, edible fruits or other useful products.

Species, which proved to be very suitable for slope stabilization in Mountain province, were Mexican sunflower (Helianthus sp.), Lantana (Lantana camara), and Japanese alder (Alnus maritima). For lower elevations bamboos and legumes like kakawati (Gliricidia sepium) and ipil-ipil (Leucaena leucocephala) are recommended.

4.7 Protection and improvement of watersheds.

The main objective of most reforestation projects in the Philippines so far is the establishment of protection forests, many of which have important functions in delicate watershed areas.

Reforestation generally is the best way of conserving soil and water in mountainous catchment areas. A forest cover raises the water storage capacity of a watershed and minimizes silting of reservoirs. The requirements for species suitable for the protection and improvement of degraded watersheds are basicly the same as those listed for erosion control. In most cases we shall find it difficult, if not impossible, to select a species, which meets all the desirable requirements listed above. The best solution would therefore generally be a mixture of several species (preferably by groups), which are complementary in their beneficial effects on the watershed.

It must be kept in mind, that only in special cases it is justified to establish a forest with only protective functions, which gives no direct economic returns. Under restricted utilization and special management also a forest in a watershed can yield timber and other forest products.

Very few quantitative data exist on the effect on the hydrological cycle of different tropical tree species: how much rainfall they intercept, how much water they consume for their own transpiration, how they influence the water retaining capacity of the soil. Species, which are deciduous like teak, narra, Gmelina are likely to consume less water for transpiration during the dry season than evergreen species. This may be a point to be considered in low rainfall areas, where springs may dry up, if the watershed is under evergreen forest.

4.8 Shelterbelts

The reduction of wind velocity on both sides of a shelterbelt consisting of several lines of trees and shrubs can result in decreased destruction on homes, gardens and agricultural crops, and increases the yield from the protected fields. The value of a shelterbelt is the higher, the more valuable the land or the crops it protects. In the typhoon belt of the Philippines, where extreme wind velocities of about 200 km./h. are to be expected almost every year, well

maintained shelterbelts would possibly reduce some of the damages. It can be expected, that the loss of productive area through the shelterbelts will be more than compensated by their benefits.

The choice of suitable species depends on what grows best under the ecological conditions of the area. Within these limitations desirable characteristics are (16):

- wind firmness,
- rapid development,
- ability to coppice,
- economic value.

In many tropical countries casuarinas and eucalypts especially Eucalyptus camaldulensis, have been successfully planted for shelterbelts. In the Philippines also legumes like ipil-ipil and kakawati would be useful. Most effective is a mixture of medium to tall trees in the center and small trees and shrubs on the outside of the belt, so that the shelter belt assumes a triangular cross-section. As a rule of thumb in planting a shelterbelt one uses 1/3 seedlings of tall to medium trees and 2/3 shrubs and small trees.

A main shelterbelt should not have less than five rows of trees or shrubs planted at a close spacing of about 1 by 1 meter. When the trees are grown up, and do not provide protection in the lower sections any more, some trees may be cut. After coppicing the full protection is re-established. The trees cut can be used as fuelwood. If no coppice can be obtained, overgrown shelterbelts must be underplanted.

A slightly permeable shelterbelt, which absorbs part of the wind energy, has proved to be more effective than a solid barrier, which only diverts the wind. The depth of the area protected depends on the height of the trees. A noticible decrease of wind velocity can be felt on the lee as far as 15-20 times the tree height. Also on the windward side a slight reduction of the wind velocity can be noticed a short distance before the shelterbelt.

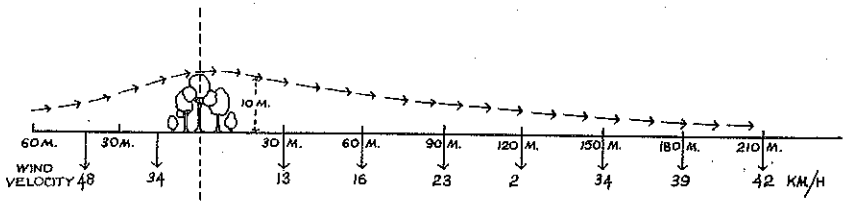


Fig. 3: Reduction of wind velocity by a shelterbelt (After GANGULY and KAUL, 1969, modified)

The interval between the shelterbelts where high wind velocities are to be expected, should be about 100 meters, under ordinary conditions about 200-300 meters.

4.9 Tree planting for beautification.

Foresters are responsible for about 50 percent of the Philippine land surface. Consideration of amenity aspects is one of their duties, especially in the vicinity of towns and cities. More and more foresters willingly or unwillingly are getting engaged in beautification programmes, which have become important public issues in some places. Often foresters are asked for their expert advise to recommend suitable species. A brief list of common ornamental trees and shrubs, which are quite robust and grow on a variety of climate and soil conditions, are listed below:

a) Trees with bright flowers

Bottle brush (Calistemon lanceolata),
Banaba (Lagerstroemia speciosa),
Dap-dap (Erythrina variegata),
Fire tree (Delonix regia),
African Tulip (Spathodea campanulata),
Calachuchi (Plumeria acutifolia),
Alibangbang (Bauhinia spp.)
Jacaranda (Jacranda mimoseifolia),
Pink and yellow flowering Cassias (C. fistula, C. spectabilis, C. siamea),

b) Trees with beautiful foliage or needles

Norfolk pine (Araucaria excelsa)
Japanese cypress (Cryptomeria japonica)
Cupressus fragrans, C. lusitanica,
Malaalmaciga(Podocarpus blumei)
Igem (Podocarpus javanicus)

Arbor-vitae (Thuja orientalis),
Pitogo (Cycas rumphii, C. circinalis),
Silverdollar (Eucalyptus cinerea),
Silky oak (Grevillea robusta),
Agoho (Casuarina equisetifolia),
Balete (Ficus spp.).

Palms

Buri palm (Corypha elata),
Betelnut palm (Areca catechu),
Pugahan (Caryota cumingii),
MacArthur palm (Actinophloeus macarthuri)
Dwarf coconut palm (Cocos nucifera),
Tikal (Livistonia spp.),
Royal palm (Roystonia elata),

c) Shrubs with bright flowers or colorful foliage

Poinsettia (Euphorbia pulcherrima),
Gumamela (Hibiscus spp.),
Yellow bell (Solandra hartwegii),
Calliandra haematocephala
Baston de San José(Cordyline terminalis)
Bougainvillea, several shades,
Sampaguita (Jasminum sampac),
Gardenia jasminoides,
Lantana (Lantana camara),
and many others

For more species consult ORNAMENTAL PLANTS OF THE PHILIPPINES by M.L. STEINER.

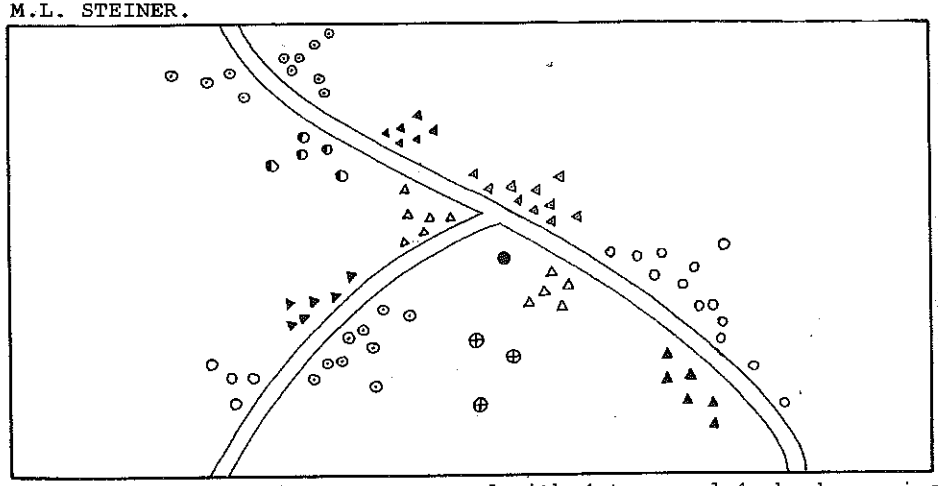


Fig. 4: Beautification along a road with 4 tree and 4 shrub species.
● Araucaria excelsa, ◐ Cupressus sp., ⊙ Agoho, ○ Bottle brush
▲ Poinsettia, ▲ Yellow lantana, △ Hibiscus, ▲ Baston de san Jose

The arrangement of trees and shrubs has to follow the rules of modern landscaping as an "expressive, harmonious, and refined imitation of nature" (23). Emphasis is on g r o u p p l a n t i n g with irregular spacing within the groups. The ground plan of groups or the relative position of the individual trees and shrubs has to be varied as much as possible. There may be single trees neighboring small groups of the same species, but an intimate mixing of single trees and shrubs of different species has to be discouraged.

Symmetry and any quasi-symmetrical arrangements as well as planting of straight lines especially along paths has to be avoided as much as possible, because it looks unnatural and awkward.

If only a small space is available mainly shrubs and only a few trees should be chosen.

Chapter 5:

MIXED AND PURE PLANTATIONS

Virgin forests in tropical countries are nearly always composed of a heterogeneous mixture of a great number of species. Pure natural stands are frequent in the cooler regions of the northern hemisphere. In reforestation a decision must be made frequently, whether a pure or a mixed stand would be best suited for the site and the objective of the plantation. Therefore we have to analyse the pros and contras of mixed and pure plantations in some detail.

5.1 Arguments in favor of mixed plantations

a) Mixed stands appear to be more natural, especially in the tropics, where pure natural stands are rare.

b) A mixed stand is possibly more resistant against pests and diseases. It is well accepted, that extensive pure and even-aged stands can promote mass reproduction of forest insects and infestation by fungus diseases.

c) Mixed stands are perhaps better able to make full use of the site, especially if the crown region consists of light demanders and the lower strata of shade bearers. The same applies to the root zone, where shallow and deep rooted species can take up nutrients from different soil layers.

d) By a skillful group mixture the variations of the planting site can be better utilized, because for each of the varying site conditions the proper species can be selected, which is perhaps the strongest argument for mixed plantations.

e) Where planting of trees has only protective functions a mixed plantation with species complementary in some respects may be more effective than a pure plantation. While some species are deep rooted, others improve the soil by plenty of litter, others may yield useful products. All these benefits are indispensible in a protection forest, but usually cannot be obtained from one species alone.

5.2 Arguments in favor of p u r e plantations

a) Pure stands are easier to handle from the technical and silvicultural point of view. If in a mixed stand the components are not extremely well suited for each other, without the constant interference by a skillful silviculturist and proper thinning the more aggressive species will eventually take over, and the final result will be a pure or almost pure stand. To maintain an artificial mixture up to maturity requires much silvicultural skill.

b) It will be of advantage for the logging operation, if there is only one species, and the entire crop can be harvested at the same time. The logging operation becomes very complicated, when different rotations have to be adopted for the components of the mixture, and felling damages would be unavoidable.

c) If the plantation is established for the purpose of pulpwood production with a very short rotation, there would be no point to start with a mixture.

d) Inspite of all biological arguments in favor of mixtures, long term increment studies in Europe have shown clearly, that mixtures generally do not produce more than pure stands (69).

Summing up the arguments in favor of mixed and pure plantations we see, that the points in favor of mixed plantations are more of a biological nature, while those for pure stands consider more practical and economical aspects.

5.3 Types of mixtures

Inspite of all arguments against mixtures there are many cases, where a mixed plantation presents the best solution, but is essential to adopt the right type of mixture. The following possibilities exist:

a) Intimate or single tree mixture: Mixing by single trees requires the greatest judgement in the selection of the species for the mixture. In general, height growth must be similar, if all the species are expected to get along with each other. In practice this seldom works out well. Distributing a number of species uniformly over the planting area has to be strongly discouraged. The greater the the number of species in a mixture, the greater is the uncertainty of the ultimate result (64).

b) Mixing by lines: Establishment of a mixed plantation by alternate lines of different species has generally the same disadvantage as single tree mixtures. It will also lead to a struggle for survival of species with possibly different growing characteristics, in which the weaker will finally be eliminated by the more aggressive.

   If one wants a line mixture to be maintained up to the end of the rotation, it would be more advisable to mix the species by several lines alternating, so that a number of lines takes "group character".

c) Group mixtures: In most instances even-aged mixtures are best obtained by group mixtures. As a rule of thumb the minimum diameter of the group area should be one tree length (about 30 meters). On the upper side there is no limit for the size of the "group" in the mixture, the different species may even occupy a whole subcompartment or compartment, and may take the character of separate stands. A skillful group mixture based on the ecological requirements of its components is the best way to utilize the varying site conditions within the plantation area.

   Technical problems arise generally in the supervision of planting group mixtures. It is not sufficient to point out the area for each species vaguely to the laborers,

but to have it demarcated temporarily by pegs or poles and to issue very clear instructions. The presence of a forester or foreman during planting is necessary.

d) Block mixtures: This is a compromise combining some of the advantages of a mixed with those of a pure stand. The blocks have an area of one or several hectares, which is sufficient to allow economic harvesting methods. Adjacent blocks can have different species or a substantially different age. Since many pests and diseases show a marked preference for certain age phases, mixing different age phases by blocks could possibly increase the pest resistance of the forest, where mixing different species is not possible. Block mixture should be considered in planning large pulpwood plantations.

e) Mixture by underplanting: In this case light demanders are underplanted with shade bearing species or species, which require shade in their juvenile stages.

   Examples: Benguet pine underplanted with dipterocarps (Malaybalay Reforestation Project, Bukidnon, Mindanao), or pines underplanted with Alnus maritima, which is a very compalatable mixture. In areas where mahogany is heavily attacked by the mahogany shoot borer (Hypsipyla robusta) a light overhead shade would avoid the formation of long sapy terminal shoots, which are of special attraction to the insect. According to BEESON (1961) under a light canopy the attack would be considerably less than in the open. Albizzia falcata, which casts a very light shade, planted a few years ahead, would probably be the best solution. The trees can be poisoned or girdled, when no longer needed. Necessary thinnings must always be carried out, b e f o r e any underplanting is undertaken.

f) Temporary mixtures: There are instances where a mixture is intended only for a limited time as in the mixed taungya plantations of teak and Leucaena leucocephala in East Java. Here, teak is sown in alternate lines with Leucaena, which is lopped every year before flowering to provide mulch rich in nitrogen and to protect the bare soil from erosion.

When the teak plantations form a closed canopy, the Leucaena is eventually shaded out. Generally the objective of a temporary mixture is that the temporary component of the mixture serves the better development of the more valuable species.

Chapter 6:

SPACING OF FOREST PLANTATIONS

There are great variations of spacing in forest plantations in different parts of the world. Limba (Terminalia superba) in West Africa is often planted 8 by 8, or even 10 by 10 meters, which means 100 to 156 trees per hectare. On the other extreme in Germany there used to be a spacing in pine and beech plantations of 0.25 by 1.3 meters, which amounts to more than 30,000 seedlings per hectare.

In the Philippines most species are planted at a spacing of 2 by 2 meters regardless the purpose of the plantation. But here we want to give now some more thought to this question.

6.1 Aspects to be considered in spacing:

a) The site conditions: On good sites the seedlings can be wider spaced than on poor sites, because of faster growth they soon form a closed canopy and make full use of the site potential. On the other hand, by planting at a wide spacing on an adverse site, the trees would take a long time to form a close canopy and to utilize the site fully.

b) The objective of the plantation: For the production of good quality sawnwood, especially with coniferous species, one has the choice between close spacing to avoid the formation of strong branches, or a wider spacing combined with artificial pruning. Which to adopt depends mainly on economical conditions such as labor wages, demand for poles, appreciation of better timber quality, etc.

In pulpwood plantations generally no thinning is carried out, branchiness plays only a secondary role, planting therefore is done at the final spacing.

If planting is for protective purposes, it will be essential, that the plantation closes up as quickly as possible, consequently spacing should be close. The same applies to fire breaks, which are planted close to shade out grasses quickly.

c) The growing characteristics of the species: Spacing should be modified according to the growth rate, tendency to branch and the ability to survive under field conditions. Species, which grow fast in their early stages can be spaced much wider than slow growing species. Trees with a natural tendency to branch like narra (Pterocarpus indicus), should be planted closely, if timber of good quality is wanted.

d) Market conditions: Where poles from thinnings can be sold at a profit or at least at the cost of their removal, close spacing has silvicultural advantages. If it is uncertain, whether any thinning would be carried out at all, it would be safer to plant at a wider spacing.

6.2 Recommended spacing for some reforestation species:

pines	2 x 2
mahogany	2 x 2
teak, good sites	2 x 2
medium sites	1.5 x 1.5
Gmelina arborea	
good sites	3 x 3 or 4 x 4
average sites	2 by 2
ipil-ipil	1 x 1
narra	1.5 x 1.5
Moluccan sau, kaatoan bangkal, other fast growing on fertile sites	3 x 3 or 4 by 4
Eucalyptus, fast growing	3 x 3
Eucalyptus, others	2 x 2
mulberry (for sericulture)	0.5 x 2 m or 1 x 1 m

Special plantations

plantation in high grass	3 x 1.5
taungya plantations	3 x 1.5
enrichment planting	10 x 3 or 15 x 3
seed orchards	6 x 6

6.3 Spacing arrangements

Besides the aspect of "distance" between the plants we also have to consider different spacing methods or spacing arrangements.

a) Square method of spacing: This kind of spacing is most common.

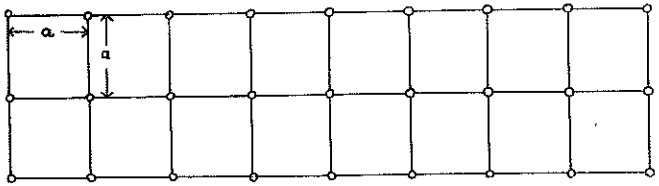


Fig. 5: Square method of spacing.

b) Rectangular method of spacing or line planting:

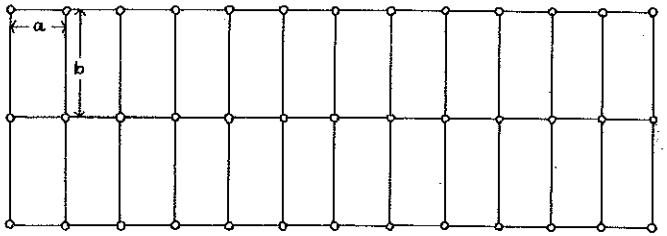


Fig. 6: Line planting or rectangular spacing method.

Planting is done in lines, where a is the distance within the line and b between the lines. This method is applicable for planting in high cogon or talahib, where the cost for strip brushing can be reduced by adopting a wider spacing between the lines and a closer spacing within the lines, e.g. 3 by 1.5 meters.

Spacing between lines	within lines	Seedlings per ha.	Running meters to be "brushed"	Rel. cost of "brushing"
2.0 m.	2.0 m.	2500	5000	100 %
2.5 m.	1.6 m.	2500	4000	80 %
3.0 m.	1.5 m.	2222	3333	66 %

Table 3: Relation between spacing and relative cost of "brushing".

For planting on steep slopes every other line is started the distance of a/2 to the right (or left) so that the formation of straight lines running up and down the slope is avoided.

c) Equilateral spacing: This method is rarely employed in reforestation. Theoretically a possible advantage may be a better utilization of the crown space. Equilateral spacing is useful for planting hedges of two or more rows.

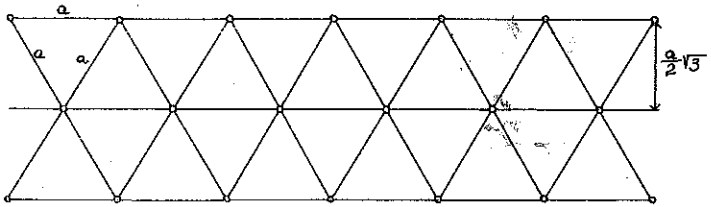


Fig. 7: Equilateral spacing

In all three of these methods of regular spacing the trees are set in straight lines. Sometimes poles are used to mark the beginnings of the lines, but generally judgement by eye is sufficient.

d) Semi-regular spacing: Seedlings are planted in lines, but the distances are freely adjusted in case of advanced growth, rocks, fallen trees, very steep portions or other impediments. Most common in reforestation.

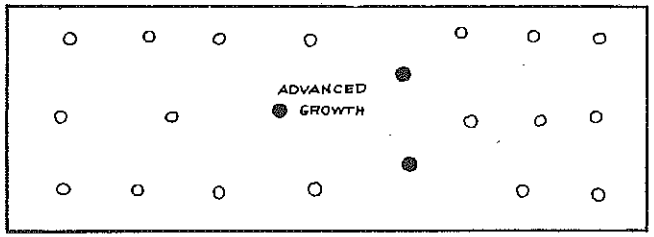


Fig. 8 Semi-regular spacing

e) Irregular spacing: No attempt is made to plant the seedlings in lines in either direction resulting in a varied pattern of small groups and individual trees.

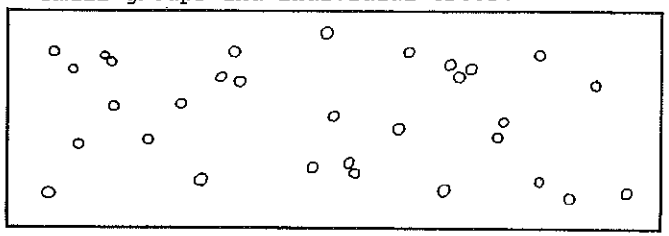


Fig. 9: Irregular spacing

This method of spacing is indicated on very rocky and rough sites, where instead of regular spacing only the most favorable micro-sites are selected for planting. Irregular spacing is also adopted in planting out small gaps. For landscaping it is mandatory because it looks more natural (64).

Generally, irregular spacing is a little difficult to obtain in practice, because the planters almost automatically tend to set the seedlings in lines. For landscaping it may therefore be necessary to mark the place for every seedling by a peg.

The main disadvantages of irregular spacing are difficulties in the organization and supervision, detecting and replanting of failures.

Chapter 7:

SUPERVISION AND TIMING OF REFORESTATION WORK

7.1 Supervision.

For successful reforestation close supervision is essential. Under the present system of short term rotation of labor employed in many projects not too much practical knowledge and responsibility can be expected from most laborers. The foresters and foremen in charge of a reforestation project are required to spend at least some time, if not the entire day with their laborers in the field during planting to guarantee efficient work. The foremen must watch, that

- the working hours are followed strictly,
- the appointed laborers are also doing their share in the field,
- proper planting techniques are employed and holes are made deep enough,
- hauling of seedlings can keep up with planting,
- correct spacing is maintained,
- the roots of bare root seedlings are not exposed to the open longer than necessary,

- useless plants are discarded,
- the planting tools are in good working condition,
- no portion of the area is left out unless it is too steep or not suited otherwise,
- the rules for prevention of accidents are strictly followed.

The pakyaw system which means to allot a certain number of seedlings to each laborer for a day telling him, that he can go home when all are planted, has to be discouraged strongly. The results in most cases have been very disappointing. The success of planting depends too much on the quality of the work, which would suffer in that case.

How to organize a planting team.

a) In ordinary field planting the available labor force is to be divided into foreman, plant hole diggers, planters, plant haulers. Where very small seedlings are to be planted, hole digging and planting is done in one operation by one man.

How many people are assigned to each particular task depends on the local conditions. Where holes are easily dug more planters than diggers have to be assigned. On difficult sites this ratio may be reversed.

In the mountains one foreman should not be given more than 12 men plus those assigned for hauling, because to supervise a greater number of men effectively on steep slopes becomes too difficult for one man alone to handle. On more or less level sites this number can be increased to a maximum of about 18 to 20.

b) On a slope planting generally should follow the contours. To avoid accidents by falling rocks it should be arranged, that the leadman starts digging the holes on the uppermost line, the next follows on the lower line by always allowing the upper man to be one planting hole ahead. The planters follow the diggers in the same manner. With large number of laborers however, this arrangement requires a lot of discipline and is hard to enforce in practice.

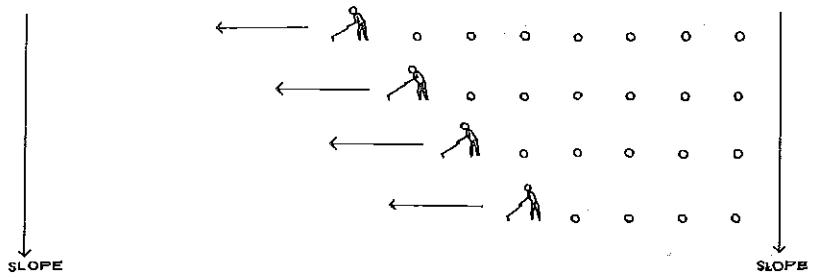


Fig. 10: Proper distribution of a small number of laborers on a slope.

c) On very steep slopes with many loose stones and boulders it has been found safer and more practical to have all men working in one line proceeding from a contour trail directly up the slope. If no one is left behind, because he is working much slower than the others, this arrangement would be much safer, especially when a large number of people is employed. Wearing of helmets must be made obligatory for everyone working on steep slopes. Planting will follow in the same manner after digging of holes has been completed on a particular slope. For small seedlings digging and planting is done by the same man.

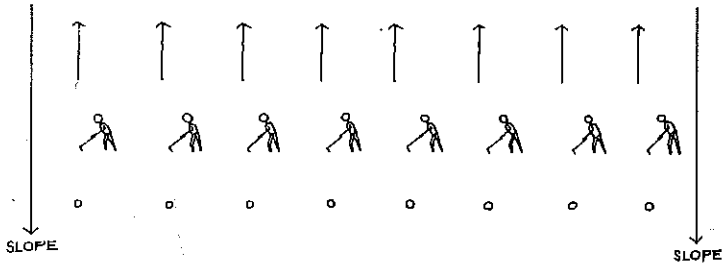


Fig. 11: Distribution of a larger number of laborers on a steep slope with many loose stones and boulders.

d) In replanting and planting on very difficult sites it is more practical that planting is completed in one operation by the same man (one man work unit): the same person carries the container with the plants, digs the hole and sets the seedlings.

There is a general rule for everyone, who has to organize workers: always assign as few men as possible to any particular task. The more people one assigns to a job, the less will be the output per person. While some work, others will be watching only or act as entertainers. There could also be delays, because they are working dependent on each other. The maximum output per person one would get, if only one person is assigned to a particular task, provided the nature of the job does not require two or more, for instance, when the load to be carried is too heavy for one man alone. Generally three men will produce only a little more than two; if one assigns more, the output per person will generally sharply decline.

For psychological reasons it is usually preferred to have at least two persons working on a particular task, because most laborers will willingly accept any job provided they have a "c o m p a n i o n".

7.2 Timing of plantation work.

Another condition for successful plantations is proper timing. A time schedule based on the local climate has to be divised, which sets the date for starting and the deadline for completing each operation. This time schedule is usually drawn up in form of a bar chart. It is essential that it serves not only for decoration of the office, but is strictly followed in the field. This implies, that all necessary preparations for timely termination have to be made well in advance. The key operations, which have to be carried out at the right time, are

a) Seed collection depending on ripening date,

b) Collection of top soil at the beginning of the dry season,

c) Ordering of supplies and equipment, if possible, 6 months in advance,

d) Sowing: When selecting the optimum date the basic considerations are the time it takes to produce a plantable seedling and the beginning of the planting season. If the time needed

to produce adequate seedlings is 8 months, and field planting starts at the end of May and goes up to the end of August, sowing has to be done during October, November,and December. Seedlings sown later under these conditions will not have the size for field planting for the next planting season, and are already at the moment of sowing condemmed to be "left overs".

e) Site preparations: Under clear felling systems, where burning of felling waste is attempted, burning has to be completed before the first rains.

f) Field planting: The optimum time to start planting is when enough rain has fallen to moisten the top 15 to 20 cm thoroughly. According to WORMALD (1969a) it is safe to start planting when the rainfall of a preceeding 7 days period reaches 60 mm.

Failures in plantations can be very high, when planting is done after the optimum planting time. If the seedlings get a late start, their roots will not be able to reach layers, which retain sufficient moisture during the dry season. Failures because of planting too early are usually less common.

g) Weeding and tending operations must be carried out before the seedlings have suffered from suppression by weeds. If weeding is delayed too much, the seedlings may not be able to survive a sudden exposure and die after weeding. If weeding is totally neglected, they will die from suppression, which takes a little longer, but is also certain.

h) Replacement of failures must be carried out at the optimum planting time, i.e. the beginning of the rainy season, before the new plantations are started.

i) Construction of fire lines has to be carried out at the beginning of the dry season.

For the termination of each of these operations a definite period has to be fixed. Especially in planting the proper timing has to be observed strictly. In Benguet Province the optimum time is May/June to August. The survival of September plantings is already very low and can drop according to experiments to mere 20 percent.

Chapter 8:

SITE PREPARATION FOR FIELD PLANTING

To classify the various methods of site preparation, we can set up the following system:

1. Site preparation by c o m p l e t e removal of the vegetation
   a) by felling and burning,
   b) by slashing only,
2. Site preparation by p a r t i a l removal of the vegetation
   a) by clearing of strips,
   b) by clearing of patches,

8.1 Site preparation by complete removal of the vegetation

a) by felling and burning: Site preparation by felling and subsequent burning is practical in some cases to replace overlogged forest or secondary brush by plantations. All vegetation is cut and allowed to dry. It is burnt just before the first rains are expected. Usually this method would be too expensive, if carried out by daily paid labor. But the cost for clearing can be avoided, if there are contractors available who would clear the area free of charge in exchange for being allowed to cultivate field crops there for two or three years. After the crops have been harvested, trees can be planted (taungya system).

The main advantage of establishing a plantation on a completely cleared and burnt site are a rapid development of the plantation, because of little competition from weeds and a good supply of plant nutrients through the ashes. The weeding expenses are generally less than in those methods, where the vegetation was only partially cleared.

The disadvantage of this method will usually be the high cost for clearing, if no taungya farmers are available who do the job free.

Some foresters object to the use of fire for clearings, but in this case the fire is employed as a silvicultural tool, which is efficient and economical at the same time. After all, the area is only burnt once before the establishment of the plantation, which will not be repeated on the same plot until the next rotation. Clearing and burning is used in many Asian countries, where teak and other valuable species which are sensitive to weed competition are planted to replace secondary brush and overlogged forests.

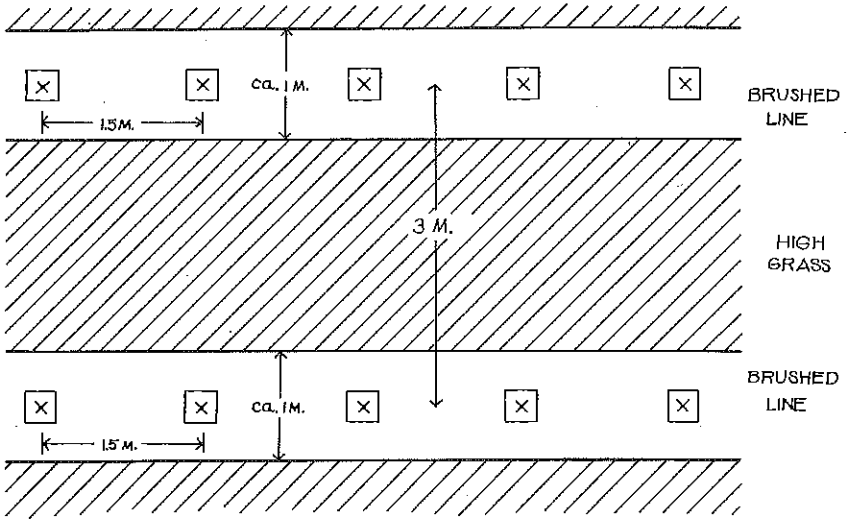
b) Site preparation by slashing only, can give acceptable results, where exploitation comes to an almost complete utilization or where pure plantations are harvested. The remaining herb and brush cover is slashed to keep it down for the start of the plantation. This very simple and cheap method of site preparation can only be employed, where the natural herb and brush cover is very light, or where extremely fast growing species are planted.

Under the conditions of the Philippine rain forest, where weed growth is extremely fast, the following tree species may have a chance to compete with the weeds on a slashed site: kaatoan bangkal, bagras, Moluccan sau, binuang, and some others of fast growth. But a close watch has to be given to the plantation, which means frequent weeding and climber cutting.

8.2 Site preparation by p a r t i a l removal of the vegetation

a) by clearing of strips. This is the standard procedure in grassland planting, where the grass is more than 1 meter

high. Usually the cogon is cut on strips about 1 meter wide at intervals of 2 to 3 meters (from center to center). The plants are set on small cultivated patches (about 40 by 40 cm), on which all rhizomes have been removed.



⊠ cultivated patches, about 30-40 cm. square, on which most of the cogon rhizoms should be removed.

Fig. 12: Line brushing and spacing in high grass.

When direct seeding in grassland is attempted, it is not enough just to cut the grass, but to cultivate a strip 50 - 100 cm wide, on which the seed can be sown. Where rotary tillers are available, this strip cultivation is done by machine.

Clearing strips of forest vegetation is practiced in so-called "enrichment planting" or"line enrichment" to introduce valuable timber trees in degraded secondary brush or where natural regeneration has failed. Strips about 2-5 meters wide are cleared at intervals of 10 to 20 meters. In the remaining untouched portion only those trees are poisoned or girdled which cast heavy shade on the lines. The lines are planted with selected tall seedlings of shade tolerant species of the dipterocarp family or mahogany. For more information on this technique see Chapter 16.

b) Site preparation by clearing of patches. Clearing of patches instead of clearing lines in grassland can mean a considerable saving of labor. But it has some disadvantages. Where the grass is very tall the planters will find it very hard to move from one plot to the next. Also the supervision of the work will be greatly impeded the same applies to weeding and replanting of failures. For these reasons, under the ordinary 2 by 2 meter spacing the seedlings are planted on brushed strips. If for some reason a very wide spacing is adopted, for example 4 by 4 meters or more, then patch clearing would be indicated.

On sites, where the ground vegetation is below about 1 meter, generally no clearing or site preparation before planting is necessary. Here it is generally sufficient to uproot the grasses around the seedling with the hoe when digging the planting hole.

Chapter 9:

GENERAL CONSIDERATIONS ON TREE PLANTING TECHNIQUES

In reforestation we have to compromise usually between very elaborate methods, which may give a higher survival in the field, but are not economical, and cheap and crude methods, which may result in poor survival. Our aim must always be a successful plantation at lowest cost.

9.1 Quality and size of planting stock.

One should only use carefully selected seedlings for field planting. Plants which do not meet the requirements should remain in the nursery for some more time or be discarded. Among carefully culled seedlings there will be less failures. Beating up failures always proves to be more expensive than first planting. Usually it costs less to produce a seedling in the nursery, than to plant it in the field, especially in the mountains with long hauling distances on steep slopes. It is waste of effort and funds to plant for example pines of only 2 or 3 inches in heavy plastic containers. On difficult sites taller plants with a well developed root system show a better survival and require less weeding. They may be slightly more expensive to produce and slightly more expensive to plant, but are more economical in the long run. However, it is not only the height that matters, but also the top/root ratio and the stem diameter. Especially under a wide spacing the quality of the planting stock is of utmost importance for the future development of the stand.

For more information on desirable quality of planting stock consult Part IV.

Benguet pine	9 to 12 inches
Mindoro pine	6 to 9 inches
Alnus maritima	12 to 18 inches
Teak	18 to 24 inches, cut back to 1 inch stump
Mahogany, bare root ...	30 to 40 inches
potted	9 to 12 inches
Narra, bare root	30 to 40 inches
potted	9 to 12 inches
Moluccan sau	12 to 18 inches
Kaatoan bangkal	12 to 18 inches
Eucalypts	12 to 18 inches
Gmelina arborea	18 to 24 inches

Table 4: Desirable height of planting stock (67).

9.2 Size of planting holes.

The planting hole must be deep enough to allow the tap root to hang down vertically without bending its tip. If the tap root is too long, it would be better to shorten it a little than to bend it. Large plants suffer more from transplant shock than smaller ones and must be planted in a way that their roots assume again their natural position, which means digging a relatively large planting hole. For small seedlings with a few and still flexible roots a small planting hole may be sufficient. Although older seedlings are growing faster when planted in a large pit, economic considerations put a limit to the size of the planting hole (64). It must be realized, however, that a large planting hole with plenty of refilled soil helps root development, results in higher initial growth, and greatly increases the survival rate especially on dry sites (64).

9.3 Depth of rooting horizon.

The seedlings must be planted in a way that the roots can reach soil layers, which retain sufficient moisture during the dry season and enable the plant to survive. This can be achieved by digging a deep planting hole and loosening the soil at the bottom of the hole to facilitate root penetration. Stones blocking the way into lower soil horizons have to be removed.

The depth where sufficient moisture is available all the year round depends not only on the climate, but also on the water holding capacity of the soil, the soil cover, the exposure and other factors.

9.4 Protection of roots during planting.

One should never expose the roots of bare root seedlings to the open longer than necessary. For bare root planting this is one of the most important planting rules, perhaps more important than the planting technique itself. It has to be strictly avoided, that the roots and rootlets dry out during careless transport, prolonged and faulty storage, and badly organized and poorly supervised planting. Experiments have clearly shown, that seedlings whose roots had been exposed to the sun for only a few minutes can already be seriously affected. When planting bare root seedlings the planter has to carry the seedlings in a container especially designed to protect the roots, or he has to wrap them in wet cloth. One should never assign a plant distributer as done with potted seedlings.

9.5 Correct planting depth.

When c o n i f e r o u s seedlings are planted too deep, especially in heavy soil, early growth is slow and the plant assumes a stunted appearance. The reason for this is the dormancy or death of the old roots and the development of a new root system just below the surface. Through the dead roots of the old root system a fungus might enter, which can cause the death of the tree years later (64).

However, it is recommended also for coniferous seedlings, especially in light soil to give some allowances for the soil to settle and for surface erosion around the seedlings which almost always occurs during tropical rain showers.

Most broadleaved species can be planted considerably deeper than their original position, which has the advantage, that the root system will not be exposed, if some soil is washed away by heavy rains.

a. Correct position of the root collar

b. Seedling planted too deep

c. One or two years later: the old roots are dead, new roots developed below the root collar

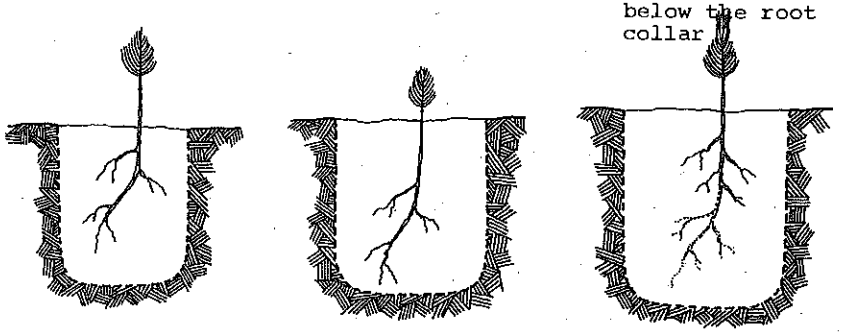


Fig. 13: The effect of deep planting (after TOUMEY & KORSTIAN, 1962)

Chapter 10:

TREE PLANTING TECHNIQUES AND TOOLS

Classification of planting methods:

1. Planting of potted seedlings,
2. Planting of bare root seedlings,
   a) Methods, in which the plant hole is made by removing the soil from the hole and piling it up on the sides,
   b) Methods, in which the hole is made by a thrust of a planting bar or a notching spade,
   c) Methods, in which the soil is only lifted without digging a hole,
   d) Fully mechanized planting with planting machines.
3. Stump planting.

10.1 Planting of potted seedlings.

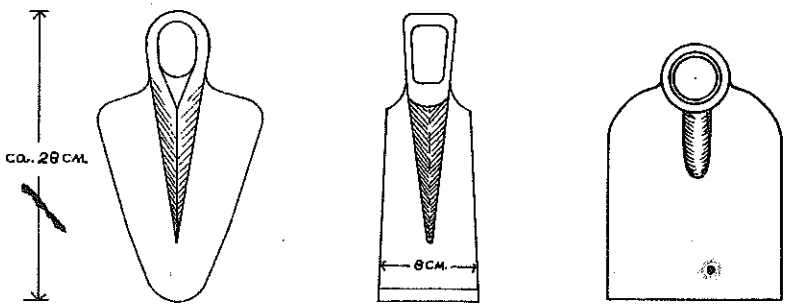
Potted seedlings are raised in individual containers, which usually have to be removed before planting. The containers most in use are plastic bags, followed by boho pots, old tin cans and veneer pots.

The use of containers is little practiced in temperate countries, where mainly bare root planting stock is used in the field. All field planting in Central Europe for example is carried out during spring or autumn, when the seedlings still or already are in a resting stage. All broadleaved species are without leaves at this time, and there are hardly any transpiration losses. The young

seedlings of most tropical timber trees do not have such an absolute resting period. Therefore the best way to succeed in field planting for most species is by planting potted stock.

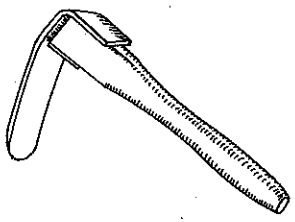
a) Tools

- Planting hoes: Various types of planting hoes are in use. They vary in the shape, length and width of the blade, the length of the handle, and the angle by which the blade is attached to the blade. The most universal planting tool of all the tools tested was the oval blade planting hoe (fig. 14a). It weighs about 1200 grams, the blade is reinforced by a midrib. The oval blade is to be preferred to a blade with a straight edge, because it penetrates the soil more easily without being damaged. For rocky soil also a sturdy, narrow blade with a straight edge was found useful (fig.14b), but it proved to be unsuitable for grassland with a dense mat of rhizoms.



a) Oval blade planting hoe suitable for most sites
b) Narrow blade planting hoe for rocky sites
c) Hoe with a broad straight edge, unsuitable for tree planting

Fig. 14: Types of planting hoes.



For the planting operation itself also a light short handled planting hoe can be employed similar to the Reissinger model planting hoe used at the Training Center in Baguio. (fig. 15).
All planting hoes must be sharpened from time to time with a file to keep them in optimum working condition.

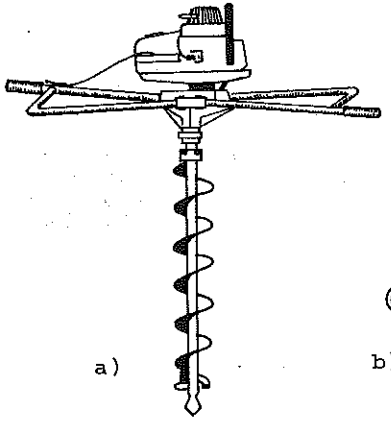
Fig. 15: Reissinger model planting hoe

- Motor plant hole drillers. Most earth drillers are operated by a chainsaw motor. Therefore, where a chainsaw is available, relatively small extra expenses are involved for the purchase of the driller.

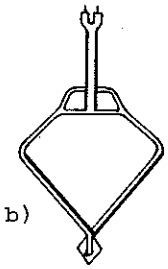
  Two types are available:

  Spiral drillers, ordinary type, deposits about 2/3 of the soil around the hole, sizes from 15 to 30 cm diameter (fig. 16a),

  Frame drillers, the soil is only loosened and mixed, but remains in the drill hole, easier to handle than a spiral driller.



a)



b)

Fig. 16: Motor plant hole driller with chainsaw motor. a) spiral driller, b) frame driller.

An advantage of the motor drillers is the deep hole they produce, which helps root development and root penetration into greater depth and might increase the survival rate on dry sites. Motor drillers are also useful for setting fence posts.

A disadvantage is that their operation requires two men and is somewhat tiring without achieving significantly more than manual labor. The use of motor driller has its limitations on rocky soils and steep slopes.

- German circular spades were found useful for planting on loose forest soils without many stones. They are also suitable for lifting earth balled seedlings and wildlings.

b) The planting technique: Just before planting, after the hole has been prepared, the seedling is removed from the container. Care is to be taken not to break up the earthball. Plastic bags can be easily torn open or cut with a small knife, after the soil has been compacted slightly by pressing it gently. Also removing the boho cylinder generally does not require. any tools, because at planting time it may be disintegrating already. But when removing a seedling from a metal can without proper slits, very often the earthball breaks into pieces and the whole effect of planting potted seedlings is gone.

When placing the earthball into the planting hole the upper part of the ball should be level or slightly deeper, but never higher than the surrounding soil surface. After planting, the soil around the seedling is thoroughly tamped to fill all air spaces between the ball and the sides of the planting hole to avoid interruptions in the capillary system. Where rainfall is critical, a light depression is formed around the tree as a catchment to promote infiltration of rain water. Finally some mulch is deposited around the seedling in form of grass or litter to reduce evaporation and to avoid hardening of the top layer.

The accomplishment for planting potted seedlings per man day varies according to site condition and the size of the pots

between 100 and 150 seedlings per man, without considering the time for hauling the seedlings to the planting site.

c) Advantages and disadvantages of potted seedlings:

The main advantages are:

- potted seedlings have a higher chance of survival under adverse conditions,
- the root system is only little disturbed in the planting operation,
- planting need not to follow transport of the seedlings immediately, the seedlings can be stored for some time at the planting site, provided that they are kept under a light shade and are watered.

The disadvantages compared to bare root planting are mainly the higher costs:

- for the purchase and preparation of the containers,
- for transportation and hauling, because a considerable quantity of soil has to be transported,
- to secure good potting soil is a problem in some places and involves additional cost.

10.2 Planting of bare root seedlings.

Bare root planting is done in the Philippines with more resistant species on favorable sites. Species, that are commonly planted bare root are narra, molave, kalantas, ipil-ipil, Alnus, Para rubber. There are some species, which are often planted potted, but on favorable sites survive well as bare root seedlings such as Benguet pine (planted bare root on Mt. Data) and mahogany. For bare root planting many different tools and methods have been developed. A number of the older methods were very elaborate and are not practiced any longer. There is a tendency now towards more simplified and crude methods to make tree planting more economical with only a slight sacrifice in the survival rate. Here only those methods will be described more in detail which can be applied under Philippine conditions.

a) Planting, in which the plant hole is dug by removing the soil from the pit and piling it up on the sides.

This is the most common method for planting bare root seedlings in tropical countries. Usually planting hoes as described above are used, but also motor plant hole drillers and other implements can be employed.

Plant holes are dug at least 20 to 25 cm deep, the soil is piled on the sides without scattering it too much. The planter who follows the digger, carries enough seedlings for one line with him. The roots of the seedlings have to be covered with a moist cloth all the time. The plant is set with the help of a small planting hoe like the Reissinger Model used in the Training Center. One can also use the hands to fill back the soil and sort out green grass and stones. Afterwards the soil is tamped firmly with the heels or the back of the planting hoe.

The daily accomplishment varies according to site conditions and the size of the planting stock from 200 to 300 seedlings per man.

The planting technique using the oval blade planting hoe in combination with the Reissinger hoe appears to be the most universal planting technique for Philippine conditions. Both tools can be used for planting bare root and potted seedlings on almost any type of soil.

b) Planting methods, in which the planting hole is made by a thrust of a planting bar or a notching spade.

This group includes planting methods, in which the opening is made by thrusting an iron bar or a heavy notching spade into the ground pressing the soil to the sides and producing a cone or wedge shaped hole. After the roots of the seedlings had been inserted to the required depth, the hole is closed by a second thrust of the planting bar or with the help of a small planting hoe.

- Planting with planting bars. In many places, 6 to 7 feet long planting bars with an iron or hardwood tip, or made of solid

iron are still in use. It should be noted, that a stick for planting (digging stick) was the first agricultural tool developed by mankind and was already used in the Neolithic Age. Under special conditions this tool can be very effective and is still widely used in many tropical countries.

The original form of a planting bar is a tool similar to a spear. More developed forms have a T-handle and a foot rest to be able to use the feet when pushing the planting bar into the ground (Fig. 17) (20).

The planting bar is thrust vertically into the soil and then withdrawn. The seedling is inserted in the opening so that the roots hang downwards. The tool is thrust into the soil again in a slanting position a few inches from the original spot in a way, that the lower points of the openings come together. It is then moved forward firmly pressing the soil against the roots of the seedling. If the planting bar is not properly inserted for the second thrust, the lower part of the planting hole will remain open.

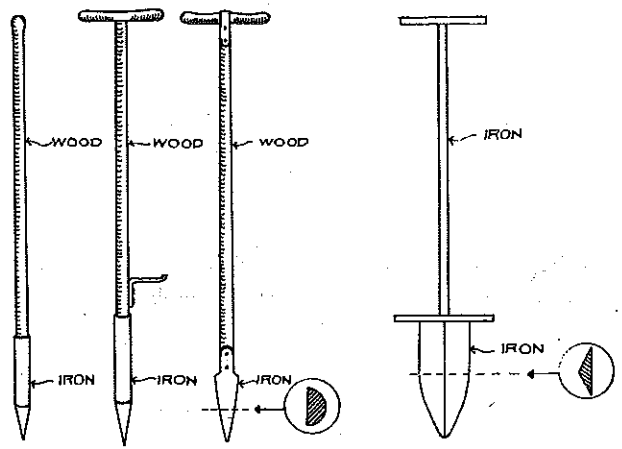


Fig. 17: Planting bars and notching spades.

This method is useful for stumps and very small seedlings and can be employed on light soils only.

- Planting with a notching spade. Tools of this kind were seen occasionally in the tool rooms of reforestation projects, but they were obviously rarely used. Several types of notching spades have been designed to overcome the small openings made by planting bars. Notching spades have a wedge shaped blade and have a weight of about 3000 grams. The spade is thrust vertically into the soil opening a v-shaped cleft. After the seedling had been inserted, the opening is closed with the foot or a second thrust of the notching spade a few inches besides the first one. With notching spades slightly larger seedlings can be planted than with planting bars. On heavy soils this method will generally be a total failure.

  Under Philippine conditions the use of notching spades is not recommended, because

  - the soil is compacted at all sides of the openings, which makes root penetration difficult,
  - the roots are crowded together in a small hole or pressed into in a single plane, sometimes the holes are so small, that the roots may bend upwards,
  - there are limitations on heavy soils and regarding the size of seedlings,
  - the use of notching spades is very tiring because of their weight.

c) Planting methods, in which the soil is only lifted without digging a hole.

These methods for planting bare root seedlings have become more and more popular with foresters in Europe, after it had been realized, that even by relatively crude planting methods good results can be achieved. The two most widely used methods are:slit planting with the oval blade planting hoe and L-slit planting with the axe-hoe.

Slit planting with the oval blade planting hoe. After the vegetation had been cleared on a patch or strip the hoe is thrust to the full length of the blade into the soil. The handle is moved upwards with a light pull to create an opening

for the roots, then the handle is moved downwards to produce the slit. The worker makes a step forward, until he is able to look into the slit.

The plant is swung as deep as possible into the opening by the left hand (while the right is pressing the handle down) and pulled up, until the root collar is level with the soil surface.

The seedling is kept in this position and the handle is pivoted on the knee to move it out of the slit. Finally the soil is carefully tamped with the foot (Fig. 18 a).

It is also possible, that two men work dependent on each other (two men work unit): one is handling the hoe, the other carries the container with the seedlings, sets the plants and tamps the soil (Fig. 18 b). The achievement of the two men work unit is slightly less than that of one man working alone.

a: one man work unit, b: two men work unit

Fig. 18: Slit planting with the oval blade planting hoe (drawn after LOYCKE, 1963)

Slit planting with the oval blade planting hoe is considered to be one of the fastest planting methods for bare root seedlings on suitable sites. Under favorable conditions a man can plant 100 seedlings per hour. Trimming of the roots before planting is very important. This method can be used for seedlings up to about 25 cm above root collar. The fact that the plants are planted in a slanting position has no effect on their survival, and they will straighten up very soon.

The method can only be recommended for loose soils and relatively small seedlings, and may not be suitable for reforestation of wasteland and degraded grassland.

L-slit planting with the axe hoe. This is a further development of the ordinary slit planting technique to overcome the narrow planting holes. A special hoe with an axe blade on top had been designed for this method. The plant hole is made by one stroke of the axe followed by one of the hoe (47). In Germany this method is considered to the most advanced and economical planting method for bare root seedlings. Under Philippine conditions the value of this method, however, appears to be doubtful, and therefore it is not described here in detail.

d) Fully mechanized planting with planting machines.

Up to now fully mechanized planting has no application in the Philippines and is mentioned here only to complete the list of bare root planting techniques.

The machines developed for this purpose are generally drawn by a tractor. A plough opens a furrow, into which the plants are set by a device, which regulates the spacing. The only manual labor required is to feed the seedlings into this spacing device. After the plants have been set, the furrow is closed by two plough blades or two wheels with tilted axles passing along both sides of the furrow pressing the soil firmly against the roots of the seedling.

Planting machines can operate only on more or less level ground with not too many impediments. A well known planting machine is the FINNFORESTER, which under average conditions can plant about 4,500 seedlings per day, under favorable conditions up to 12,000.

10.3 Stump planting.

Planting of stumps is only known in tropical countries. With some species a higher survival rate can be expected from stumps than from bare root seedlings (7). The main reason for the

success of stump planting is the reduction of transpiration losses by removal of the shoot.

A stump is produced from a seedling 2 to 3 feet high. After lifting the plant from the nursery bed the stem is cut 1 inch above the root collar. Tap root and side roots are also shortened, The length of the stem portion retained has no effect on the growth. With long stumps, however, there is a tendency to produce more than one shoot. A diameter between 12 and 15 mm is generally considered the optimum for teak stumps. For Gmelina arborea LAMB (1973) recommends 12 - 25 mm diameter at root collar with one foot of the tap root and 3-5 cm of the shoot left.

When the stump is too thin, it has only little reserves and only a short shoot is produced. All stump planting should be carried out just before or right after the beginning of the rainy season, so that the plants are well established, when the dry months start.

For planting stumps very crude planting techniques can be used, and very often only a pointed stick or a planting bar is employed. When planting with a hoe, the slit method is generally adequate.

On burnt over areas where no further site preparations are required a man can plant 100 stumps per hour. In grassland where the rhizoms have to be removed, the average achievement is only 30 to 35 stumps per hour without the time needed for strip brushing.

The main advantages of stump planting are

- Reduction of transpiration losses,
- Stumps are easy to transport,
- Storage for a week or so is possible without harm,
- They are cheap to plant, because crude planting techniques can be employed,
- Stumps can already be planted just before the rainy season,
- For some species survival of stump planting is higher than bare root planting.

Species, that successfully can be planted by stumps include according to LETOURNEUX (1957) Tectona grandis, Gmelina arborea,

Lagerstroemia speciosa, Albizzia procera, Alstonia scholaris, Cassia fistula, Cassia siamea, and others. In the Philippines only stump planting of teak and in a few projects of Gmelina arborea is popular, but experiments are recommended for stump planting of other species.

Chapter 11:

PLANTING OF WILDLINGS

Planting of wildlings is practiced with species, which are difficult to raise in nurseries, because their seeds have only a very short viability. Species often planted as wildlings include almaciga (Agathis alba), and dipterocarps as white lauan (Pentacme contorta), bagtikan (Parashorea plicata), Mayapis (Shorea squamata) and others.

The following practice is recommended: the seedlings are lifted with a ball of earth and potted on the spot in the forest. They are then kept in a temporary nursery under light shade for recovery for 3 to 6 months, before they are planted in the field.

Even with proper techniques the survival of dipterocarp wildlings usually is not very high. There are casualties when the wildlings are potted, and then later when they are planted in the field.

An overall survival of only 50 percent is not uncommon. From experiences in Malaysia it appears, that younger wildlings show a better survival rate than older ones. However, they should not be potted before the cotyledons have fallen. The optimum time for potting is when the first real pair of leaves has fully developed. If the wildlings are too old, they will suffer from the transplant shock and mortality will be very high after potting.

Bagtikan (Parashorea plicata)		White Lauan (Pentacme contorta)	
Height of wildling	Survival	Height of wildling	Survival
0 - 20 cm	88 %	0 - 20 cm	56 %
20 - 40 cm	74 %	20 - 40 cm	52 %
40 - 60 cm	74 %	40 - 60 cm	24 %
60 - 80 cm	66 %	60 - 80 cm	10 %
80 -100 cm	40 %	80 - 100 cm	2 %

Tab. 5: The survival of directly transplanted dipterocarp wildlings of different size classes. The plants were mud-puddled and stored for one week before planting (MAURICIO, 1957).

The wildlings should be transplanted to the field, before they have reached a height of about 40 cm. If they are taller, the rate of survival drops sharply as experiments with white lauan and bagtikan have shown (50).

Planting of dipterocarp wildlings has justification in enrichment plantings, where the following rotation may be based on natural regeneration again. If planting of wildlings is considered on a large scale, it would be worthwhile to clear the ground vegetation and do some soil working under selected mother trees, just before the seed falls. In many cases the regeneration will spring up as dense as in a nursery seed bed. This method gave excellent results in Java for the regeneration of Agathis loranthifolia.

Chapter 12:

DIRECT SEEDING

Direct seeding is the oldest method of artificial regeneration and was practiced as early as the 14th century by the "fir sowers of Nuremberg" (Bavaria), the first historical record of artificial regeneration of forest trees. Later direct seeding had been more and more replaced by planting which for most species gives better results. But there are still a number of species, which are easily propagated by direct seeding because they

- produce plenty of seeds,
- grow fast in the early stages,
- have large seeds with plenty of reserves,
- produce a long tap root at an early age,
- have seeds with a high germinative capacity, that can be maintained well under ordinary conditions.

Species, which have been successfully established in the Philippines by direct seeding, include ipil-ipil, lumbang, bagilumbang, akleng-parang, casoi, teak and Cassia siamea.

Methods of direct seeding:

- Sowing on cultivated patches 1 to 3 feet in diameter is applicable for larger seeds, which are sown at a wider spacing e.g. lumbang, casoi.
- Sowing on cultivated strips 2 to 4 feet wide is usually practiced with finer seeds such as ipil-ipil, which are sown more densely
- Broadcasting the seed without soil working gives good results only under very favorable conditions (moist sites, loose soil, not too much ground vegetation). There is a possibility, that

the seeds are already intercepted by the grasses and do not even reach the ground.

- Broadcasting the seeds from planes can be successful only under very favorable conditions.

Generally direct seeding gives acceptable results only, when soil working was carried out to facilitate root penetration. It is also important, that the seeds are covered with a soil layer 1 to 2 times the thickness of the seed and, if possible, with a light mulch. To ensure establishment during the rainy season, direct sowing must be carried out at the very beginning of the rains, so that the seedlings are already strong enough to survive the heavy monsoon rain later in the year. The success depends on so many unforeseen factors, that it is strongly recommended to conduct small scale experiments first before embarking in any larger operation.

The quantity of seed needed can be estimated from the number of viable seeds per pound, but ample allowance has to be given for losses through birds, rodents and insects. In the Los Baños area 7 to 8 gantas of ipil-ipil seed are sown per hectare (1 ganta = 3 liters).

There are some chemicals available to treat the seeds before sowing to make the seed less attractive to rats and birds or even poisonous like red lead powder (1 kg. red lead powder for 8 kg of seed).

To insure even distribution of seeds, the quantity of seeds for one line across the area must be measured in a tin can or similar container as a guide.

Advantages of direct seeding:

- For direct seeding no nurseries are required.
- Direct seeding is more flexible, it does not depend on the availability of nursery stock.
- The shock of transplanting is avoided.
- Species, which produce a long tap root at an early stage, are generally difficult to transplant. Direct seeding is likely to

give better results in those cases.

- Due to a greater density in direct seeding (if successful), the quality of the future timber stand may be better.

Disadvantages of direct seeding:

- Sometimes the total costs of establishment are higher than planting, because of higher weeding expenses. The initial cost may be lower, but the total cost of establishment must include also weeding expenses, which in direct seeding can be very high.
- Poor survival of seedlings, if conditions are not very favorable, because they cannot be watered as in a nursery. If the seedlings cannot reach soil layers, which keep sufficient moisture during the dry season, an initial success may turn into a complete failure.
- Many of the seeds and young seedlings become victims of rodents, birds and insects, from which they could be protected in the nursery.
- The success is very uncertain, because it depends on many unpredictable factors.

Chapter 13:

REPLACEMENT OF FAILURES

Even with most careful planting techniques there will always be a number of seedlings, which do not survive. Causes of death can be

- injuries from transport,
- unforeseen dry spell after planting,
- damage by insects or rodents,
- improper planting techniques,
- suppression by weeds,
- poor quality of planting stock,
- trampling by livestock,
- effect of dry season.

Replanting or "beating up" such failures is always more expensive than first planting. The cost per seedling may double or triple. Therefore it is necessary to decide carefully, whether replanting is required or not based on a small sampling check to estimate the failure.

As a very crude guide for sampling it is suggested, that in areas below 2 hectares every 5th line, and above 2 hectares every 10th line is sampled. It is advisable to use two counting machines: one marked "survival", the other "failure". If counting machines are not available, the results can be recorded on tally sheets by dots and lines:

Example:

Line No.	Survivors		Failures	
2	1 2 3 4 5 6	63	7	8
7	1 2 3 4 5 6 7	69	8	4
12	1 2 3 4 5 6 7	67	8	9
17	1 2 3 4 5 6	55	7	13
22	1 2 3 4 5 6	58	7	10
27	1 2 3 4 5 6	64	8	3
Total		376	+	47=423

$$\frac{47 \times 100}{423} = 11\ \%\ \text{failure}$$

Replacement will be necessary only, if the overall percentage of failure is above 20 percent, but only where at least two successive seedlings have failed. If the overall rate of failure is below 20 percent, replanting will be carried out only where the failures are heavily concentrated (see tally sheet).

For replanting, the best available seedlings are selected and planted at the beginning of the rainy season, at the optimum planting time.

To avoid, that unnecessary time is spent in walking and searching, all operations of replanting are done by the same man (one man work unit):

- detecting the failure,
- digging a new planting hole,
- planting the seedling.

There may be need for more than one replanting on the same area during the first years of the plantation. But where after two replanting operations the area still is not adequately stocked, the planting procedures should be revised for improvements, or another species must be chosen for the site.

Chapter 14:

REFORESTATION OF ADVERSE SITES

The areas provided for reforestation generally are those sites, which are not fit or not wanted or agriculture. For obvious reasons the production of food is given priority to forestry. Only in very rare cases the site offers ideal conditions for tree planting. Most sites alloted for reforestation are adverse in one or the other respect, which may include:

- dry sites or adverse southern exposure
- rocky and shallow soils
- coastal sands
- swampy sites
- steep slopes
- high cogon or talahib

14.1 Dry sites and adverse southern exposure.

Difficult sites of this sort can be encountered in almost every reforestation project in the Philippines. The most important rules for planting on a dry site are:

a) On dry sites potted plants generally give better results than bare root seedlings. The pot size for dry sites should be as large as possible to provide a good start for the seedling.

b) The planting stock should be of the best available quality, that means that only seedlings of optimum size with a well developed root system are to be planted. The root system must be able to reach layers, which retain sufficient moisture during the dry season.

c) On dry sites it is very important, that a large and deep planting hole is prepared with plenty of refilled soil to stimulate the root development and facilitate root penetration into deeper soil layers.

d) Where rainfall is scarce, it may be of advantage to form a basin around the seedling to catch as much water as possible. In humid areas the formation of such a basin might lead to accumulation of water and cause the death of the seedling for lack of oxygen at the roots.

e) On tall broadleaved species young sapy shoots and part of the foliage must be trimmed to reduce transpiration, until the seedling is well established. Heavy transpiration losses otherwise can lead to the death of the seedling.

f) Mulching with grass or leaves greatly reduces evaporation from the soil surface around the seedling and prevents hardening of the surface soil.

g) In extreme cases delicate and newly planted seedlings are shaded by fern fronds and branches to prevent heavy transpiration.

h) It is essential on dry sites that planting is carried out at the beginning of the rainy season, which is the optimum planting time.

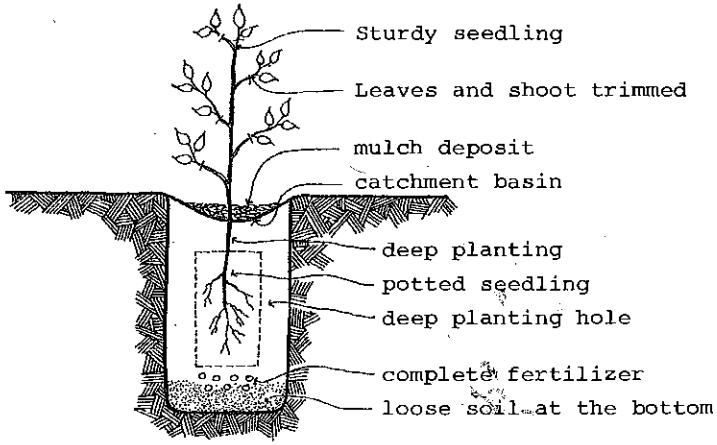


Fig. 19: Planting technique for dry sites.

i) Application of a table spoon of complete fertilizer containing nitrogen, phosphorus and potassium has a very positive effect on the development and the draught resistance of the seedling.

14.2 Rocky sites.

Very often the nature of the site is the result of erosion. Sometimes only the topsoil is washed away, sometimes the subsoil has gone too, leaving an almost bare rock behind. Some soil might still remain in the cracks between the boulders. The possibilities for planting depend very much on the nature of the underlying rock, the exposure, the gradient and the climate. Some sites appearing impossible at the first glance, may have some cracks and soil pockets able to support trees. Very often the site appears more rocky than it really is because of the many stones accumulated on the surface after the soil has been washed away. Only by local experience it can be judged, whether the site would be able to support trees (15).

Where subsoil is left, contour trenching may be helpful in reducing run-off and increasing infiltration of rain water. Instead of regular spacing the seedlings are set on the best available spots. When the plant hole is refilled all stones must be sorted out. On an extremely degraded site application of a table spoon of complete fertilizer would provide a good start for the seedlings.

14.3 Coastal sands.

There are very few species, which can be considered for planting on coastal sands. The most suitable species seem to be agoho (Casuarina equisetifolia), talisai (Terminalia catappa), aroma (Acacia farnesiana) and the rather slow growing bitaog (Calophyllum inophyllum). Only tall plants at least 50 cm high should be used. They are planted in large and deep planting holes with some good soil as refill. Around the tree a deep basin has to be formed to catch as much rain water as possible. It is important, that planting is done

right at the beginning of the rainy season. Where it is possible, a weekly watering of about 5 liters per plant during the first dry season would greatly increase the survival of the seedlings on coastal sands.

14.4 Swampy sites.

Planting is done on mounds or ridges to minimize the period during which the seedlings are submerged during floods and to improve the aeration of the root system. Species to be considered for swampy sites are banaba (Lagerstroemia speciosa) and Eucalyptus robusta (Austr. "Swamp mahogany"), and Casuarina glauca.

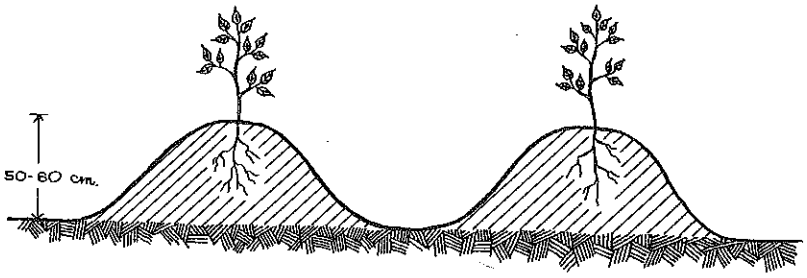


Fig. 20: Planting on a swampy site

The most favorable planting time for very wet and swampy sites which are submerged during the rainy season would be the end of the rains, so that the seedlings are well established before the next wet season starts.

14.5 Steep slopes.

On steep slopes a small horizontal platform has to be prepared where the planting hole will be dug (see fig. 23, below).

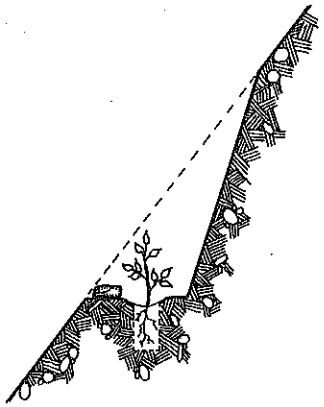


Fig. 21: Planting on a steep slope

In extreme cases safety ropes have to be used, which are tied around the waist of the planters. To avoid accidents from falling stones, the laborers should not be allowed to work one below the other and wear helmets. The one working above must be always one planting hole ahead (See also chapter on supervision and organization).

14.6 Planting in high grass.

Where the grass cover does not reach more than two or three feet, planting is not very difficult. In high grass the seedlings are usually planted on cleared strips. For each individual plant a small patch of about 50 cm in diameter is hoed and as many rhizomes as possible are removed before planting. The success of the plantation depends to a high degree on subsequent weedings.

To reduce the weeding expenses on cogon land, only tall plants should be used. The application of complete fertilizer (one table spoon per seedling) would not add too much to the cost of the plantation, but helps to overcome the weed competition.

To save costs for line cutting, it is recommended to adopt a wider spacing between the lines than within the lines. BARNARD (1956) even recommends spacing between the lines double the distance within the lines. A 1.5 x 3.0 m spacing would amount to 2222 seedlings per hectare as compared to 2500 seedlings under 2 x2 m spacing.

Chapter 15:

TAUNGYA PLANTATIONS, A POSSIBLE SOLUTION OF THE KAINGIN PROBLEM

15.1 Forms of the taungya system.

The word "taungya" originally in Burmese means "field in the hills" or in Philippine language a kaingin. When BRANDIS, a German botanist and forester employed in the Indian Forest Service, saw the vast Imperata areas created by the hill tribes in Burma through shifting cultivation, he started a scheme to turn them into teak plantations. The tribal people were given a piece of land and were allowed to clear and to cultivate it for two years. The only condition was, that before abandoning the plot they had to plant it with teak stumps provided by the Forest Department (35).

This was about 100 years ago. The original form of taungya has been improved and the term taungya is now known all over the tropics as a combination of agriculture and forestry. The principles of taungya farming are still the same as a century ago, when it started in Burma. A certain area, generally situated in a forest reserve, is alloted to individual families. The farmers are allowed to cut, burn and cultivate the land under the limitations stipulated in the taungya agreement. The trees are planted either in the first or second year or after all agricultural crops have been harvested. Important is that the trees are planted before the area has turned into grassland. In places of acute land shortage, the farmers may even accept to weed the plantation during the first year.

Today taungya is widespread in Africa, India and some countries in Southeast Asia. In the Philippines a modification of taungya on a voluntary basis is practiced at the tree farming projects of the PAPER INDUSTRIES CORPORATION OF THE PHILIPPINES (PICOP) at Bislig, Mindanao. Farmers who have titled land of at least 10 hectares within 100 kilometers of the paper mill can participate in the project. "The scheme is to devote 20 % of the farmers total landholding to food and livestock production and the remaining 80% to fast growing, shortrotation pulpwood trees. Intercropping of food crops between the newly planted trees can also be done to provide supplemental food or cash income" (PICOP information pamphlet 1974). The paper mill with a daily capacity of 430 t guaranties to buy all the pulpwood at prevailing market prices. The Development Bank of the Philippines is granting loans of ₱ 1000.- per hectare for the development of the free farms. The main species planted so far is Albizzia falcata, managed under an 8 years rotation. The seedlings are provided by the company at a cost of ₱0.10 at nursery site or ₱ 0.15 at plantation site, and have to be paid for when the first pulpwood is sold.

Another special form of taungya is reported from the Zambales Mountains, where according to Director JOSE VIADO the Aetas are allowed to clear and cultivate a patch of forest under the condition, that they plant it afterwards with Lumbang (Aleurites moluccana). The BUREAU OF FOREST DEVELOPMENT guaranties the Aetas to buy all the Lumbang nuts they harvest from their "own" trees. For this reason it is also within the interest of the Aetas to protect the stands.

15.2 Conditions for successful taungya

a) Land shortage. There has to be a certain land hunger, only then the farmers will accept the limitations imposed on their usual kaingin practice by the taungya agreement. In very densely populated areas the forest authorities have a very strong position, and the farmers may be willing in addition to planting and tending the trees to pay

a certain amount for the use of the land. In other parts the forest department may have to pay a substantial premium for a successful plantation to stimulate the farmers interest in the trees. In very thinly populated areas it may be impossible to find taungya farmers at all.

b) Legal basis. The second condition for successful taungya is a suitable legal basis. It is quite possible -and has happened often before- that a group of people had been given an area for clearing and cultivation under a taungya agreement, and later refused to abandon the land claiming it as their own. They may find the help of a local politician to support their case. It is essential therefore that any taungya agreement is based on a w r i t t e n contract. Even then there is the danger, that land, which has proved to be suitable for agriculture, will be claimed as "alienable and disposible".

15.3 The taungya agreement

The following items among others have to be reglemented in a taungya contract:

a) Duration of the agricultural period. Under normal conditions this period should not be extended beyond two years. Otherwise the soil will be depleted of plant nutrients too much and the growth of the trees will be retarded. In drier areas, where the soil is not so heavily leached, three years may be permissible, if the farmers refuse to sign for two years only. Farmers, who are used to cultivate the soil until it is completely exhausted, often would refuse to abandon the area after two years, if this was not fixed in the contract.

b) Planting and treatment of the trees has to be reglemented in detail in the agreement, because naturally the farmers have not the least interest in a successful tree plantation. They might even cut back the trees where they interfere with their crops. It has to be decided, if the trees are to be planted in the first or second year, or

or after the field crops have been harvested. Also the spacing of the seedlings has to be subject of the contract, and weeding during the first year.

c) The kind of field crop the farmer is allowed to cultivate has to be made part of the contract. If the trees are planted together with the field crops, those crops which because of their size would suppress the seedlings as sugar cane, maize or cassava have to be limited or forbidden. A limitation would be, if a certain distance between the rows or individual plants is prescribed. There are also crops, which might promote diseases of the trees. It had been observed, that pines planted on old fields, where root crops like cassava had been cultivated before, suffered severely from heart rot.

d) The size of the lot for each family has to be settled, which depends also on how far the farmers have other sources of income. According to several investigations in normal kaingin practice the area cultivated annually is only 0.2 to 0.3 hectares per head. A family of five cultivated only an average of 1.0 to 1.5 hectares, as long as only subsistence farming is practiced. Since only manual labor is employed in kaingin making, the area the farmer can cope with has a definite limit. On steep slopes 0.3 hectares may be the absolute maximum, while under very favorable conditions the farmer may be able to manage 0.5 hectares. In planning a taungya project o.3 hectares per working person may be a safe figure to start with.

e) Reglementation of fees, premiums and penalties. To avoid, that any feeling of ownership develops, it is desirable, that the farmer pays at least a nominal fee for the utilization of the land. But there may be also cases, where the forester has to pay the farmer for planting the trees.

Very important is a premium for a successful plantation to stimulate the farmers interest in the trees. Also penalties for bad planting or damaging the trees on purposes have to be made part of the contract. The hardest penalty would be the exclusion of the farmer from any future taungya planting.

For the utilization of fuelwood in connection with taungya it is advisable to ask the farmer to pay a nominal fee to avoid that forest rights would develop.

15.4 Some common agricultural crops suitable for taungya planting (35).

a) Upland rice is a typical crop of the Asian kainginero. In contrast to the irrigated or wet rice it is cultivated in kaingins, and is the staple crop in the less developed parts of the Philippines. Upland rice is grown for example by the Mangyans of Mindoro, the Ilongots of Nueva Vizcaya or some hill tribes of Mindanao. Both, the wet and the dry rice, are varieties of Oryza sativa. The yield of upland rice is much less than what is obtained from the varieties grown in irrigated fields.

Upland rice is more demanding regarding the soil fertility than corn or cassava. Therefore a fresh kaingin gives only about two consecutive harvests of rice, then it must be abandoned or planted with a less demanding crop like cassava or camote.

For taungya planting upland rice is very suitable, because it does not reach the height of most other crops.

b) Maize or corn is a crop cultivated already in ancient times by Central American Indians. Numerous breeds of maize are now cultivated all over the tropics and subtropics, and the southern part of the temperate zone. Because of its size, planting of maize has to be restricted in taungya plantations, wherever it is planted together with the tree seedlings. A distance of at least 1.5 meters from the seedlings is to be maintained which means that the lines of maize must be at a minimum 3 meters apart.

c) Camote or sweet potatoe (Ipomoea batatas) can be cultivated from moderate altitudes onwards up to 1500 meters or higher. Propagation is by cuttings, which are planted during moist weather conditions. The tubers mature after 4-5 months, when the leaves turn yellow.

Camote is suitable for taungya planting provided care is taken, that the creepers do not suppress the seedlings.

d) Cassava (Manihot utilissima) is a member of the Euphorbiaceae and had been introduced from South America, where more than hundred varieties of this species are cultivated. Some of these varieties contain prussic acid, which has to be removed by washing the pulp before preparation of the cassava meal. The non-poisonous varieties can be prepared the same as camote.

Propagation of cassava is by stem cuttings. Also in exceptionally dry years it gives adequate yield and is able to grow on very poor soils, which have been depleted of plant nutrients by previous cultivation. The experienced kainginero therefore plants cassava at the end of the agricultural period, while during the first and second year more demanding crops like upland rice or maize are planted.

The tubers mature 6-12 months after planting according to variety and can remain in the field for some years to form a reserve for times of starvation. In spite of the many advantages for the farmer, there are some objections against the use of cassava in taungya plantations:

- cassava grows very fast and may suppress the seedlings,
- it depletes the soil of nutrients more than any other crop,
- the tubers are loosely arranged around the stems, digging them up might destroy the seedlings,
- it was observed, that cassava will promote the attack of heart rot (Fomes annosus), if associated with conifers.

The disadvantages can be minimized, if some restrictions in the taungya contract limit planting of cassava. For example: prescribing a late time for planting (second year) and allow only a wide spacing (3 meters) or restricting it to the outer border of the plot only. By planting fast growing tree species like Gmelina arborea suppression of the seedlings can be avoided.

e) Gabi or Taro (Colocasia esculenta) is a herbacious plant with large arrow shaped leaves belonging to the family of Araceae. This plant is commonly cultivated all over South East Asia.

As the hygromosphic habit already suggests, gabi requires moist site conditions. The plant is shade tolerant and can grow under a canopy of trees. If not planted too dense, it may be a suitable taungya crop. At a leter stage it may even benefit from the shade of the trees.

There are many more crops suitable for taungya planting. What restricts their use is mainly their size and dense foliage by which the plants suppress the tree seedlings.

15.5 Planning and organization of taungya projects.

Taungya on a large scale requires very careful planning, because the forester-in-charge carries a great deal of responsibility for the well-being of the families concerned. It is advisable to start at a small scale with some selected and reliable farmers from the casual labor force, who usually are kaingineros anyhow. There must be field staff available with sufficient authority to control the limitations imposed by the taungya agreement. The field staff is also responsible for the distribution of the plots for each individual family and the demarkation of boundaries. Complaints will generally arise from those farmers, who get less favorable sites. It is therefore necessary to study the area carefully before making the subdivision. After enough local experience had been obtained with a few farmers, the project can be expanded.

According to FAO (Technical Report No. 9, 1971) in the Philippines 80,000 hectares of forest land are destroyed by kaingin annually which involves about 120,000 families. If only a portion of these farmers can be engaged in a taungya agreement, the area reforested annually could be increased significantly.

Chapter 16:

IMPROVEMENT OF OVERLOGGED AREAS BY ENRICHMENT PLANTING

Enrichment planting means the introduction of valuable species in forest areas, where economical species are lacking. The long term goal of enrichment planting often is to improve the species composition in a way, that natural regeneration methods can be adopted in the next rotation. The methods of enrichment planting had been eveloped by French foresters (14) and are extensively practiced in the former French overseas territories in West Africa and Indochina.

Areas to be considered for enrichment planting include:

- Overlogged areas, where seedbearers as well as regeneration of economical species are absent or inadequate. If regeneration is sufficient or not has to be determined by diagnostic sampling methods.
- Secondary forest after shifting cultivation, where there is usually only a low proportion of desirables in the earlier stages of the succession.
- Areas naturally poor in desirable species, but with a potential for valuable timber trees.

16.1 Methods of enrichment planting

The common form of enrichment practiced today is line enrichment. Enrichment by irregularly spaced groups had been abandoned because of difficulties in control and retracing the groups for tending operations.

When conducting enrichment planting over extensive tracts of rain forest, not always an experienced forester can be on the

spot. It is essential therefore to issue clear and simple instructions to the workers, which can be followed mechanically.

Several modifications of line enrichment had been carried out with success (16) of which only two will be discussed below.

a) Line enrichment with shade tolerant species.

At intervals of 10-20 meters strips 2 meters wide are cleared of all vegetation. Larger trees on these strips are poisoned with sodium arsenite or a hormon arboricide (2,4,5-T). All desirablesare spared. For most favorable light conditions it is recommended, that the lines run in East-West direction.

On both sides of the 2 meter strip the lower stratum, which includes trees up to about 15 meters, is felled by chainsaw or poisoned in a zone 5 meters wide. In the middle stratum (trees of 15 to 25 m approximately) only occasionally a tree with exceptionally dense foliage is poisoned or girdled.

If a distance of 20 meters between the lines (from center to center) is adopted, there still remains a zone of 8 meters of untouched forest inbetween. For more intensive enrichment it can be considered to reduce the distance between the lines to 15 or even 10 meters, so that the untouched 8 m zone in the center will be omitted.

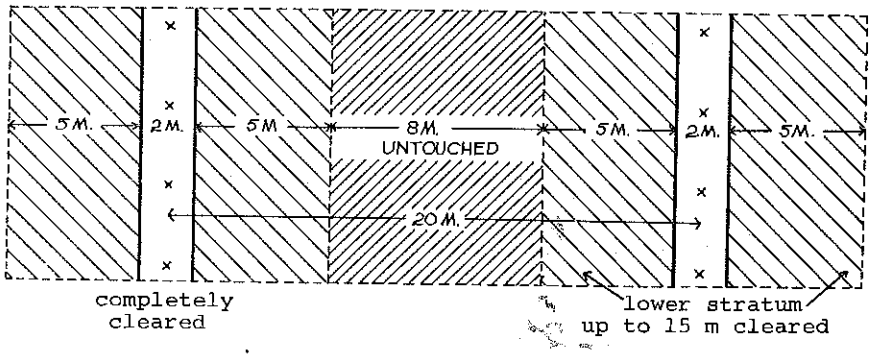


Fig. 22: Line enrichment with shade tolerant species.

Planting is done on lines at a spacing of 3 to 5 meters according to species and size of planting stock. This amounts to 100 - 165 plants per hectare.

This modification of line enrichment is recommended to be tried with dipterocarps, which require partial shade during their early stages. The high shade provided by the taller trees in the 5 meters zone on both sides of the lines will also help to reduce the growth of the weed species and climbers.

b) Line enrichment with light demanding species.

For the light demanding species of the Meliaceae family like mahogany the first method would not provide enough light, and CATINOT (1965) suggests the following modification:

All vegetation is cleared on lines 5 meters wide at intervals of 20 meters from center to center. In the remaining zone between the lines all trees higher than 15 meters (which roughly corresponds to a dbh of 15 cm) are cut, girdled or poisoned, except the desirables.

While in the first method mainly the understorey is removed, in the second modification more light is obtained by removing the higher trees. For more intensive enrichment the distance between the lines can be reduced to 10 m.

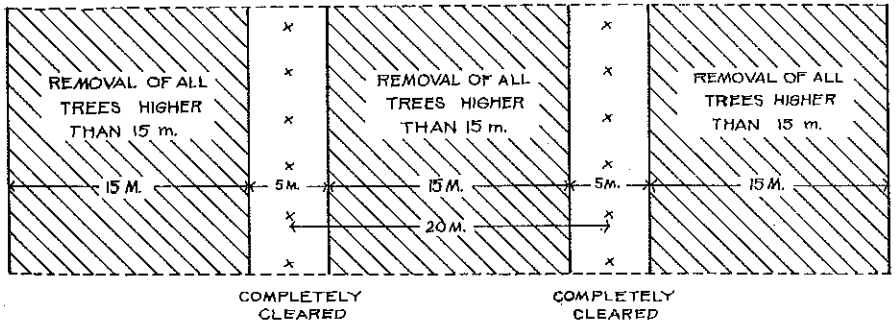


Fig. 23: Line enrichment with light demanding species.

16.2 Planting stock and suitable species.

A species, which has already proved its value in enrichment planting, is mahogany (Swietenia macrophylla). Since it is also one of the most successful reforestation species in the Philippines, it should be given preference where the shoot borer permits its cultivation (FAO, 1970).

The dipterocarps are more problematic, because of the short viability of their seed and sometimes poor survival, when transplanted. With improved techniques these difficulties may be overcome. Successful line enrichment with dipterocarps on an experimental scale can be seen in the concession area of the Bislig Bay Lumber Company in Mindanao. Of the large number of dipterocarps only the faster growing species like Bagtikan (Parashorea plicata), White Lauan (Pentacme contorta), Apitong (Dipterocarpus grandiflorus), Mayapis (Shorea squamata) and others are recommended.

Because of the small number of plants, these must be of the best quality available, balled or potted. Saplings or striplings have an advantage over the weeds because of their size. But tall balled wildlings taken directly from the forest generally suffer too much from the transplant shock and generally show poor survival rates.

The best method is to collect the dipterocarp wildlings with a small ball of soil right after the first true pair of leaves has developed. They are potted and then kept in a nursery under partial shade, until they have reached planting size.

Since the number of plants is only 100 to 165 per hectare, it would add very little to the costs to apply some complete fertilizer (12/24/12 or 14/14/14) by mixing it with the soil of the planting hole. A small quantity of 20 to 30 grams per tree according to size would have a great effect on the initial growth and enable the seedlings to cope better with the rapidly developing weed species. From observations it appears, that fertilizer application also would enable the trees to put on good growth, even if the light conditions are not very favorable.

16.3 Tending operations.

The most decisive factor for the success of line enrichment are the tending operations during the first 5 or 6 years:

- weed control, especially during the first two years,
- poison girdling of all undesirable trees overtopping the lines, especially when the seedlings become older and more light demanding,
- systematic cutting and poisoning of undesirable secondary vegetation on the lines,
- climber cutting whenever necessary.

It is absolutely essential, that the required funds for these tending operations are guaranteedat the time of planting, otherwise the funds spent for the establishment are spent in vain. Here lies one of the most common reasons for the failure of enrichment planting.

For the removal of undesirable tree growth the use of chemicals is now a well established procedure in tropical silviculture (28,70). There is the choice between the very poisonous, but highly effective and cheap sodium arsenite and the non-toxic hormon based weed killer 2,4,5-T (For more information on arboricides consult Chapter 18.3).

16.4 The cost of line enrichment.

The cost of line enrichment for a 20 meter spacing between the lines can be estimated as follows (CATINOT, 1965, modified):

		man days/ha
1. Year:	Selection of area, marking of blocks and lines,	2
	Clearing of lines, poisoning of trees between lines,	11
	digging of planting holes	3
	production of planting stock	5
	planting and replanting, incl. transport of planting stock	4
	weeding	2
2. Year:	Weed control, climber cutting, further poisoning	3
3. Year:	-dto.-	3
4. Year:	-dto.-	3
5. Year:	-dto.-	3
6. Year:	-dto.-	3
	Total	42

In addition about 5 lbs of sodium arsenite (about 50 centavos per lb) and some fertilizer are needed, the value of which will hardly exceed ₱ 15 per hectare. This sums up to roughly ₱ 435 per hectare (based on a daily wage of ₱ 10) including the cost of the seedlings and the maintenance during the first 6 years. About 2/3 of this amount are needed during the first year.

16.5 Advantages and disadvantages of line enrichment.

a) Enrichment planting offers a possibility to bring unproductive forest areas into production again, and provides a chance for natural regeneration in the following rotations.

b) Enrichment planting provides an opportunity for re-introduction of valuable dipterocarps, which cannot grow in the open in their early stages.

c) In line enrichment with mahogany there is often less shoot borer attack than in open plantations (40). The possible explanation is that through side and partial overhead shade the formation of long sapy shoots is avoided, which make the tree attractive for the insect. It is also possible, that the forest environment has a positive effect on the life cycles of the natural enemies of the shoot borer.

The main difficulty in enrichment planting generally is to prevent the lines from closing up from the sides and to keep climbers and pioneer vegetation down. Assistance has to be given sometimes several times a year up the age of 6 years.

Considering the success of line enrichment in other tropical countries it would be definitely worthwhile to give it a wide scale trial in the overlogged areas of the Philippine rain forest.

Chapter 17:

SOME PRACTICAL GUIDELINES FOR FERTILIZER APPLICATION IN YOUNG PLANTATIONS

Numerous experiments carried out in temperate and tropical countries have shown, that a considerable increase of height growth and volume production can be obtained through fertilizer application. A significant effect can already be achieved by relatively small quantities applied in the proper way.

17.1 The role of the main plant nutrients and their sources.

a) Nitrogen (N): Because the atmospheric nitrogen cannot be used directly by higher plants, the available N comes mainly from the following sources:

- Mineralization of humus,
- Nitrogen conveyed by rain and thunderstorms,
- Nitrogen-fixing bacteria living in the root nodules of some trees.

Since humus is very unstable under tropical conditions, nitrogen is in short supply in most tropical soils. Nitrogen is an important element in nucleic acids, chlorophyll and proteins, and so determines the production of vegetative matter, including leaves, needles and wood.

b) Phosphorus (P): Though the total phosphorus content of organic and anorganic compounds in the soil is usually relatively high, the quantity of dissolved phosphate-ions

available for the plants, however, generally is quite low. Especially in acid soils most of the phosphorus is rigidly tied up in metal compounds and not available to the plants.

Phosphorus is an important element in the nucleo-proteids and in form of phosphatic acids controls the energy metabolism in the plants. The fundamental biochemical processes of photosynthesis are not possible without the action of phosphoric acids (5). Application of phosphorus has marked influence on diameter growth and lignification of tissues.

c) Potassium (K): Potassium is part of soil minerals, namely feldspars and micas, but it does not become part of organic compounds. Potassium among other functions increases the osmotic pressure in the cells, favors the uptake of water and opposes wilting. With other words, it increases the draught resistence of plants (5).

d) Calcium (Ca): Calcium is found in various combinations in rock and soil minerals. By adding lime we can increase the pH-value of the soil. If the pH-value is too low, the availability of phosphorus would be affected, If it is too high, it would affect the uptake of iron and magnesium.

e) Magnesium (Mg) and Iron (Fe): Magnesium and iron are the central components of chlorophyll and are required in considerable quantities by all green plants. Magnesium is also essential as a regulator for a number of biochemical processes in the plant.

17.2 Type of fertilizer.

Because generally nitrogen and phosphorus are in short supply in most tropical soils, best results were obtained with a well balanced complete fertilizer containing nitrogen, phosphorus and some potassium. In most cases the use of complete fertilizer is to be preferred to the application of

a single nutrient. If only one nutrient is applied, the increased growth would lead also to an increased uptake of those nutrients, which were n o t supplied by the treatment. This may cause deficiency of these other nutrients which is known as the "dilution effect" (5).

The three or sometimes four numbers printed on fertilizer bags indicate the contents of primary nutrients in the sequence nitrogen - phosphorus and potassium. The fourth number sometimes found indicates the magnesium content. Combinations recommended for forestry purposes are 12-24-12, 14-14-14, 12-12-12 or similar types. Some fertilizers also contain trace elements such as iron, manganese, boron, copper, zinc, molybdenum and others, which are needed only in minute quantities.

17.3 Method of application.

Because of the wide spacing commonly used in the plantations an individual application generally is most economical. For the first application it is recommended, that the fertilizer is mixed with the soil at the bottom of the planting hole. This method is to be preferred to a top dressing after planting, because the fertilizer would not be washed away easily by heavy rains and cannot be taken up by shallow rooting weeds.

All subsequent applications, if any, are done in form of a top dressing. The fertilizer is strewn by hand on a radius, which is probably penetrated by the roots ("drip line"). If this radius is chosen to large, the weeds will benefit unnecessarily. For the same reason all weeds in the vicinity of the seedling must be uprooted and used as mulch, mere cutting would not be sufficient. Care must be taken that a high concentration of the fertilizer does not get in direct contact with the root collar. Young teak seems to be particularly sensitive and may be easily killed that way.

A fertilizer dressing combined with soil working around the seedling can give very good results, if done properly. Soil working would help the infiltration of the fertilizer into the soil and increase aeration. The cost of application, however, is higher and there is the possibility of damages to the root system.

All fertilizer application must be carried out during the main growing season. A very favorable time is right at the beginning of the rains, or towards the end of the rainy season, when it is already too late for planting, but the growth of many tree species reaches a maximum. During the peak of the rainy season fertilizer application would probably interfere too much with the ongoing planting work.

17.4 Quantity to be applied.

The effect of different quantities of fertilizer on the increment follows the well known input-output curve and may be illustrated by the following experiment:

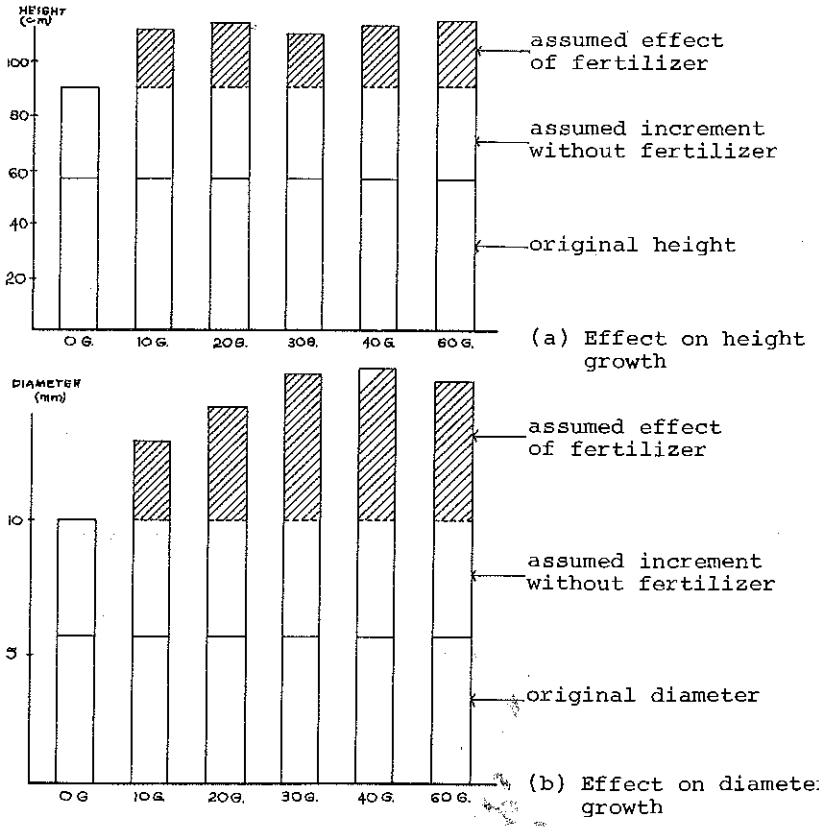


Fig. 24: The effect of different doses of complete fertilizer (12/24/12, plant hole application) on Eucalyptus camaldulensis 11 months after the application. Binga.

Considering the effect on h e i g h t increment the most significant effect against control ("no fertilizer") was achieved by the 10 gram treatment without any additional increase with higher doses.

For the diameter increment at root collar also the 10 gram application resulted in the most significant increase. 20 gram per seedling, however, showed a greater effect, but the additional increase was only small, for the 30 gram treatment the additional increase was less still.

The quantity applied should result at least in the major portion of "possible" increment. In the above example something between 10 and 20 gram per seedling according to the availability of fertilizer would be the proper dose. The quantity of 20 grams of complete fertilizer per seedling is also in line with recommendations of GUSSONE (1964) for European tree species. For larger seedlings, of course, the optimum quantity would be higher.

If 2500 seedlings per hectare are treated with a 20 gram application, 50 kg (one bag) will be needed per hectare. Based on the prices of 1974 this would cost about 100 Pesos. For application as a surface dressing without soil working about 1 man day is required per hectare, with soil working about 3 man days are needed. To save costs, fertilizer application should be combined with weeding.

17.5 Indications for fertilizer application in plantations.

- On sites, where deficiency symptoms occur (5,37),
- Sites, which are degraded by erosion and where the A-horizon had been washed away entirely,
- Poor sites, indicated by a meager ground vegetation,
- In plantations of fast growing timber species, if after economic analysis fertilizer application would result in higher financial net returns,
- On dry sites application of complete fertilizer would result in a deeper root system and increased draught resistence (effect of K) (27).

- Sites with a strong weed competition. Here the fertilizer must be applied in a way to give advantage to the trees without favoring the surrounding weeds.
- In enrichment planting, where only very few trees per hectare are planted fertilizer application would possibly compensate for light deficiency and enable the seedlings to cope better with the weed species.

Chapter 18:

THE CONTROL OF WEEDS, CLIMBERS AND UNDESIRABLE TREES

18.1 Weed Control.

a) General considerations

The more hot and humid the climate, the more weeding operations have to be carried out. In the humid parts of Eastern Mindanao three or four weeding operations during the first year are not uncommon, while in Northern Luzon one or two weedings during the first year would be sufficient. In some places no weeding at all may be required. The number of weeding operations has to be increased, where small and poor planting stock was used for field planting.

A common mistake in weeding is that too much of the vegetation is cleared around the plants. It should be borne in mind, that the grasses and herbs growing near the seedling may also have Some beneficial effects on its development. The seedlings might indeed benefit from a light shade, provided they are not suppressed. A light weed competition at an early stage might reduce the formation of strong side branches having a similar effect as close spacing. Besides this the grasses perform a useful function as a soil cover and protection from erosion. Not more vegetation than absolutely necessary should be cut ("ring weeding"). The grass cut is placed as a mulch around the seedling to reduce evaporation and check the new growth of weeds.

For light demanders more clearing is required than for shade tolerant species which do not suffer so much from weed competition. There are species, however, which are very sensitive to any weed competition like teak and most eucalypts. In these cases just cutting the weeds may not be enough, but it may be necessary to eleminate competition in the root zone by uprooting the weeds and doing some cultivation around the seedling.

Care must be taken to avoid sudden exposure of plants, which have already been suppressed by weeds. Here only the overtopping weeds are cut, leaving a side shade. It should be carefully studied, if any "brushing" is necessary at all during the first year, because the grasses in many cases will dry up anyhow. On steep slopes it often happens, that wilting grasses form a complete blanket on top of the seedlings, which must be removed as early as possible.

Any weeding must be done early enough, before the seedlings are suppressed and consequently may suffer severely from sudden exposure. Proper timing of weeding therefore is a decisive factor for the success of the plantation.

b) Tools for weeding.

- Bolos, there are many local modifications of this useful tool. For weeding in high cogon and talahib a modification of the

ordinary bolo with an elongated blade and an elongated handle called tabás in Ilocano has proved to be very handy. Since laborers all over the country are used to work with bolos, no new introductions hand tools for weeding are recommended for ordinary field conditions.

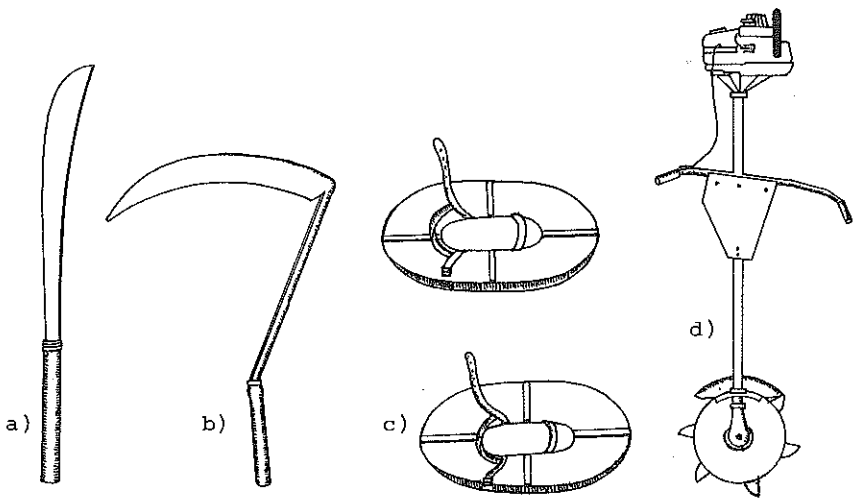


Fig. 25: Weeding tools: a) Tabás, b) sickle, c) weed tramplers, d) motor weed cutter with chainsaw motor.

- Motor weed cutters are already found in some reforestation projects. They are driven by a small gasoline motor (chainsaw motor), which operates a circular saw attached to a long handle. Where a chainsaw or a motor plant hole driller is already available, the weeding attachment may be a useful addition. The machine has proved to be quite useful in clearing high cogon, runo, talahib and other sharp edged grasses as well as brushes.

- Weed tramplers consist of a pair of frames of oval shape, which are attached to the shoes. The weeds are not cut, but simply pressed down by the weight of the body, which weakens them more than cutting. Their effectiveness should be tried under Philippine conditions. The job must be assigned to a heavy person.

c) Possibilities of chemical weed control in plantations.

Because of the high cost of labor chemical weed control had become very popular with foresters in Europe and the United States. The ideal weed killer required for forest plantations should have the following characteristics:

- effective against Imperata, not necessarily kill it, but retarding its growth,
- harmless for conifers and broadleaved species,
- the use must be cheaper than manual labor,
- the chemical should not be poisonous to man or livestock,
- after the desired result had been obtained, the chemical should desintegrate without any residual effect on the ecosystem.

Up to now there is no herbicide available, which meets all these 5 requirements. In recent years DOWPON with the active ingredient DALAPON had been used with good success in temperate countries to kill grasses with rhizoms. It is taken up by roots and leaves of the grasses and in lower concentrations does not affect most forest trees. From some small scale experiments it appears, that DOWPON is also effective against cogon to some degree, which resists most selective herbicides. But more tests are needed regarding

- the compalatability with different tree species,
- the optimum time for application,
- the quantity required per unit of area,
- the economical analysis of the costs compared to ordinary brushing.

Preliminary tests, however, have shown, that the quantities required to weaken cogon are so high, that also most forest trees are affected (68), and the cost of the chemical will in most cases exceed the cost of manual labor. The prospects of chemical weed control in forest plantations therefore at present are not very favorable. For more information on the different types of chemical weed killers see Part IV.

18.2 Climber cutting.

Climber cutting is a very important tending operation in the moist and humid regions of the Philippines. Severe infestation of climbers can completely cover and deform small trees of sapling size. The control of climbers is often more of a problem than the control of herbaceous weeds and grasses. Because of buried and surviving seeds there are generally more climbers on a forest soil than on a grassland site. Most climbers however, are very light demanding, they disappear as soon as the plantation forms a closed canopy and the conditions for their germination become unfavorable.

Fig. 26: Freeing a tree from climbers with a Y-shaped stick (after HENGST, 1954)

When a tree is completely covered by creepers, one has to use a y-shaped stick and push the vine up. By pulling it down one would easily break the branches or the top of the tree. The vines thus removed from the tree are not cut - they would sprout again- but curled up and deposited at the base of the tree. This weakens their vigor more than cutting (34). With very persistant climber species it is recommended to spray the curled up climber with a 2 % solution of 2,4,5-T, a hormon-based arboricide, to prevent any sprouting.

A climber, which is a very serious pest in Mindanao and Mt. Makiling is Uoko (Mikania scandens). Another species which is hard to control is bikal (climbing bamboo), which can form impenetrable thickets suppressing any young tree growth especially in a more seasonal climate. In the humid parts of Mindanao, bulacan (Merremia peltata) is often a big problem.

18.3 Removal of undesirable trees.

Undesirable tree growth under 6 cm diameter can be easily cut with the axe or the bolo. If larger undesirables have to be removed, this can be done by chainsaw or girdling. Nowadays the use of chemical tree killers had been found more economical and effective, because not all tree species can be killed by girdling alone or would coppice after cutting.

For the preparation of enrichment planting and timber stand improvement two chemicals are widely in use in tropical countries: sodium arsenite and 2,4,5-T. The latter is sold under different trade names (TORMONA or TORDON). Their main characteristics can be compared as follows:

Sodium arsenite	2,4,5-T
anorganic poison,	hormon based arboricide
highly toxic to human and animals,	if pure, low toxididity to men and animals

Sodium arsenite	2,4,5-T
highly effective for most species, very economical,	acts slower, does not kill all species, more expensive, when diluted in diesel oil,
10 % (by volume) solution in water,	3 % mixture with diesel oil, with water less effective,

If sodium arsenite is to be used, very strict safety measures have to be adopted, because it is a very dangerous poison. For further information on handling sodium arsenite consult FAO, Technical Report No. 3 on Forest Management (1971) or Malayan Forest Record No. 23. Also the use of 2,4,5-T requires all the safety precautions normally used in handling poison. 2,4,5-T normally is not toxic to human beings and animals, but it may contain dioxine as an impurity, which is one of the most dangerous poisons known and toxic in minute quantities.

Methods of application

- 2,4,5-T applied with a paint brush on the bark around the tree has a lethal effect on most trees provided that the bark is dry and the zone painted is wide enough so that it cannot be bridged by callus formation. More hardy species must be girdled first.

- The poison is applied by pouring a small quantity of it into a continuous frill of overlapping cuts made with a bolo around the tree trunk. The chemical is carried in a dispensing can of 2-3 liters with a long spout and a tight fitting cap and is poured into the frill. This method is very effective against very resistant species like all latex bearing trees (Moraceae, Sapotaceae).

- Application in notches is practical for small trees and large trees with high buttresses or irregular trunks. It is also possible to fill the dry crystals of sodium arsenite directly into the notches.

The advantages of poison girdling

- cheaper than cutting, the savings can be 20 % or more,
- for sprouting species more effective than cutting,
- the tree poisoned does not cause damage in the regeneration by falling, but is disintegrating slowly, the branches fall one by one,
- there is no sudden opening created, which has silvicultural advantages.

Chapter 19:

PRUNING AS A MEASURE OF STAND IMPROVEMENT

Almost all trees have branches. There are very few exceptions only in the tropics like for example palms and younger individuals of malapapaya. Branches are necessary to carry and support the leaf surface of the tree essential for assimilation of carbohydrates and growth, but wood with ingrown branches is considered defective and of inferior quality.

Ingrown living branches are less harmful than dead onces which may cause defects and holes in the lumber. Artificial pruning should therefore be directed more towards the removal of dry branches than of the green ones.

19.1 The process of natural pruning.

The extent to which the lower branches die depends largely on the stand density. As soon as a closed canopy is formed, the growth of the branches below the canopy decreases and they finally turn dry. The time in which the canopy closes and the branch is shaded influences to a certain degree the diameter the branch can reach. Natural pruning therefore is best in close even-aged stands without prominent individuals. Heavy branching is sometimes observed on good sites, while the same species on poorer sites shows less branching (61).

The branchiness of the individual tree depends also on genetical factors. We can sometimes observe, that the branching pattern of the mother tree repeats itself in the offspring in a very similar way.

Tropical pines, like Benguet pine often show normal branching at higher altitudes, while at lower elevations the branches grow almost as fast as the terminal shoot resulting in trees without commercial value (example: Benguet pine near Magat, Nueva Vizcaya). Increased shoot borer attack at low elevation may be only part of the explanation.

The great disadvantage of natural pruning is, that the dying branch does not fall for some time. When the branch is dead, it may take years until it is weakened by fungi and insects and finally falls by the action of wind or rain. The activity of fungi is very important for natural pruning. Where the branch wood is protected from decay by a high resin content, natural pruning is delayed. By keeping a conifer plantation dense, we can only influence the thickness of the branches, but not the falling of the dead branches (61).

With most broadleaved species it is different. Here generally dead branches decay very quickly and are dropped. A dense canopy usually is all that is required to obtain clear boles. Artificial pruning in broadleaved stands generally is not carried out as systematically as in conifer plantations. Pruning here is more of a corrective nature as part of the early tending operations (removal of forks, etc.)

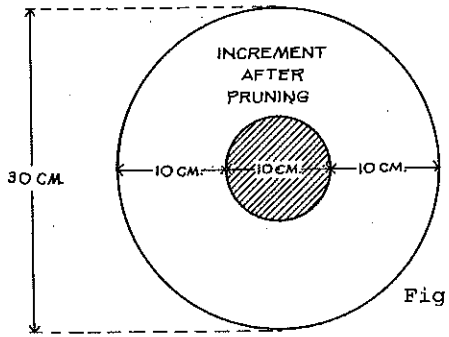
19.2 Artificial pruning in conifer plantations.

a) General considerations:

Systematic pruning of entire plantations is a very costly operation. It must be considered, that the expenditure for pruning has to be compounded at current interest rates up to the end of the rotation. Pruning can only be economical, if the increase in value of pruned timber is higher than the compounded cost for pruning.

In the Philippines at present, pruning of conifers may only be indicated in some of the commercial plantations intended for lumber production in long term concessions, where the investor also is in a position to derive the benefits from his investments later.

Another consideration is, that the cylinder of clear wood put on after pruning must be thick enough to be of any value. The part of the stem containing knots should be limited to the innermost core of about 10 cm. The expected coating of clear wood should be at least 10 cm thick. Pruning is therefore economical in the b e s t stands only. It is not advisable for example to prune the heavily branching pines at low elevation, from which never any timber of good quality can be expected.



$$\frac{(\pi(15)^2 - \pi(5)^2) \times 100}{\pi(15)^2} = 88.8\ \%$$

Fig. 27: Proportion of clear wood after pruning.

According to fig. 27 a log of 30 cm diameter, which had been pruned as a young tree of 10 cm diameter contains 89 percent of clear wood.

Conifer plantations are usually pruned in three successive stages following the natural development of the crown, until in the third and last stage the tree is pruned up to about 6 or 8 meters. To prune higher than one can reach from the ground, is rarely indicated, because the cost of pruning is progressive at higher levels. Also because of lower increment at higher levels, the output of clear boards can hardly be increased. Generally the most valuable portion of a tree are the lower 6 to 8 meters, which may account already for about 2/3 of the total value.

Since pruning is not yet a standard procedure in the Philippines, as an example the South African pruning instructions for pines may be quoted:

1. Stage: When the stand reaches a top height of 6 meters, all trees except forked and suppressed individuals are pruned up to 2,50 meters.

2. Stage: When the tree reaches a top height of 9 meters, all stems which are left after the first thinning, are pruned to half their height.

3. Stage: When the top height reaches 12 to 15 meters, 375 well formed stems per hectare are selected and pruned up to 6,50 meters.

b) Tools for pruning.

- A light pruning saw with fine teeth, which can be attached to a handle or bamboo pole of varying length according to the pruning stage. While for the first stage only a short handle is required, for the second stage we already need a pole of about 4,5 m length.

  Of all the various models of pruning saws tested at the Training Center the HENGST model gave the best results, it cuts on pull only (Fig. 28).

- Indispensable for pruning are protection glasses to protect the eyes from falling saw dust and small branches. These "glasses" are preferably made of celluloid or a similar material, but not glass.

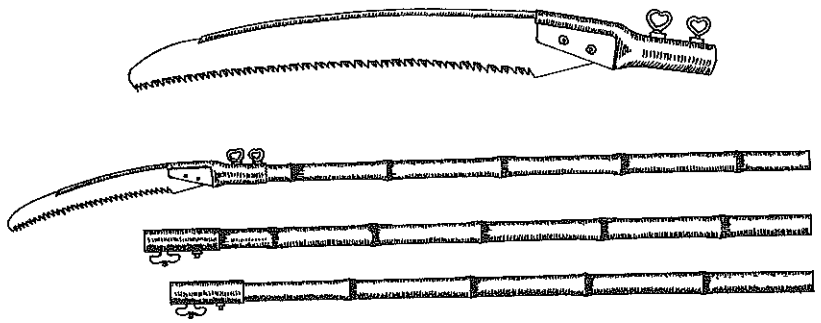


Fig. 28: Pruning saw (HENGST Model) with extension poles.

c) Pruning technique

The branches to be removed are cut directly at the stem with a clean cut. Care must be taken, that the bark below the cut is not injured, which would cause resin pockets in the lumber later. No splinters should remain at the lower side of the cut, because this would delay occlusion and may cause defects in the trunk. Generally only dry branches are removed in pruning of conifers. If occasionally some green branches are cut, this would not have much effect on the tree or the increment, as long as not a major portion of the green crown is removed.

d) Advantages of pruning:

- The financial advantage of pruning depends largely on how much timber free of knots and branches is appreciated,
- Pruning of conifers admits a wider spacing and heavier thinning without a decrease in the quality of the timber. But it is only economical on good sites, where a first class timber crop can be expected, and the increment of clear wood after pruning is sufficient to justify the expenses.
- Some foresters emphasize, that by low pruning the danger of crown fires in conifer plantations is somewhat reduced. The dry branches cut can be piled up where they cannot cause danger in a ground fire as was demonstrated in a small scale at the Bobok Concession.

19.3 Correction of growth forms in hardwood plantations.

The correction of growth forms is a very important stand improvement operation in the early stages of a hardwood plantation. The cost usually is very small compared to the increase in timber quality. Since only a portion of the trees receives treatment preferably at an early stage, the expenses are only a fraction of the costs as compared to pruning conifer plantations.

a) Removal of forks: This particularly important for species, which have a natural tendency to fork like narra (Pterocarpus indicus). But also in all the other species forks must be treated as early as possible. After a greater diameter had been reached, no corrections can be made any more for the danger of fungus infections. Besides true forks also branches, which form an abnormally small angle with the trunk have to be removed, because they almost inevitable will cause defects in the timber, after the branch has died (Fig. 29).

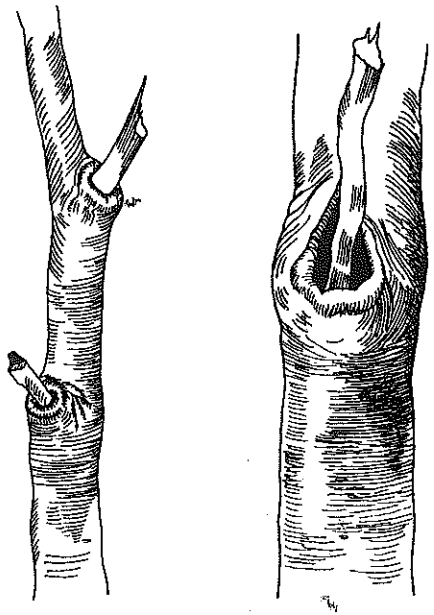


Fig. 29: The effect of forks and branches which form a small angle with the trunk: water enters the pockets after the branches have decayed and causes defects (drawn after HENGST, 1954)

The fork is cut directly at the stem, as long as its diameter is below about 4 cm. For larger forks the same procedure as for large branches is recommended (see below). Forks of over about 8 cm generally cannot be removed from forest trees anymore.

In young plantations cutting of forks is only a matter of a few hours. The treatment should be repeated at least 2 times. The first treatment is recommended before the plantation reaches 2 meters in height, the second when the top height reaches about 6 meters. In the first treatment pruning shears are the main tools (Fig. 30) for the second stage a pruning saw attached to a bamboo pole (Fig. 28).

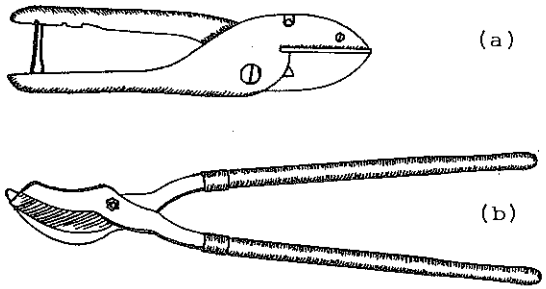


Fig. 30: Pruning shears: (a) Model "LOEWE" for thin branches (b) Model "WALDTEUFEL" for branches up to 6 cm diameter.

The commercial value of a tree forking right above the ground is much less as compared to a tree where all the increment had been conentrated on one trunk only. As stated before, the major portion of the value of a plantation normally is constituted in the lower 6 to 8 meters. If we can eliminate forking that portion, we would increase the timber value of the plantation considerably.

b) Removal of abnormally strong branches.

Trimming a tree with abnormally strong branches back to normal shape is carried out in three cuts, as illustrated in Fig. 31.

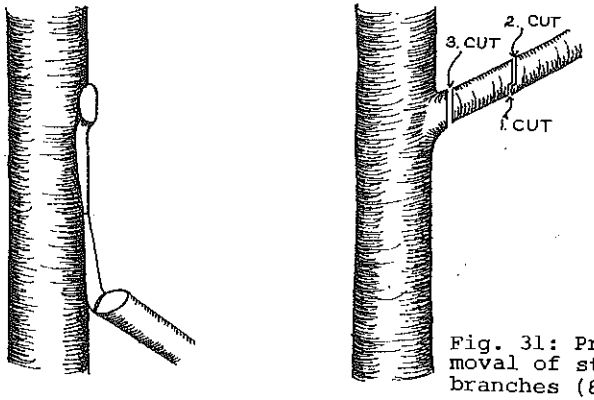


Fig. 31: Proper removal of strong branches (8).

If we attempt to cut the branch directly with one cut, there would be always the danger, that the branch goes off with a piece of bark inflicting serious injuries to the tree. It is very important, that the branch is cut d i r e c t l y at the stem. Leaving a stump, which grows into the tree, would cause very serious defects in the timber (Fig. 32).

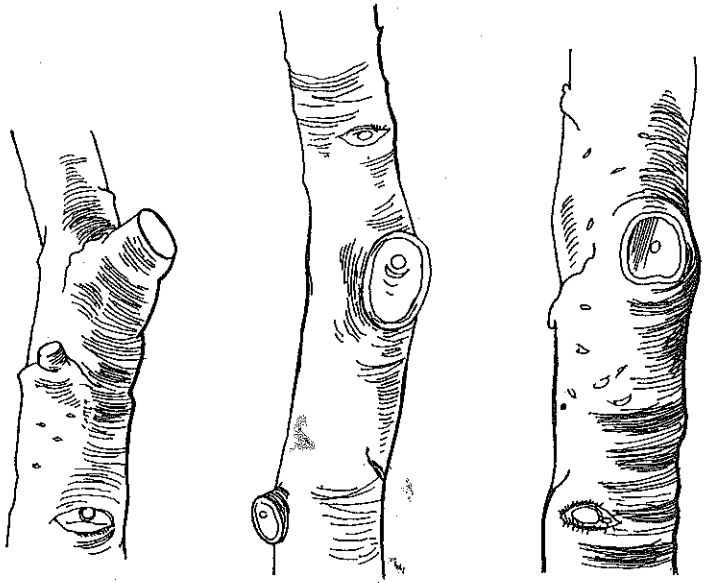


Fig. 32: Cutting of branches: a) too much of the branch is left b) improper cutting angle, c) cutting through the branch swelling causes a very large wound, only the outer margin of the swelling should be slightly touched by the cut, d) proper cut (drawn after HENGST, 1954)

For European timber species it is known through experiments up to which maximum diameter a green branch can be cut safely without risking fungus infection. Similar experiments as a basis for tending instructions are recommended for the Philippines. With a species like teak with a wood very resistant to rot, a larger diameter can be pruned than with a softer and easier rotting species. The scars of teak branches of 4 cm diameter pruned in Binga were completely occluded by callus formation after 12 weeks. To avoid, that the cut is exposed for a long time and risking fungus infection, the work should be carried out during the main growing season. The application of tree wax is usually not done in forest plantations. Only for valuable ornamental trees a mixture of bitumen and creosote is recommended for protecting large cuts.

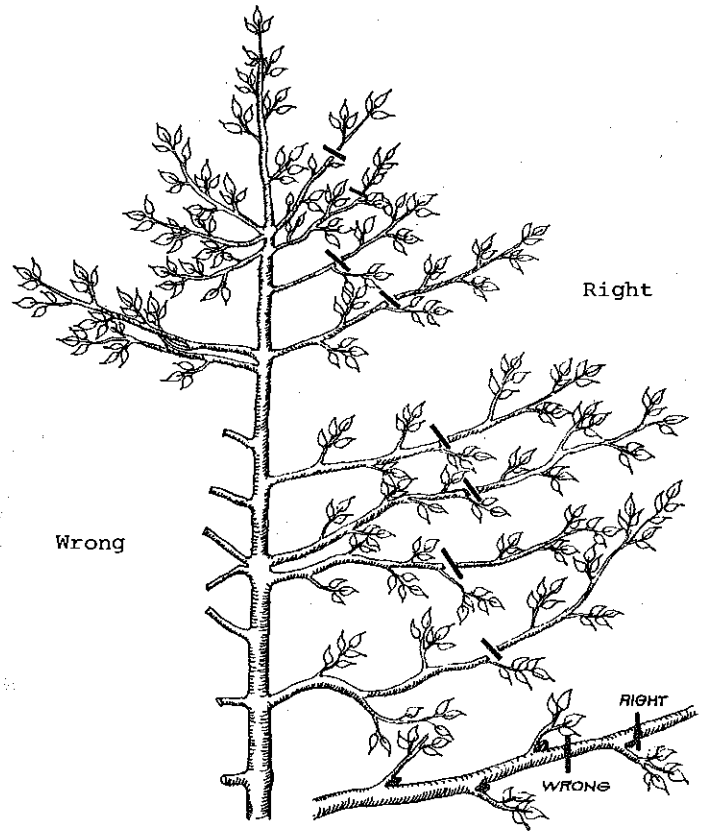


Fig. 33: Proper trimming of abnormally strong branches. (drawn after HENGST, 1954)

When branches are too thick for pruning already or the species is very delicate, the branch is not cut directly at the stem, but about 3 feet away. Cutting only a portion of the branch has the effect of reducing a strong branch to secondary importance. The remaining portion of the branch must still be long enough to fall by its own weight, once the branch is dead and decaying. Leaving stumps of about 30 cm as can be often seen is a serious mistake and will cause defects in the timber. The cut has to be conducted right behind a bud pointing downward or sideward. Cuts made behind buds pointing upward would stimulate forking (HENGST, 1954).

c) Treatment of poorly shaped trees: A forester is quite often confronted with teak plantations of poor shape due to fire, grazing and illegal fuelwood cutting resulting often in crooked trees, multiple leaders, and heavy branching. The best remedy is to cut back those trees directly above the ground. The reserves of the root stock will produce within a year a straight branchless shoot several meters high. A few weeks after cutting one has to remove all but the strongest shoot from every root stock. A similar treatment is also given to leaning trees.

d) Treatment of wolf trees. Wolf trees are individuals, which show abnormally fast growth combined with excessive branching. In very young plantations these can be directly removed without harm. At a later stage it is preferable from the silvicultural point of view, that they are only heavily pruned and their top is cut. If we remove them completely at a late stage, we would create a large opening, into which the neighbors would extent strong branches. A large opening at a late stage may also be the starting point for wind fall.

Chapter 20:

THE BASIC PRINCIPLES OF THINNING PLANTATIONS

When we start a pine plantation we plant commonly at a spacing of 2 by 2 meters, which amounts to 2500 seedlings per hectare. In the final stand after 60 years or so the number of trees reaching maturity is only 250 to 500 per hectare. All the rest of the initial number, about 80 to 90 percent, will have died through natural causes or had been eleminated by successive thinnings. The aim of thinning is to correct the course of nature in the elemination of individuals and to retain only the best stems up to maturity.

20.1 Thinning of young stands.

All the undesirable individuals are removed at an early stage of the plantation, which at first may be part of the tending operations, later, when the diameter has reached salable size, is part of thinning.

This negative selection is also called r e f i n i n g, which means to remove impurities from a mixture (18). Refining is the contrast to l i b e r a t i o n of the best stems at a later stage. The individuals to be removed in the refining operation are:

- Individuals of undesirable species,
- Trees, which show abnormal tendency to fork,
- Wolf trees,
- Trees, which are defective otherwise,

Thinning must start as soon as crown competition sets in to provide enough growing space for the remaining crop. If thinning is delayed, the plantation would become stagnant. The struggle for survival can be very prolonged with shade tolerant species. In dense stands of light demanders, the weaker individuals succumb quickly and only the most vigorous survive.

Mechanical thinning: In young overcrowded plantations and natural regeneration, very often a so-called mechanical thinning is carried out as long as the individuals are not yet well differentiated in respect of height growth and diameter (61). The objective is merely a regulation of spacing, where extensive plantations are to be treated, and where only untrained labor is available.

According to circumstances, in mechanical thinning, for example, every second or third line or tree within a line is removed, or in natural regeneration a minimum distance between trees is prescribed. Deviation from the prescribed spacing is only tolerated in exceptional cases where an obviously good individual would have to be removed in favor of an inferior one.

20.2 Thinning of older plantations.

For a given species, each site has a certain potential increment. The objective of thinning is to concentrate this potential increment on the best trees only by removing the competition of inferior neighbors. The trees of the lower stratum, which do not compete much in getting a share of the potential increment, are generally spared in thinning as a useful ground cover. In most cases their timber value does not cover the cost of removal.

While in young stands we have selected the inferior individuals to be cut, we now change our point of view and make a positive selection instead. We select the best trees and cut those, which compete with them in the crown region. This is also known as "liberation cutting" (18). So, only a tree will be removed, if a better substitute will really profit

from the additional root and crown space.

When marking the trees for felling we always have to look at the situation in the canopy, not at the spacing on the ground. All the increment of a tree depends on a well developed crown, because this is the place, where the carbohydrates, the elements of wood, are produced. To develop a healthy crown capable of high increment, it is important, that thinnings are carried out early enough. If thinnings have been delayed, many species would not respond to additional growing space at a later age. One important principle of thinning is therefore "early - moderate - often". Species which are able to make use easily of additional growing space by extending their branches into the newly created openings, those can be thinned more heavily, e.g. Gmelina arborea and Albizzia falcata on good sites.

The edges of the plantation have to be kept as dense as possible to maintain a favorable "forest" climate in the interior of the stand.

A situation often faced when marking trees for thinning is that there may be two trees of equally superior quality growing closely together on a relatively small area. Observations under natural conditions have shown, that the increment of both of them may not be reduced, as long as there are possibilities for lateral expansion. In this exceptional case the two trees can be treated as a "thinning unit" without losing increment.

20.3 Numerical guides for thinning.

In many countries exact instructions exist -sometimes as part of the yield tables - how much to remove and how much to retain in thinning operations at different ages. These instructions are sometimes based on the basal area, sometimes only on the number of trees per hectare, or even the average distance between the trees.

a) Where growth is very uniform thinning instructions may be based only on the number of trees per hectare to be

retained at the respective ages, perhaps differentiated for different site classes. But this would imply, that the plantation area is known and the trees are counted, or the number of trees per hectare has to be transformed into average distance between the remaining trees. As an example the thinning schedule for slower and fast growing pines in South Africa may be quoted:

Thinning schedule for s l o w e r growing pines in South Africa

Site Class I		Site Class II		Site Class III	
Age	Stems/ha	Age	Stems/ha	Age	Stems/ha
0	1265	0	1265	0	1265
9	700	8	700	7	700
14	500	13	500	13	350
20	275	18	275	20	200
25	225	23	225	60	Final felling
40	Final felling	50	Final felling		

Thinning schedule for fast growing pines in South Africa

Site Class I		Site Class II		Site Class III	
Age	Stems/ha	Age	Stems/ha	Age	Stems/ha
0	1265	0	1265	0	1265
8	750	6	750	6	750
14	500	12	500	14	375
20	325	18	325	20	250
25	250	23	250	50	Final felling
30	Final felling	40	Final felling		

Table 6: Thinning schedule for pines in South Africa based on the number of trees per hectare (SCOTT, 1960).

b) Another numerical guide for thinning used in Germany and other countries is the basal area, which is a good indicator of the stand density. The basal area has to be kept well below the possible maximum, otherwise the diameter increment will be reduced or becomes stagnant. Only by cutting some trees the selected remainders will put on new increment, until the maximum basal area is built up again.

c) In some countries the relation between top height (the height of the 100 highest trees) to average distance is used as a guide for thinning. This is based on the assumption, that

higher trees require a wider spacing. Thinning instructions for Pinus merkusii in Indonesia according to COOLING (1968) are based on an average spacing of 22 % of the top height.

20.4 The relation between thinning intensity, volume production and financial return.

A logical indicator of the thinning intensity is the basal area. If we assume the basal area without thinning as 100 percent, then

light thinning would be	90-95 percent
medium thinning	70-90 percent
heavy thinning	50-70 percent

The question is now, which of the four possibilities gives us the maximum volume and which the maximum financial return or both.

For illustration the results of a thinning experiment with Pinus radiata, Penola Forest Reserve, South Australia are quoted here (43):

Trees per ha	age 17		age 24	age 30	age 36	age 38
	before	after th.				
No thinning	2161	2161	2043	2006	1917	1892
light thin.	2211	1247	765	620	496	496
medium thin.	2100	988	610	511	366	366
heavy thin.	2124	773	553	425	245	245

Table 7: Reduction of the number of stems per hectare by successive thinnings in a Pinus radiata plantation planted 1923 at an initial spacing of 2.10 by 2.10 m, site class IV, first thinning at the age of 17 years (after LEWIS, 1962).

While under natural conditions in this case without thinning still 88% of the trees remain at the age of 38 years, under heavy thinning, however, their number is reduced to a mere 12 % (but of considerably larger diameter).

Thinning intensity	Total volume (cbm per ha) inc. thinnings	Total volume (cbm per ha) of thinnings	Cumulative value up to 38 yrs. (Australian Pounds)	Net present value of the age of 38 years
1	2	3	4	5
No thinning	790	-	L. 1571	L.148
light thin.	911	311	L. 1909	L.808
medium thin.	899	344	L. 2016	L.946
heavy thin.	873	461	L. 1941	L.988

Table 8: Volume and value production at a rotation age of 38 years under different thinning intensities. The net present value (column 5) considers cost of establishment, maintenance and logging at an interest rate of 5% (Faustmann formula) and is based on current royalty rates (after LEWIS, 1962).

Total volume (column 2, table 8): The volume produced by the unthinned stand is considerably less than the thinned plots. Because of the high density of the unthinned plots many stems can reach only diameters below 10 cm which is too low for general industrial use and therefore is not considered in the volume computations. The differences in total volume production between the ligh, medium and heavily thinned plots are not significant. The results of this experiments show, that thinning within reasonable limits does not have a significant effect on volume production, which also is in line with findings in Europe (69).

Total volume of thinnings (column 3, table 8): The figures show that in the lightly thinned plot about 1/3 of the volume, and in the heavily thinned plot about ½ of the volume is obtained from thinnings.

Cumulative value (column 4, table 8): The cumulative values of the thinned plots differ significantly from the value of the unthinned plot. This has two reasons: first, the average diameter of the timber from the thinned plots is higher and therefore commands a higher price. Second, by thinning we remove the inferior trees and concentrate the potential increment of the site on the best individuals, which raises the average quality of the stand and the value.

Net present value (column 5, table 8): The net present value considers compound interests from the time on when the yields are actually obtained, but deducts all costs (establishment, maintenance, logging) also at compound interest. The figures clearly show the advantage of heavy thinning, because high yields are obtained already at an early date.

Besides resulting in higher value production, thinning also increases the resistance of the stand against windfall. But cutting of trees has to start at an early age of the plantation and has to be carried out gradually. A sudden opening at a later age could have the contrary effect and promote wind damages. Also the resistance against pests and diseases is increased in a properly thinned plantation, because there are not so many dead and dying trees.

Chapter 21:

FOREST FIRE CONTROL

The effective control of forest fires is one of the greatest problems of the reforestation program in the Philippines. Especially areas with a seasonal climate are hard hit by forest fires almost every year. According to the annual report of the former Reforestation Administration for the fiscal year 1969/70 a total area of 3300 hectares was burnt, 1970/71 rd. 1400 hectares were reported burnt (58).

21.1 Fire causes

- Burning of pastures: Cattle owners set fires in cogonal pastures annually to burn the old cogon and induce new growth, which is palatable for their cattle, while the old and dry cogon cannot be eaten. Burning of pasture land is practiced throughout the tropics and may be one of the most frequent fire causes in forest areas.

- Incendarism: It had been reported frequently, that forest fires were intentionally caused out of personal grudge against the forestry personnel. Laborers, who were laid off, were said to have started sometimes forest fires out of revenge.

- Escaped kaingin fires may be another very frequent cause of fire. Burning of kaingins is generally done at the peak of dry season, when the danger of forest fires is highest. Especially on slopes the kaingin fires often get out of control easily and destroy neighboring forest land.

- Carelessness: Many forest fires are started out of carelessness from abandoned camp fires, cigarettes, burning of trash and other causes. Very often playing children are involved.
- Lightning: A fire caused by lightning is theoretically possible, but rare in practice. When there is lightning generally it will be followed by rain, which would extinguish the sparks.

21.2 The development and behavior of a forest fire

If an inflammable material is heated and oxygen is added, a fire will start. The ignition temperatures for some fuels are as follows (32):

- Dry paper	132°C
- Pine shavings	227°C
- Average forest fuel	293°C
- Heavy logs	578°C

By radiation from the flames the neighborhood is heated and the fire will progress. Where grasses or litter are already dry, only little heat is necessary to evaporate the remaining moisture and allow the fire to spread. When the flames are able to reach the bark of the trees or the needles of the lower branches, the g r o u n d f i r e may develop into a c r o w n f i r e. In young pine stands the crown fire is the usual case. In middle aged stands there is no crown fire without a steadily progressing ground fire to prepare the crown region of the uplift of the fire. A crown fire causes a strong upward movement of air (convection column), which sometimes takes sparks high up and deposits them far ahead of the fire front. New spot fires may be started that way. A black smoke, whose color is due to charcoal particles, usually indicatesa great number of sparks (44).

From the place of origin the fire spreads in all directions, but only the edge of the area is burning, beyond this edge only some stumps and thick branches are still on fire. The depth of the fire front may be only one or two feet.

If the ground is level and the weather is calm, the fire will spread more or less evenly in all directions. If there is wind, the fire will progress fast in wind direction, against the wind however, the progress will be slow. The result generally is a fire area of elongated shape with a curved front line.

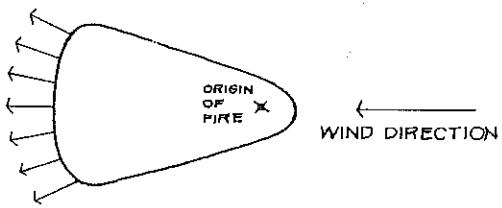


Fig. 34: Spreading of a forest fire

The front of a forest fire progresses with a speed of 200 to 1200 meters per hour, large fires burning uphill may reach 2000 meters per hour. On level ground the normal speed is below 500 meters (44). Uphill the progress is very fast, downhill quite slow. A slight down slope can reduce the speed already considerably.

The intensity of a forest fire depends on the type of vegetation, and atmospheric conditions.

a) Vegetation: Most easily a fire can spread in a plantation with a massive cover of dried up grasses. After the plantation has formed a close canopy and shaded out the grasses, the fire hazard is reduced. For dangerous localities it is desirable therefore to chose a species, which is able to shade out grasses very early.

The more fuel is available in a place, the higher will be the fire intensity, especially, if the fuel is concentrated and highly inflamable. This is often the case in areas which had been successfully protected from fire for two or three years and have built up a thick cover of dry grasses.

A middle aged conifer plantation with many dry branches down to the ground can still be destroyed by fire, even if the grass cover is very thin. Though most conifers are very susceptible to fire

in their younger stages, they may develop a thick bark when older and become quite fire resistant. According to LIZARDO and CALEDA (1959) pines over 13 cm dbh have a fair chance to survive a medium grass fire.

Diameter cm. d.b.h.	Survival Percent
below 4	0
4	0
5	12
6	21
7	16
8	22
9	12
10	16
11	16
12	26
13	61
14	85
15	89
16	100

Table 9: Survival of Benguet pine in a medium grass fire (45)

Plantations of deciduous broadleaved species with a thick ground cover of dry leaves are more liable to be destroyed by fire than a plantation of evergreen species. A dense, slightly moist, plantation of broadleaved species with a scarce ground vegetation will hardly ever catch fire.

b) Atmospheric conditions (temperature, rel. humidity, wind): The effects of temperature and humidity on the intensity of a forest fire are closely interrelated. With rising temperature in the morning the relative humidity of the air will drop, reaching a minimum in the early afternoon. At this time also the fuel is dried up and the fire danger is highest. During the night, however, the relative humidity increases with falling temperature and the fuel absorbs moisture, which reduces the fire intensity. Fire danger is high on southern and southwestern slopes, especially when the relative humidity drops below 50 percent.

The effect of wind on the fire intensity is that it adds more oxygen. A strong fire always creates its own air movement by

sucking in fresh air, consuming its oxygen and releasing the heated air in a convection column. On a slope usually an uphill wind will develop.

After having outlined fire causes, the development and behavior of a forest fire, we have to deal with the actual fire control. Four phases can be distinguished (32):

- Preventive measures,
- Detection of fires,
- Organization of fire fighting,
- Suppression of forest fires.

21.3 Preventive measures. This is the most important phase in fire control. It includes

a) Education: Fires caused by carelessness can be prevented by starting a well planned education campaign as undertaken by the U.P. Forestry Extension Office through the mass media radio, television, press, and lecturing on the benefits of forest conservation and the dangers of forest destruction. Involvement of teachers and school children is very important. Signs and posters with slogans have to be put up. Special film shows combined with lectures must be arranged for the communities (25).

b) Involvement of the community: A possibility would be to set up a non-fire bonus system. Where no fire occurs during the year, the barrio or the barangay will be given a certain amount for community projects. For the government forests this bonus system still needs the legal approval. Private companies have adopted it already with success. Some government foresters practice an indirect bonus system by giving employment for a certain number of days to people from barrios where there was no fire.

c) Burning permits: Kaingineros and pasture owners have to be requested to obtain a burning permit from the fire guard or district office. This permit is valid only for the day and

area indicated, so that the necessary precautions can be taken to avoid that the fire will spread into neighboring plantations.

d) Strict law enforcement and the heavy punishment of the offenders can only be the last resort. Since it is easy to put fire on a plantation, but very hard to catch the offenders, strict enforcement of forest laws may not be very effective.

e) Separation of forestry and grazing: See chapter 25 Part II and chapter 5.5 Part V.

f) Construction and maintenance of a forest road system.

Besides for effective management, an adequate road system is essential for transporting the fire fighters to any part of the area within reasonable time, after the outbreak of a fire was reported. A good road system also opens up the possibility to use a f o r e s t f i r e t r u c k, a vehice especially equipped to deal with forest fires.

At present many places in the critical Binga-Ambuklao Watershed, for example, can only be reached after many hours of exhausting hikes.

g) Measures to reduce the fire hazard in plantations.

There are several species, which are able to sprout after a fire like teak, guava, some eucalypts and some legumes which should be given preference on dangerous sites. Pines are very sensitive to fire in their young stages, but become quite fire resistant once they are older and have developed a thick bark.

Large plantations of inflammable pines must be broken up by fire breaks consisting of less inflammable species with a dense foliage. As minimum width of these fire breaks 10 to 20 meters is suggested. The distance in between depends on judgement. It should be closer up and down the slope than along the contour. To shade out grasses quickly fire breaks are planted more closely than ordinary plantations.

Once established these fire breaks need no maintenance in contrast to fire lines. In the Pinus merkusii plantations of Sumatra extensive artificial fire breaks of Macadamia hildebrandii (Proteaceae), which form a very dense canopy, are effectively employed. If there are natural fire breaks like creeks with a moist type of evergreen vegetation, these must be carefully preserved. It is also advisable to establish fire breaks of broadleaved species, along roads passing through the plantation areas.

Another measure to reduce fire damage are fire lines. These fire lines are strips about 10 meters wide on which all inflammable vegetation is to be cleared at the beginning of the dry season. The effectiveness of fire lines is disputed among foresters. They may be able to stop a ground fire, but they are easily crossed by sparks. Fire lines are laid out in strategic positions, where the fire would burn with less intensity like along roads, ridges, creeks, etc.

21.4 Fire detection

It is not reliable to assume, that the people living in a certain area will report the outbreak of a forest fire to the fire guard or the district office. Therefore it is essential during the dry season to appoint fire guards and to have fire patrols. These fire guards have to be supervised closely to be efficient in their duties.

Where large areas have to be guarded, it is advisable to construct watch towers at prominent places, from where wide areas can be overlooked. Because of frequent typhoons these fire look-outs must be quite solid. The uppermost platform must have windows on all sides. At the center of the room the so-called fire finder is erected, which consists of a dial with a 360^{o} subdivision and a sighting device. If the fire guard notices smoke at a certain bearing, he will contact the district office or any place responsible by phone or radio. The message must contain the designation of the watch tower, the bearing of the fire, the estimated distance from the tower

and the probable intensity of the fire. When two fire guards report the same fire, the exact location of the fire can be determined on a map.

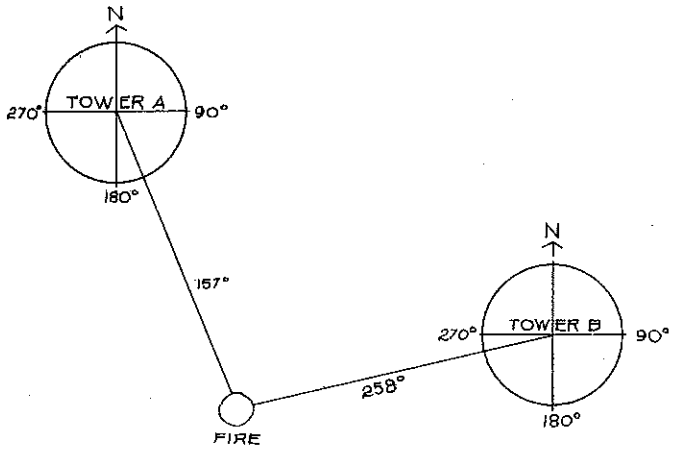


Fig. 35: Location of a forest fire on a map, after the fire had been reported from two different lookouts.

21.5 Organization of fire control.

Every district office and project office should have a plan what to do, when a fire is reported. Instructions about the technical details of fire fighting are to be given to the staff every year at the beginning of the dry season. Arrangements should be made with the army to help in extensive forest fires. The alarm plan must be hung visible in the office and include also the telephone numbers of the nearest police station, nearest forest office, army headquarters and hospital.

Vital equipment needed for fire fighting must be ready at any time. This includes:

- a vehicle with sufficient gasoline,
- fire swatters, sharp bolos, spades, grub hoes,
- water bags for drinking water,

- a first aid kit equipped for burns, cuts, smoke poisoning, snake bites,
- helmets

Red arrows must be prepared to show the way to the meeting place. A person with organizing talent is to be appointed as the fire boss.

21.6 Fire Suppression

There are several possibilities to attack a forest fire.It is up to the fire boss to decide on the proper method.

a) Direct attack

A direct attack from the front is only possible in smaller forest fires progressing with low speed. If they are larger and progressing fast, a flank attack may be more advisable. For very intensive fires burning uphill an indirect attack would be the safest.

In direct attack the flames are extinguished with the help of long handled fire swatters or, if not available, with branches. Intensive fires are first cooled and weakened by throwing mineral soil into the flames. The first aim in attacking the fire front is to create a gap. The second step is to widen this gap on both sides. Without actual experience one does not realize, how the flames will collapse on both sides of a gap only one meter wide (44). Attacking the front at first sight often appears to be impossible because of strong heat, smoke and sparks. But when the wind changes the direction or the fire passes an area with less fuel, there may be chances for a frontal attack (44).

The use of fire swatters or branches in a frontal attack on a ground fire is more effective, when several persons beat the fire simultaneously in a rhythm. When the heat radiation of the fire does not permit to get close enough, soil will be thrown to suffocate the flames. Most effective is when several persons throw their load simultaneously to the same spot. The bare places, from where the soil was taken can serve

as a fire line (44).

Where backsprayers and water are available the frontal attack is easier. The water spray is directed against the base of the fire on the ground. The steam will cut off the oxygen supply. After the fire has been weakened by spraying, the rest is done by throwing soil or beating with branches. Water is used only where it is most urgently needed.

b) Defense measures or indirect attack

Defense measures include the construction of fire lines well before the advance of the fire front. Already existing fire lines have to be widened, if they are suitable, or new ones must be laid out at strategic points. New defense lines are preferably constructed on ridges, roads, trails, creeks, or other natural fire breaks. In flat country bulldozers can be used for rapid construction of defense lines.

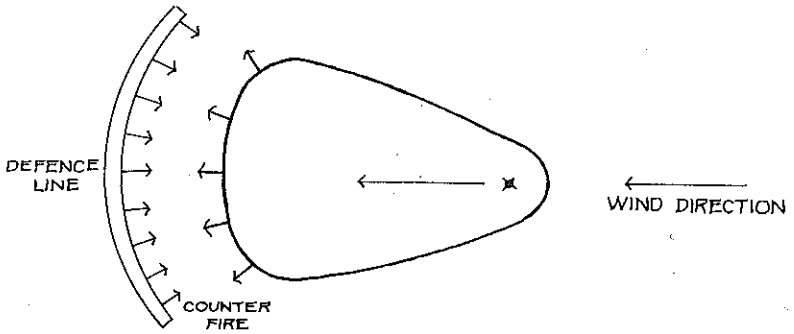


Fig. 36: Defence line with counter fire

In the beginning it may be sufficient to have a width of about 50 cm, but the line must be strengthened later when there is time. The more intensive the fire, the faster its progress, the wider the defence line has to be. On steep slopes a wide fire line is required.

When organizing the fire fighters for defense line construction, there are two possibilities:

- Each man is responsible for a complete section,

- Each man gets only a 3 m section to complete, then the whole team shifts to another section.

All vegetation on the fire line is cut and placed outside about five meters away. There must be constant patrolling for weak points and eventual spot fires developing from sparks beyond the line.

Sometimes forest fires had been successfully controlled with the help of a b a c k f i r e, which can only be started from a fire line before the fire front. It is allowed to burn slowly in the direction of the main fire. If the counterfire has been successful, it soon will get into the suction of the main fire and approach the fire front with increasing velocity. When both fires meet, they die off due to lack of fuel.

In practice a counterfire often has increased the damage, because it got out of control. All the people working on the fire front have to be notified, before a counterfire is started, that they will not be trapped between two fires. Very often backfires have jumped the fire lines or have escaped control at the flanks. While theoretically a counterfire seems to be the right thing to do, in practice it proved to be difficult.

c) Mopping up a forest fire

After the team is in control of the fire, all the burning remains have to be extinguished very thoroughly until no embers are left on the burnt over area. The mop up includes:

- separation of burning fuels,
- cover burning fuel with soil,
- strengthen fire lines,
- stay with the fire until all sparks are out.

After the mop up has been completed, a guard should stay behind to watch for any new outbreak. The man left behind should be equipped with all necessary tools, food and water. Very often there is a new outbreak of the fire the following day about noon, when a fresh breeze is coming up. It has often

happened, that the second fire did more damage than the first. Therefore adequate guarding of the burnt over area for one or two days is very important.

21.7 Equipment for fire fighting

a) Fire swatters with flexible steel blades mounted on long handles (200 cm) are used to extinguish light grass or ground fires. They are more effective than pine branches, but a little heavy and difficult to use on steep slopes.

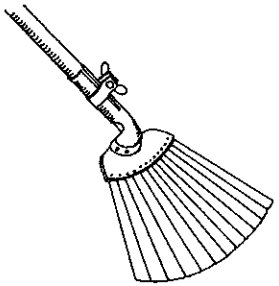


Fig. 37: Fire swatter

b) Bolo: A sharp bolo should be carried by every man proceeding to the fire site. It is used to chop down branches to be employed as fire swatters, to clear fire lines and trails.

c) Shovels and hoes are only to be taken to the fire site where conditions permit their use.

d) Backpack pump can: The tank contains 20 liters of water. The water is used only where it is most urgently needed: in frontal attack to create a gap, to break up fire concentrations, in mopping up remaining embers.

e) Containers for drinking water are equally important than the rest of the tools. Minimum 2 liters per person, better more.

f) First aid kit equipped to deal with cuts, burns, snake bites, etc. The first aid kit is the responsibility of the team leader. All medicine must be fresh and clean, and be replaced from time to time.

Chapter 22:

PREVENTION OF FUNGUS DISEASES IN FOREST PLANTATIONS

In contrast to temperate regions until now there were relatively few reports from tropical countries, that a fungus disease had become a serious calamity. The reason may be the heterogeneous composition of tropical forests, which had been a safeguard so far. But the trend now in tropical countries is also towards large even-aged stands for mass production of lumber and pulpwood. These extensive even-aged plantations often consisting of exotic species replacing the native heterogeneous tropical forest may cause a breakdown of the environmental resistance, and increased incidents of fungus epidemics can be expected to occur in future.

Fungus attack on forest trees can have many manifestations:

- Damping-off of young unlignified seedlings is found in moist, overcrowded seed beds or seed boxes (for more information see Part IV, NURSERY TECHNIQUES).
- Heart rot is caused by fungus attack of the central tissue of a stem, which is very common in overmature trees. Entry occurs through dead roots, dead branches or major stem injuries (Fomes, Ganoderma).
- Rusts are caused by fungi of the order URODINALES. For their complete development many species need alternate hosts, e.g. the bamboo rust found on Dendrocalamus strictus needs the presence of Randia spp. (Rubiaceae) as an alternate host.
- Root rot is caused by fungus infection of the root system and is responsible for the death of many trees

without a visible sign from outside (Armillaria mellea, Ganoderma spp., Poria spp. and many others).

- Blights and mildews are caused by fungus attack on the needle or leaf surface. (Dothistroma, Botrytis)

Of the numerous parasitic fungi found in tropical Asia, the following three are quite common and have economical importance:

- Armillaria mellea: This fungus is common in almost all the forest regions of the world, and attacks conifers and broad-leaved species. BROWNE (1968) describes the species as follows:

  The fungus commonly exists as a saprophyte in forest soils but, once established on dead wood, it can become an active and virulent parasite. It spreads mainly by means of black, shoe-string-like rhizomorphs and enters living trees and shrubs through their roots or even through sound bark. The principal symptoms are thick layers of white mycelium between the dead bark and the wood and the presence of the characteristic black rhizomorphs. The foliage of the host becomes pale and thin, and conifers exude considerable quantities of resin. The fungus causes a fibrous white rot, in conifers usually confined to the sapwood, but in dicotyledonous trees often affecting the whole heartwood near the base of the bole and extending upwards in a conical column. The disease is favored by high humidity and is particularly dangerous where young conifer plantations have been established soon after the clearing of old, natural, broadleaved forest. The assessment of susceptability of different tree species is complicated by environmental factors and by the fact that the pathogen appears to exist in the form of a number of strains of varying virulence.

- Ganoderma lucidum (syn. Fomes lucidus): Also this species is a cosmopolitan parasite found in most temperate and tropical forest regions. It is essentially a wound parasite of broadleaved trees and found less frequently in conifers. Recorded hosts include according to BROWNE (1968): Acacia auriculiformis, Albizzia falcata, Albizzia procera, Aleurites moluccana, Anacardium occidentale, Cassia javanica, Cassia siamea, Casuarina equisetifolia, Delonix regia, Eucalyptus citriodora, Mangifera indica, Pterocarpus

indicus, Samanea saman, Tamarindus indica. The fungus invades the trees through the roots, especially trees with reduced vitality, and causes a white soft decay in the lower part of the stem. The sporophore, which often appears only after the tree had been killed, is blood-red in color and has a varnish-like crust (11).

- Dothistroma pini (Pine needle blight) is found in temperate as well as tropical regions. The disease only infects pines, which show varying resistance depending on species. Infection is most severe in dense overcrowded nursery beds, especially in a humid climate, but the infestation can also spread to young plantations. Characteristic symptoms are chlorosis and necrosis of the needles, especially of the lower branches. The needles wither towards their tips, the basal part remaining green, and the lower needles of a shoot die first, producing a shaving brush appearance. Growth may be considerably retarded or even halted, in heavy infections the mortality of young trees may be high (11).

In the Philippines infestation with Dothistroma pini was observed in seedlings of Benguet pine at the Pacdal Nursery, but rarely in young trees of sapling size. P. caribaea seems to be quite susceptible to blight especially in a humid climate.

Preventive measures.

It is a well accepted fact among plant pathologists, that it is much easier and cheaper to prevent a fungus disease than to cure it. In forestry where a relatively cheap raw material is produced under extensive management, a chemical fungus control in the field would be impossible. This situation is quite different from agriculture where a very unnatural and artificial balance is maintained by extensive use of chemical pesticides. This is also true to some degree for forest nurseries, but for plantations a chemical control of fungus diseases generally is uneconomical. We therefore have to rely almost entirely on preventive measures.

- Site requirements of the species must be properly observed. It is well known, that species outside their optimum habitat,

where growth is somewhat affected, are more susceptible to diseases.

- Planting a tree species in dense and extensive artificial stands, greatly increases the risk of forest diseases. Fungi and insects, which occur only sporadically in a mixed natural forest now multiply enormously because of a vast food supply. Diseases, which affect only sick and dying trees in a mixed forest (secondary diseases), may turn to healthy individuals and become primary pests. For effective prevention it is not necessary to establish o n l y mixed plantations, because they have silvicultural disadvantages, but rely on species mixtures by blocks, which do not exceed a certain size. Mixing different age classes - not necessarily different species - would also greatly reduce the risk of a mass infestation, because some fungus diseases have a marked preference for certain age phases.

- Breeding and propagation of resistant provenances or strains would be a long term project, but offers the best way of preventing forest diseases in the long run.

- Careless logging practices often cause serious injuries to the residual stand. These injuries are often the entrance for fungi which may destroy the entire stem. The official logging instructions (Handbook on Selective Logging, Bureau of Forestry) stress very much the importance of this point.

- An application of a complete fertilizer with trace elements, did in some cases improve the resistance against fungus diseases in plantations and nurseries.

- There are a number of fungi belonging to the group of Urodinales (rusts), which only thrive on alternate hosts. If we destroy the other host plant in the vicinity of the plantation, the fungus cannot complete its life cycle. Many rusts with alternate hosts have been identified in temperate countries. In the tropics, however, the rather complicated relationship between the different stages of the fungus and alternate hosts are not yet fully known for many species. As an example for a heteroecious rust from tropical Asia the bamboo rust (Dasturella divina) may be quoted, which depends for its complete life cycle

besides bamboos on the presence of Randia spp., shrubs belonging to the Rubiaceae.

- Where old natural rain forest had been cleared for conifer plantations, heavy attack of Armillaria mellea was often observed. Where the attack is extreme other species which offer more resistance must be selected.

Chapter 23:

PREVENTION OF INSECT CALAMITIES

23.1 Common insect pests in forest plantations

During recent years there have been more and more reports from different parts of the Philippines, that plantations have been attacked by insects. For example: the mahogany shoot borer has heavily infested mahogany plantations in Nueva Vizcaya, Eastern Mindanao and elsewhere, bark beetles are destroying pines in the Mountain Provinces and the Cagayan Valley, termites are eating newly planted seedlings, defoliators have stripped teak plantations in Nueva Vizcaya.

Research on tropical forest entomology is still in the beginning. Of the many hundreds of harmful forest insects the biology of only a small number had been investigated so far. In the context of this book only a few species, which have economical significance in the Philippines, can be described.

a) Bark beetles

A bark beetle identified as Ips interstitialis, which is native to Central America and the West Indies, has become established in the Philippines after the second world war (11) and is causing extensive damage to Pinus insularis in the Mountain Provinces. Reports about serious outbreaks, which resulted in the death of many trees came from Itogon Reforestation Project, Ambuklao area, the Bobok Concession, Lagangilang Reforestation Project the Cagayan Valley and other places (13). The insect produces many generations a year and a large population is built up rapidly. The beetle is polygamous and the gallery pattern comprises a central nuptial chamber with in the average four radiating mother galleries and larval feeding tunnels.

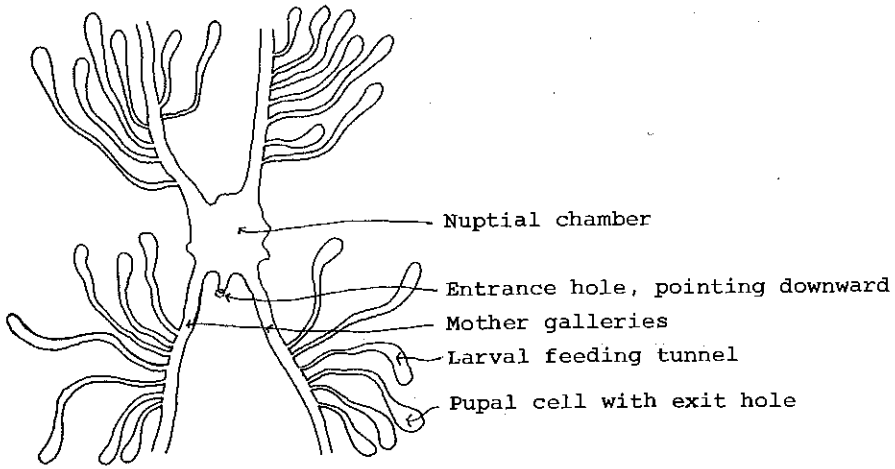


Fig. 38: Typical gallery pattern of bark beetle

Bark beetles are essentially secondary pests, which in the first place attack trees, which had been weakened physiologically after a forest fire or an unusually long dry spell. After the beetles have multiplied in those trees, they may also attack healthy individuals. The same can happen, when

the beetles multiply in logging debris, which soon dries up and forces them to search for other sources of food.

Control

A chemical control of bark beetles on living trees is impossible, we therefore have to concentrate our efforts on preventing an outbreak.

Since trees, which have suffered in a forest fire or long draught, are of magic attraction to the insect, fire prevention would be a very important preventive measures against mass propagation of bark beetles.

Also the site requirements of Benguet pine should be carefully observed and it should not be planted on very dry sites, where the trees offer little resistance towards the insect.

If attack on isolated pines is observed, these should be cut immediately. It was observed in Consuelo Reforestation Project, that beetles and larvas of Ips interstitialis (?) were dead within a few days after cutting the trees, which could be explained by the exposure to high temperatures. The beetles do not seem to transfer to a new tree, after their host has been felled. In high elevations, however, it may be necessary to debark the logs.

Clean logging practices can minimize bark beetle attack in logging areas. In Germany where bark beetles can be a serious problem, all coniferous logs have to be debarked right after felling. A minimum requirement would be to transport felled coniferous logs right after felling to the saw mill site or log pond.

b) Teak defoliator (Hyblaea puera) (6).

The teak defoliator has a very wide natural distribution ranging from Pakistan, the entire Indo-Malayan Region to New Guinea including the Philippines.

Description

The moth has a span of 30 to 40 mm, the forewing shows variable

shades of grey, brown and red with suffused bands of darker color. The hind-wing is dark brown with a curved orange band, which is sometimes broken up into patches. The larva, which reaches a size of 30 to 35 mm, is at first greenish with a dark head, but later become darker with a varying pattern of stripes (6).

Biology: During the day the moths are hiding in dark places. At night they fly and migrate considerable distances. Mating takes place 2-3 days after emerging from the pupa. The female deposits 500 to 600 eggs on the lower side of young foliage.

The larva cuts out patches of the leaves, leaving behind a skeleton of the coarser veins only, young leaves are consumed entirely. In the later stages the larva prepares a shelter by folding over part of the leaf and spinning silk to tie the leaf together. The older larvas consume all soft tissue, so that finally only the midrib and the stiffer side veins remain (the teak skeletonizer in contrast produces a finer pattern).

Pupation takes place in a leaf fold strongly spun together. If not enough leaf material is left, the larva may descend on a silk thread to find new foliage or reach the ground.

Duration of life cycle:

Egg	2 - 4 days
Larva	8 -17 days
Pupa	5 -13 days

The moth has a life span of about 3 months. In a warm climate there can be up to 15 generations a year(6).

Aspects of damage: The pattern of damage in a plantation generally is irregular. There are groups of trees or individuals, which are completely defoliated, while their neighbors are spared entirely.

The intensity of infestation also varies with age. In India according to BEESON (1961) the infestation reaches a maximum in teak plantations of 20 to 30 years, but decreases thereafter rapidly, which coincides with observations in the Philippines.

Though the trees are generally not killed by the defoliator, the increment is greatly reduced. The damage is more serious where young foliage had been destroyed, and not so serious, where defoliation occurred towards the end of the growing season, because the leaves would be dropped anyhow. An almost 100 percent defoliation was observed by the author in 1973 at the Magat Reforestation Project.

Possible ways of control: Chemical control is impracticable, we therefore have to rely on biological and silvicultural control measures. The natural vegetation of the teak area should be partly preserved, because it is important for the life cycle of some of the predators and parasites of the teak defoliators. The mixed natural vegetation contains a number of shrubs and trees, which are the host plants of other defoliators (which do not attack teak). These defoliators on the other side are hosts of parasites, which also destroy the teak defoliator. For conditions in India there exists a list of tree and shrub species, which are important for the life cycles of defoliator parasites and therefore considered d e s i r a b l e. This list includes species of the following genera, which are also found in the Philippines: Cassia, Lagerstroemia, Bauhinia, Eugenia, Ficus, Grewia, Hibiscus, Alstonia, Albizzia, Melastoma, Solanum, Morus, Mangifera.

There are also species, however, which serve as alternate food plants for the teak defoliator and sustain a large number of individuals during the time teak has no leaves. These species are considered to be undesirable near teak plantations. In this list BEESON (1961) includes Gmelina arborea, Lantana camara and species of the following genera: Macaranga, Dolichandrone, Oroxylon, Premna and Vitex.

The best prevention against a widespread attack of the teak defoliator would be the preservation of the natural vegetation along creeks, streams and other sites but eleminating the alternate host plants, where this is possible. In a larger teak area this natural barrier against infestations should occupy not less than 1/5 of the total area. The effectiveness of such natural reservoirs of parasites may be reduced. When abnormal weather

conditions cause a breakdown of the natural control factors and vaor the outbreak of a mass infestation.(6).

c) Teak Skeletonizer (Pyrausta machaeralis, syn. Hapalia machaeralis) (6): The natural distribution of this insect coincides more or less with that of the teak defoliator.

Description: The moth has a wing span of 19 to 26 mm, the forewing is yellowish with zigzag markings of varying color. The hind-wing is pale with a reddish or yellowish marginal line. The pattern and the color of the markings are very variable and can differ in different seasons. The larva, which can attain a length of 22 to 25 mm, is at first light green and turns brown or purplish later. The anal claspers or false legs are conspicuous (6).

Biology: A remarkable feature in the population of this insect is, that the females by far outnumber the males. The moths hide during the day in the undergrowth or dead leaves on the ground. Mating takes place the night after mergence from the pupa. About 250 eggs are deposited starting 1-4 days after mating during a period of about one week. The eggs are deposited on both sides of the leaves. The lifespan of the moth is only about one month. The larvas hatch after 3 days and feed under a protective cover of silk. All tissue between the network of veins is consumed leaving only a fine skeleton.

The later stages of Pyrausta machaeralis use a silken shelter with an escape hole, which enables them to retreat immediately to the other side of the leaf in case of danger. Pupation takes place in a thick shelter webb with an emergency exit on one side.

Duration of life cycle (6):

Egg	3-4 days
Larval period ...	12-14 days
Pupal period	5-7 days
Pre-oviposition period ..	3-4 days
Total	23-29 days

Aspects of damage: The eggs are deposited on all types of teak leaves, on the tender young leaves as well as the older ones. The larvas are very active and make their own choice after hatching. But in contrast to Hyblaea puera the larva of Pyrausta machaeralis are able to survive on old brittle leaves, therefore they are still found at the end of the growing season, when H. puera is already absent. During the main growing season both insects are often found in association. Regarding the age classes the teak skeletonizer has the same preference as the teak defoliator (6). Control measures: the same as for the teak defoliator.

d) Mahogany shoot borer (Hypsipyla robusta)

The mahogany shoot borer is a very important insect throughout the tropics of the Old World and does extensive damage to timber trees of the Meliaceae family. In the Philippines notably Swietenia macrophylla and Toona calantas are affected.

Description: The moth reaches a size of 26 to 42 mm, the females being larger than the males, forewing brownish with a black design, hind-wing whitish and pale. The larva, which often changes color during its development reaches a size of 20 to 30 mm.

Aspects of Damage: The attack is commonly noticed on saplings and pole size trees, when the terminal shoot becomes dry and dies back. The result of repeated die-back is the formation of a bushy crown, which retards the height growth and cripples the tree. When the trees become older, they will be forked and branchy. The insect has a marked preference for vigerously growing trees of sapling or pole size with sapy terminal shoots.

The eggs are deposited at the new undeveloped leaves near the tip. The larva feeds at first at the epidermis of the shoot, until it finds a suitable spot to enter. Once established in the shoot it excavates a tunnel in the pith, which may reach 60 cm in length. Sometimes a larva might even attack more than one shoot. On the entire length of the tunnel the shoot dies and breaks off. Within the tunnel the larva constructs

partitions of silk at intervals, which prevent entering of predators, parasites and rain water (6,19).

Possible Control: Since the larva is well protected inside the shoot, chemical control cannot be effective. Cutting and destroying of infested shoots is also difficult in large plantations. Again this leaves only preventive measures.

It had been observed, that especially young vigorously growing trees with sapy terminal shoots had been attacked. This was sometimes the case, where mahogany was planted on very fertile sites resulting in very vigorous height growth. Older trees, however, beyond pole size, which do not produce long terminal shoots any more, are only seldom attacked. On these observations the preventive measures are based:

It is important not to stimulate the growth of mahogany in the early years by fertilizer application. On very fertile sites a light shade of Albizzia falcata planted a few years ahead would prevent the formation of long terminal shoots, and render the plants less attractive to the shoot borer. Where infestation is severe BEESON (1961) recommends a close spacing to reduce the development of vigorous lateral branches, which otherwise may be attacked as well. Also mixed planting with ipil-ipil (Leucaena leucocephala) in alternate rows could reduce Hypsipyla infestation, because the faster growing ipil-ipil provides a beneficial lateral and overhead shade.

From experience in West Africa it appears, that enrichment plantings of Meliaceae on cleared lines in secondary forest suffered less from shoot borer attack than open plantations (40).

e) Pine shoot moth

The scientific identity of the pine shoot moth has not yet been established. The insect, which is considerably smaller than the mahogany shoot borer, causes serious and wide spread damage to Benguet pine (13). Infestation takes place mainly during the dry season, between December and May. The infested shoots become limb on the length of the tunnel, then turn brown and fall off. The effect of repeated attack is,

that the pines become very bushy, height growth is retarded, and the trees are crippled. Not only the terminal, but also all lateral shoots can be attacked. Infestation is most severe in pines below 5 meters in height.

From observation it appears, that infestation can reach 100 percent, where Benguet pine is planted below its natural lower limit of distribution, which is about 800 meters above sealevel. The extremely poor shape of Benguet pine planted around 300 to 500 meters above sealevel (Binga, Magat, Lagangilang) can perhaps at least in part be attributed to the pine shoot moth.

The best way of preventing the infestation therefore is to observe the altitudinal limit of Benguet pine and not to plant it on sites lower than 700 to 800 meters in Luzon.

23.2 Natural control factors against insect calamities (6,19).

The population density of noxious forest insects is subject to wide fluctuations. Animal populations in general have a tendency to be in balance with their environment. If the environmental conditions change, the density of the insect population will change too.

Though many of the forest insects have a tremendous reproduction potential, their abundance does not grow without limits. There are natural control mechanisms which inhibit unlimited growth of the insect population. Such natural control mechanisms are for example:

- limited food supply
- host resistance
- climatic factors
- diseases, parasites and predators

All these factors combined constitute the environmental resistance against the outbreak of a pest. If any of these mechanisms fails, we may have to face a calamity.

(a) Limited food supply: In a natural forest the food situation for a specialized insect is not very favorable for

mass propagation. The insect has to cover some distance from one host tree to the next, while it is exposed to predators. The discovery of new host trees, after the supply in one place is exhausted, may present physical difficulties. It may also not be easy to find a mate on widely scattered host plants. The trees even of the same species may belong to different age phases. But many of the important forest insect have a marked preference or even depend on a certain phase of the host. All these factors contribute to the resistance of a heterogeneous forest.

In a dense pure stand without ground vegetation the conditions are just opposite. The insects will encounter a vast concentrated food supply without having to waste energy in searching for food and can multiply enormously. The poorly developed ground vegetation will be unable to support many parasites and predators, which could keep the insect population at bay.

b) Host resistance: Most trees offer at least some resistance to insect attack. Some species may simply not be palatable to the insect, others may contain substances, which deter certain pests, others again may be resistant as long as they are in good physiological conditions. If healthy pines are attacked by bark beetles, these will be often drowned in a flow of resin. Only after a healthy tree has been weakened by repeated attacks, the insects finally are able to enter. Trees, which have suffered physiologically and especially those, where the cambium is already in a state of slight fermentation, exert a magical attraction to some borers. Trees which exude latex (Moraceae, Sapotaceae) easily repel insects entering through the bark. Generally woods with a high lignin content are quite resistant against termites, those with a low lignin content most susceptible (6).

An indirect resistance to defoliators is also found in teak, which is able to produce a second set of leaves during the same season, after the first had been destroyed, as could be observed during the defoliator outbreak at Magat, 1973.

c) Climatic conditions: Also the normal climatic conditions have their part in the environmental resistance against a pest. We can feel this clearly in years with exceptional weather conditions, which can often be the ultimate cause for the mass reproduction of destructive insects. Exceptionally dry and hot years may lead to an increase of insects, which are not frequent in normal years. The insects may be able to complete their life cycles faster than normal because of higher temperatures, the hosts may offer less resistance due to draught, losses in the insect population from heavy rains may be reduced parasites may not find their optimum conditions, all factors combined may lead to an outbreak of epidemic proportions.

d) Diseases parasites and predators play a very important role to keep the population of noxious insects low. The number of the natural enemies of insects is very high, and biological control is mainly the activation of these diseases, parasites and predators. The most important groups according to BEESON (1961) are:

- Fungus diseases: For example, a parasitic fungus, which is important for the biological control of the Coconut beetle (Oryctes rhinoceros) is the green muscardine fungus (Metarrhizium anisopliae). Beauveria bassiana often kills Hoplocerambyx spinicornis, a cerambycid beetle that does serious damage to dipterocarps.

- Virus diseases in insects are also known as polyhedral diseases. In the caterpillars of Hyblaea puera this is characterized by complete disintegration of the larval tissues which turn into a liquid containing millions of polyhedral particles.

- Parasites of importance include mainly wasps of the Ichneumonoidae and Braconidae. Both large groups of Hymenoptera are well represented in the Philippines. Their hosts include larvae and pupae of Lepidoptera and sometimes wood boring Coleoptera. The eggs are deposited on the host, the larvas feed outside or inside the host and pupate later inside the body or the cocoon of the dead host.

Because of their high reproduction potential these wasps have a very important function in the natural control of lepidopterous pests such as the teak defoliator.

- Predators: There are numerous insects preying on other insects, they also play their part in the environmental resistance against mass reproduction, namely mantids ("walking stick"), dragon-flies, certain wasps, some Coleoptera, spiders, and perhaps most important because of their number, some species of ants. One group of ants, the Ponerinae, has specialized on insects entirely.

Almost all species of birds, even the graminivorous species feed on insects at least during part of the year when feeding their offspring. Nestling consume more than their own weight in insects every day.

In Europe a pair of titmice (Parus major), a little bird similar to the Philippine titmouse (Parus elegans), which breeds twice a year and feeds entirely on insects, with its offspring is estimated to consume 100 kg of insects during one year.

Inspite of the huge quantities of insects devoured by birds their importance in natural control should not be overestimated as pointed out by BEESON. While the parasites like Ichneumonoidae and Braconoidae are able to multiply along with the mass reproduction of noxious insects, the density of the r e s i d e n t bird population cannot increase quick enough, and may be powerless to check the violent fluctuations in the occurrance of insects.

Usually a mass propagation of insects is followed by an increase of diseases, parasites and predators, which will finally gain control and keep the noxious insects down for some time. But then with the number of hosts diminishing, the parasites and predators also become less and the insect population can built up again. So the cycle of mass propagation recurs presenting an oscillating curve. A chemical control at the height of an epidemic is generally not recommended, because apart from the high cost, it

only prolongs the natural course of the epidemic and kills the useful parasites and predators as well.

For more information on forest insects and their control in tropical Asia consult BEESON (1961) on whose work this chapter is partly based.

Chapter 24:

RODENT CONTROL IN PLANTATIONS

Rodents can be a serious menace to plantations especially where a new species had been introduced. Damages are usually high on warm southern slopes with a thick cover of dry grasses.

The rat or mouse often eats at the base of the seedling either killing it by girdling or bringing it to fall and then eating the green shoots and leaves.

It was observed that especially species that were newly introduced to an area become easily the victim of rodents. In Binga during the heavy infestation of 1970/71, rodent damage was observed on mango, nangka, alibangbang, kalantas and occasionally even on pines.

As insect populations, also the rodent population is subject to violent fluctuations. The reasons are not yet fully understood.

Possibilities of rodent control:

24.1 Poisoning: Where only an isolated plantation of limited extent is to be protected, poisoning may not give the desired result in the long run because of new invasion from surrounding areas. Poisoning therefore generally works better on a larger scheme, where also cost per unit of area is lower.

There are two groups of rat poison available: a c u t e poisons like zinc-phosphide and c h r o n i c poisons such as Coumatetralyl or Chlorophacinone, which is known under the trade name Racumin.

Acute poisons are generally used in the initial stage of rodent control to knock down a high rat population. But the rats soon develop a bait shyness, because the animals die right after feeding on the poison. For forestry purpose the chronic poisons such as Racumin seem to be preferable.

Racumin which contains 0.5% active poison is mixed with corn grit ("binlid" or "pegpeg") at a rate of 75 g to one kilogram of grit.

Containers or baiting stations: To avoid damage to livestock and to protect the bait from rains, the poisoned bait is placed in so-called baiting stations. Very convenient are bamboo tubes at least 12 cm wide, which had been prepared by cutting half of the dividing internodes on both ends as illustrated below.

After the containers have been half filled with the bait, they are placed on supporting sticks about 4 cm above the ground. To make them more enticing to the rodents, they are covered with dry grass as a camouflage. The location is marked with a guide pole. The average distance between the baiting stations should be about 50 m, but slightly closer towards the edges of the plantation. The baits have

to be inspected once a week, and consumed bait is to be replaced. It takes 3-4 days for the rats to die after feeding on the poison.

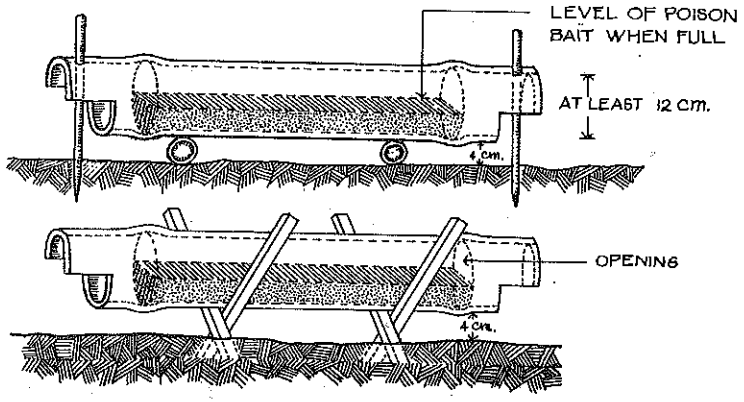


Fig. 39: Placing of baiting stations in the field

24.2 Repellents: Where only a few seedlings have to be protected, repellents may be quite effective without having to start a poisoning campaign. Repellents can be prepared from a mixture of cows urine or cows blood, slaked lime, coarse sand and a bright dye (blue or yellow). This mixture, which is harmless for the seedlings, is painted to the stem with the help of a double brush during dry weather.

24.3 Other protective measures: Protecting the lower stem of the endangered species seems to work quite well, because some of the rodent species apparently do not climb. A suitable and cheap protection would be split bamboo tubes about 25 cm long where the internodes had been removed. The two halves of the tube are placed around the seedling and tied together with string (fig. 40).

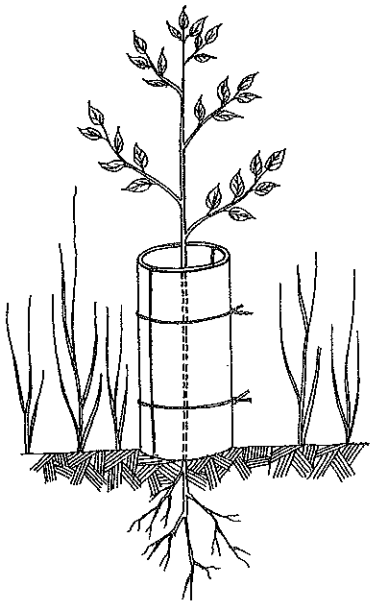


Fig. 40: Rodent protection with a bamboo tube

Chapter 25:

CONFLICTS BETWEEN FORESTRY AND CATTLE RANCHING

25.1 Aspects of damage by cattle ranching

The Philippine rules for land classification specify, that land over 18 percent slope is to be declared as permanent forest or forest reserve, but pasture leases can be granted for land up to 50 percent slope. This implies, that on land between 18 and 50 percent slope both forms of land-use have to exist side by side, and there is bound to be a conflict of interests between forestry and range management. In practice, however, in addition grazing is found on slopes even

exceeding 50 percent extending well into the domain of the protection forests.

The damage done by the grazing animals themselves is generally small compared to the damage done by pasture burning. Since most pastures consist of cogon (Imperata cylindrica and I. exaltata), they are burnt annually to induce fresh growth of palatable young shoots. This practice is not found only in the Philippines, but common throughout the tropics.

The damage done to forests and watersheds by the annual fires exceeds the meager returns from meat production several times, because many areas have only a carrying capacity of one cow for 5 hectares or even less.

In the pine region of Northern Luzon the impact of the fires originating mainly from pastures can be clearly seen. All the young natural regeneration and a few of the large trees are killed each year. As a result the stands have become very open or have disappeared completely. While on the other side it is likely, that the natural regeneration of Benguet pine is favored by occasional fires exposing the mineral soil, annual fires will definitely destroy it.

Compared to the damage by fires, the damage by browsing is relatively small, as long as goats do not enter the scene. Goats are most destructive eating almost everything. They are able to reach relatively high into the trees, when the ground vegetation is depleted. Cows, carabao and horses do much harm by trampling because of their weight.

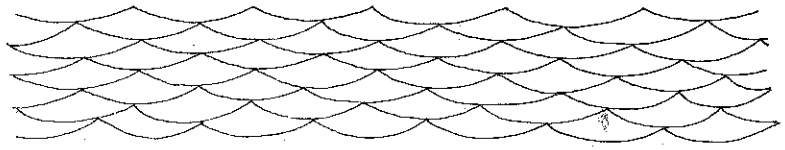


Fig. 41: Pattern of browsing trails in overgrazed pasture land in the hills

Overgrazed slopes with too many animals show a definite honey comb pattern of browsing trails visible from a distance. In

these trails the water accumulates, and they become the starting point for erosion.

25.2 Possible solutions.

a) All pasture licensees should be required to fence their pastures and adopt a system of rotational grazing.

b) Burning of pastures in forest areas is to be strictly prohibited. Pasture licensees outside the forest areas have to obtain a burning permit and are required to construct fire lines. The licensee is to be held responsible for any fire spreading from his pasture into plantations or other forest areas.

c) Grazing and forestry have to be separated because of their conflicting interests. In neighboring Taiwan no grazing is permitted in forest areas. In C. Europe, where forests were suffering under the burden of traditional grazing rights, the separation was accomplished during the 19th century. As a long term policy goal the same is suggested for the Philippines.

As a first step a revision of all existing 3636 pasture leases (figure of 1972) is suggested to investigate, if they really meet the requirements set forth in the Philippine forest laws. All leases on unsuitable land must be offered a transfer to more suitable areas or cancelled.

d) The remaining pastures have to improved in a way that they do not need burning. This is possible by introducing valuable African forage grasses such as Pennisetum purpureum, Panicum maximum and others. Another possibility would be the cultivation of leguminous trees such as ipil-ipil (Leucaena leucocephala) and its giant variety or catúrai (Sesbania grandiflora), whose foliage is nutritious and provides excellent forage. "Tree pasture" would be suitable for beef and milk cattle likewise. For more information on this subject consult Chapter 5.5, Part V of this book.

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P A R T III

ELEMENTARY COMPASS SURVEYING AND MAPPING

J. GUMAYAGAY and S. FESTIN

Chapter 1:

COMPASS SURVEYING AND RECORDING OF FIELD DATA

Basic knowledge of forest surveying and mapping is indispensable for efficient planning and management in reforestation, like in any field project in forestry.

The first step in the establishment of a reforestation project is the planting survey, after which a map has to be prepared. Only after an adequate survey the area can be divided into blocks and compartments or sub-compartments. As the project progresses, a series of surveys are carried out for planning and management purposes.

For all such survey works, the forestry box compass is of very practical use. In special cases, a more precise instrument has to be used, but where a compromise between speed and accuracy is acceptable, the Bureau of Forest Development has adopted the forestry box compass as a standard surveying instrument.

The following guide, which deals solely with elementary compass surveying and mapping, is intended for use in refresher courses. It is based mainly on the Manual of Procedure of the former Bureau of Forestry.

a) General orientation:

Consult a land classification (L.C.) map or any forestry map to get an idea about the location of the area to be surveyed. Determine at least two possible tie points, preferably forest zone corners or natural land marks like junctions of rivers,

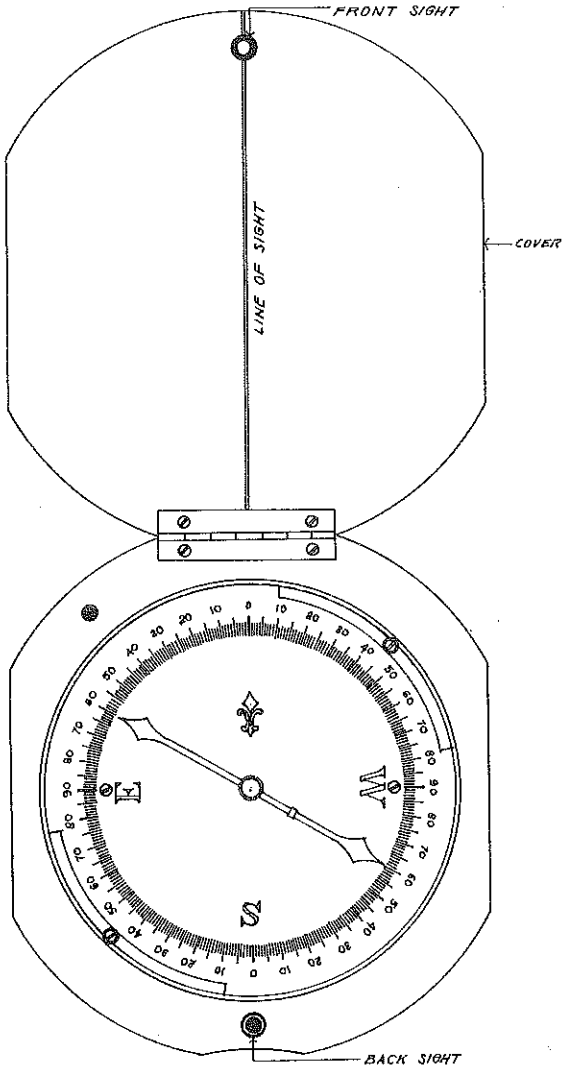


Fig. 1: The Forestry Box Compass

roads or trails shown in the map. Sketches of adjacent areas previously surveyed, if any, are likewise useful references.

b) Index numbers:

Each survey conducted has to be assigned an index number for reference purposes. Get the allocation of index numbers from the District Forester, Forester in Charge or Officer in Charge who must always keep records of index numbers issued to or used by personnel under them.

c) Tie points:

Before starting to survey, orient yourself with the area and locate your tie points. As a general practice, a survey must start from a point known in the map and later on tied to another as a check of accuracy. For that matter, if a survey starts from a point unknown in the map, it has to be tied to at least two known points.

d) Field notes:

Start supplying the information needed in the field note cover and in the field note itself; the rest upon completion of the survey (see fig. 2). As a rule, recording of field data starts from below. At the bottom of the field note, write station 1 and its description. Example: Molave, 30 cms diameter, at the junction of Balincaguin River and Mapitpit Creek, Bo. Villacorta, Mabini, Pangasinan; or Corner 4, Alienable and Disposable Block I, L.C. Project No. 10, Olongapo, Zambales.

e) Recording of compass bearing:

Occupy station 1, facing in the direction of station 2. Hold the compass steady in both hands with elbows pressed against the body. Then sight station 2 by pointing the front sight of the compass (see Fig. 1) to the station observed. When the needle stops oscillating, read the bearing quickly to the nearest degree. Record the compass reading under the column provided for, in line with station 1-2. In using the compass, see to it that it is free from the effect of magnetism due to iron objects carried by yourself or in nearby surroundings.

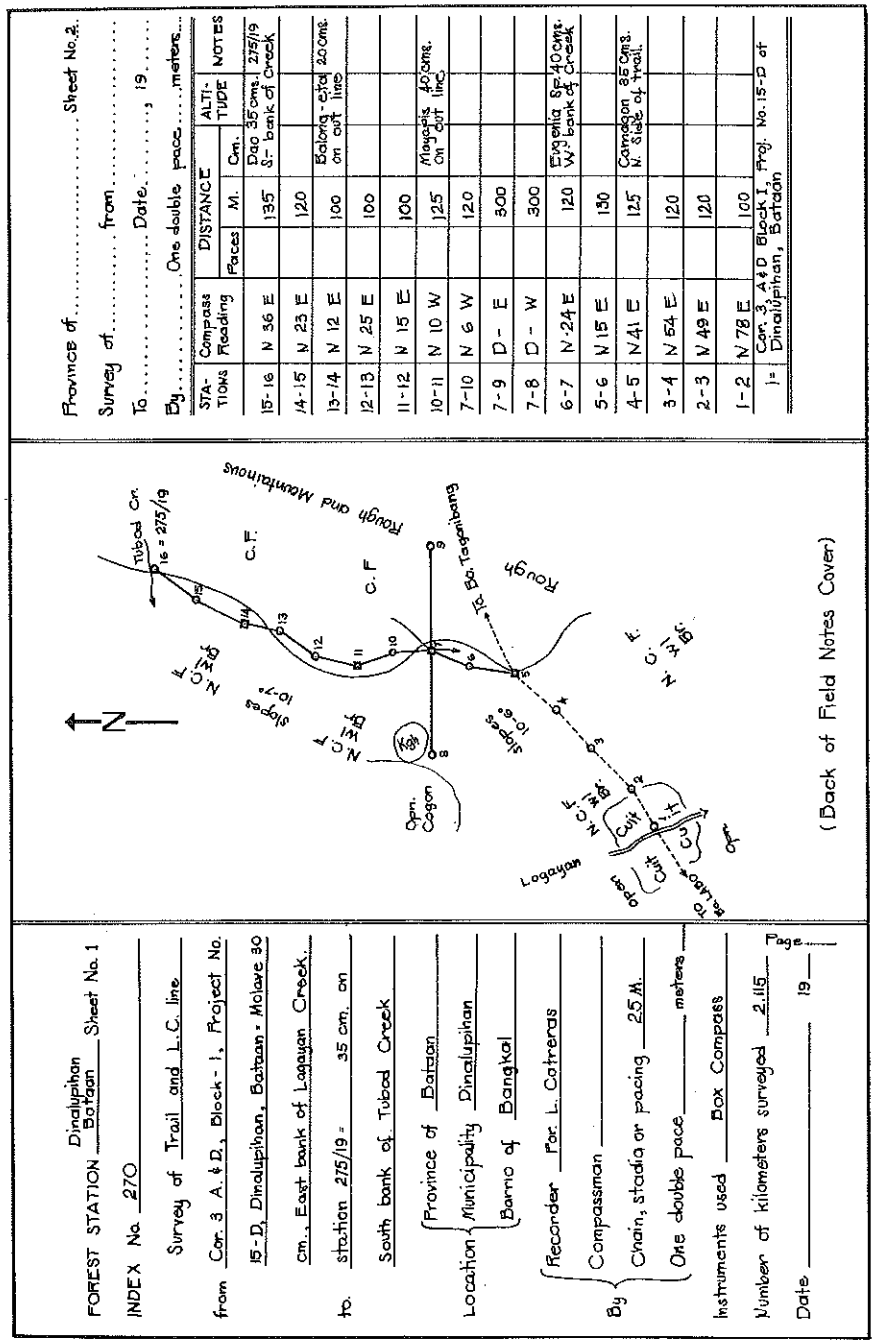


Fig. 2: Survey field notes

To check the accuracy of the compass reading, get the "back bearing" upon reaching station "2" or the station observed.

f) Field sketch

Examine carefully the general direction of the survey and start sketching at the back of the field note cover by placing a dot as station "1" on the side opposite the general direction of the survey. Orient the sketch such that the upper portion, as in a map, denotes the North direction. As you proceed to the next station, take note and draw carefully the vegetative covers, improvements and natural land marks you come across. In the sketch, show by arrow, the direction of roads, trails and flow of streams, the bearings of which must also be taken so that these details can be indicated accurately in plotting the field notes.

Show the approximate extent of different vegetative covers by light lines (Fig. 3 and 4) and indicate them by conventional abbreviations as listed below:

Cultivated - - - - - - - - - - - Cult.
Open or grass land - - - - - - - Opn.
Brush land - - - - - - - - - - - Br.
Kaingin - - - - - - - - - - - Kgn.
Non-commercial forest - - - - NCF.
Commercial forest - - - - - - CF.

For more conventional abbreviations see Appendix.

g) Measuring and recording of distances:

Measure the horizontal distance and record it under the column provided for, and in line with station 1-2. In the absence of a tape or chain, a rope with a meter graduation can be used. For rough surveys, measuring of distance may be done by pacing. Forest Officers should have their own standard "double-paces". When measuring a distance on a slope, take the horizontal distance by "breaking chain" or from a slope reduction table. Map distances are projections of horizontal ground measurements.

In the field sketch, draw line "1-2", at a convenient scale in a direction following more or less the bearing of the line.

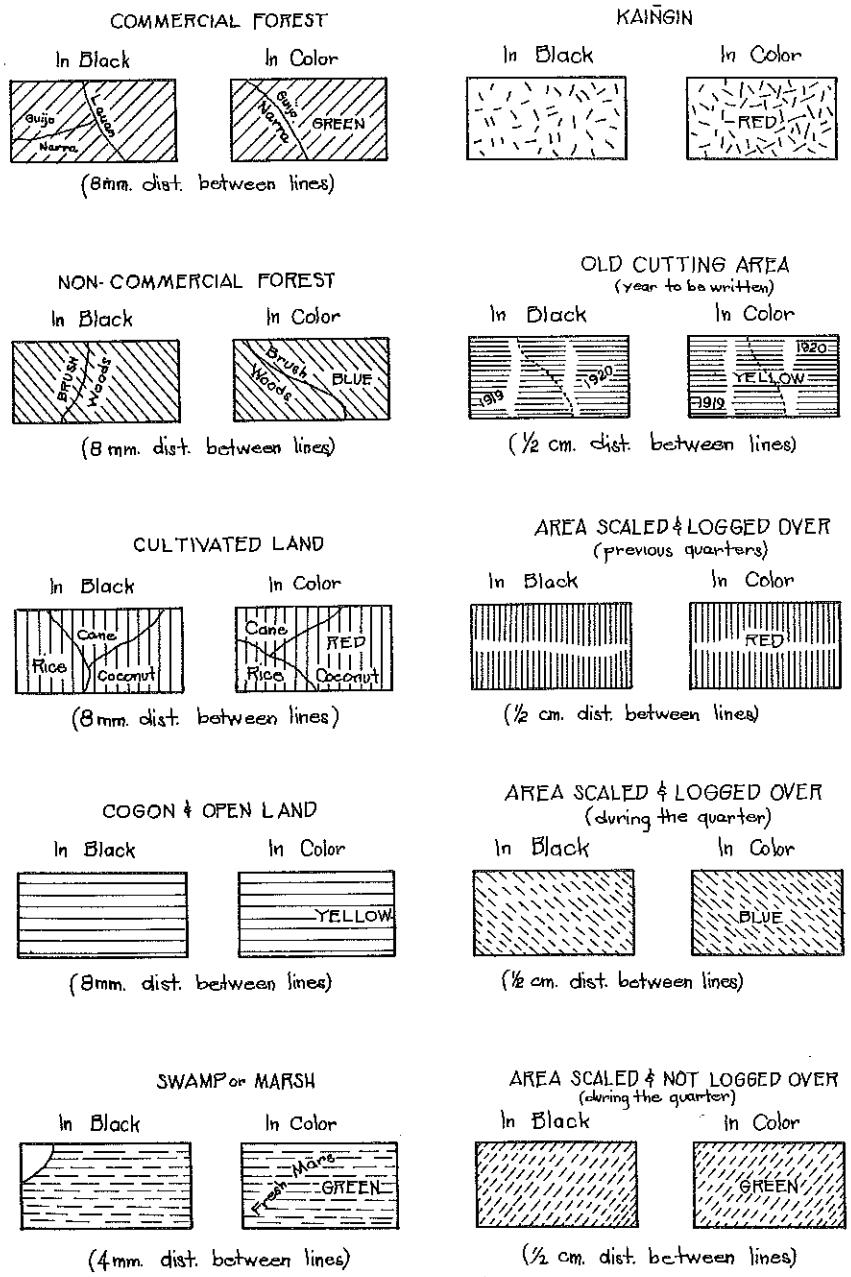


Fig.3: Conventional Signs for Field Sketches

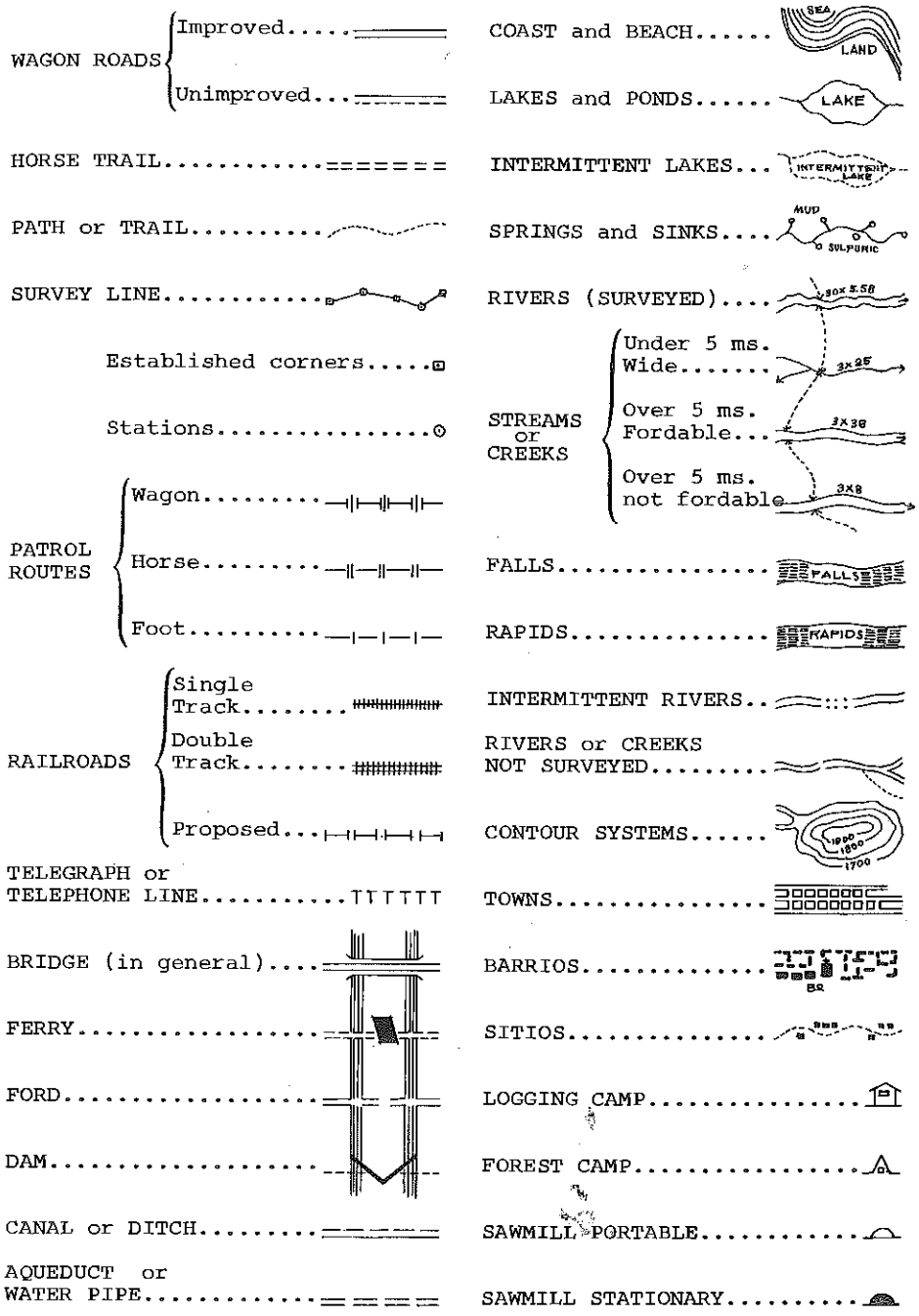


Fig.3 (continued): Conventional signs for field sketches

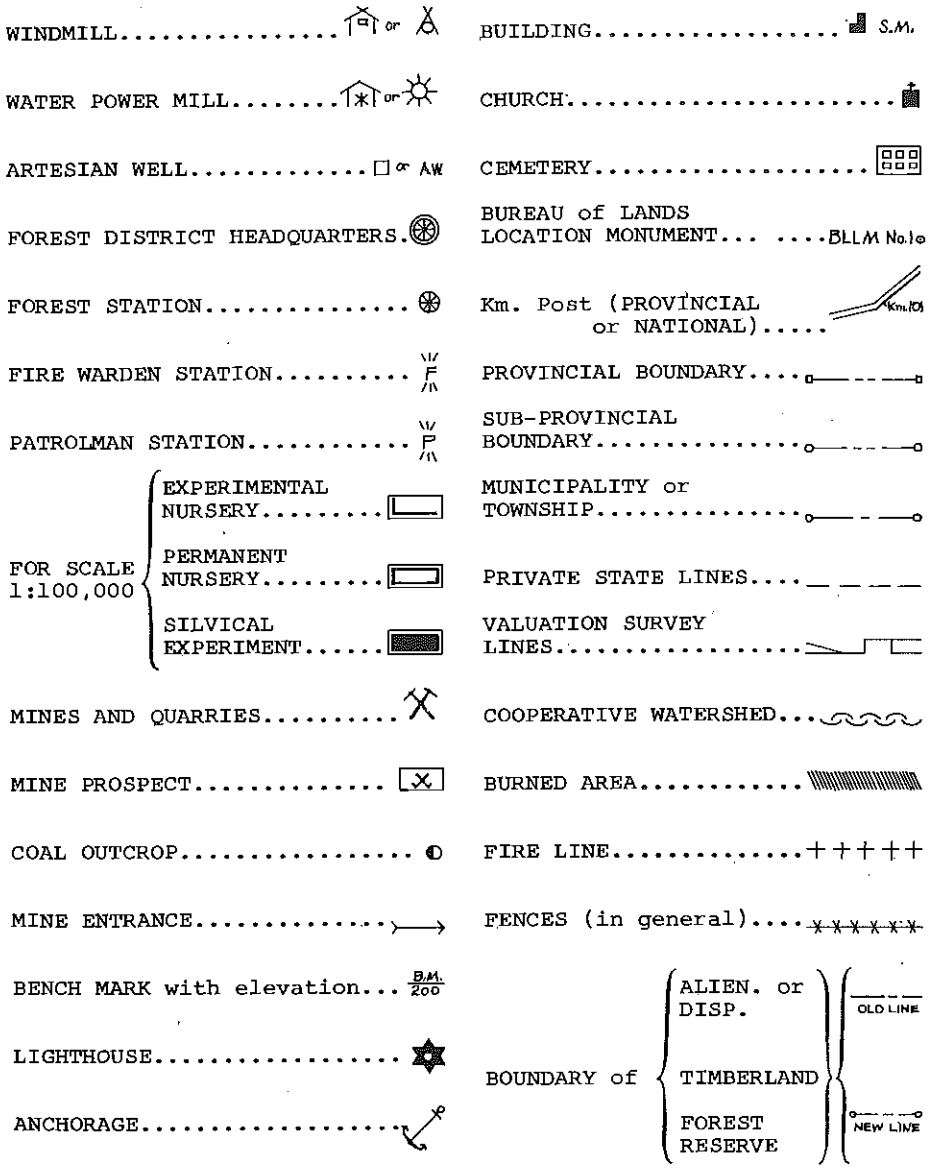


Fig. 3 (continued): Conventional signs for field sketches

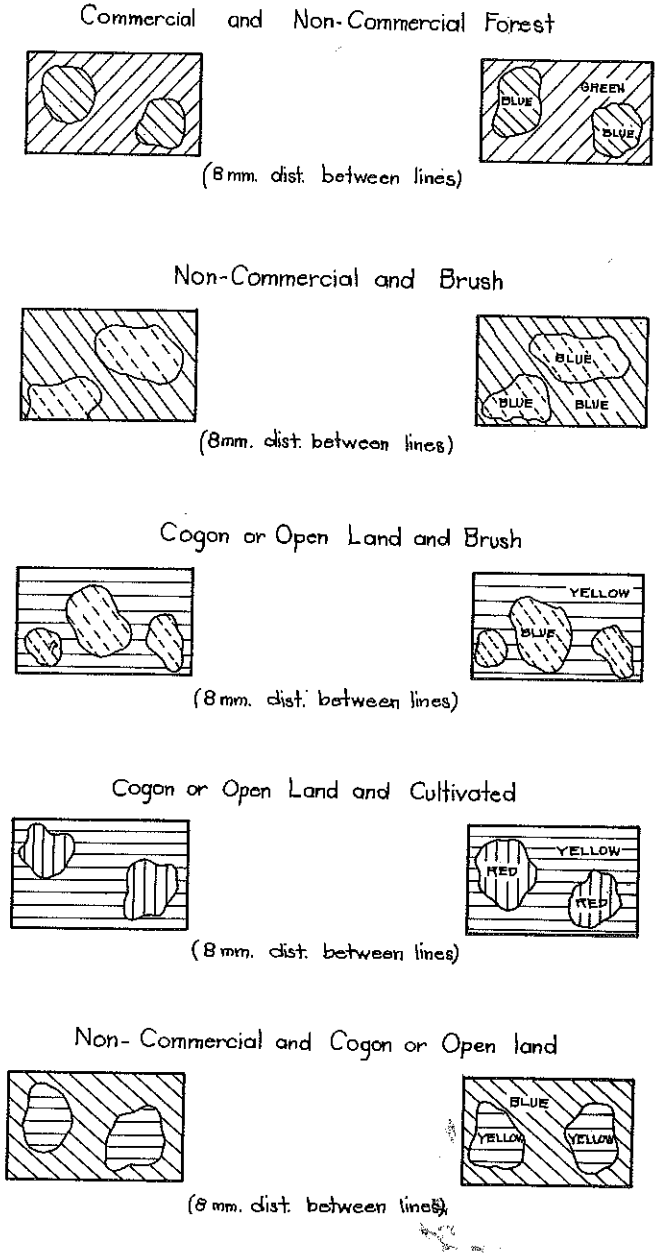


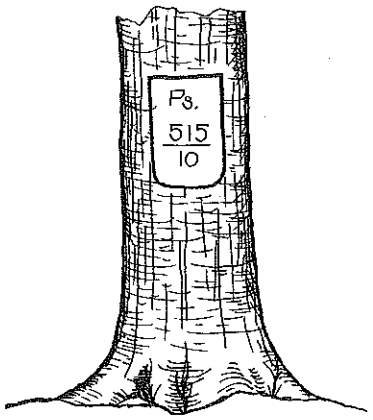
Fig. 4: Conventional Signs for Mixed Vegetative Cover

Then indicate the details traversed.

Repeat the process as you proceed to succeeding stations. Sketching proceeds as the survey progresses. When the first sheet of field note is filled up, continue recording the data on another sheet, and continue sketching at the back of the first sheet of field note.

h) Corner points:

Enclose with a square, each station established as corner, in the field note as well as in the sketch. Opposite such a station, under column "note", place the description of the corner, indicating its relative location with respect to any physical feature nearby like, "Benguet Pine, 50 cms., on top of ridge" or "BFD cylindrical concrete monument, 15 cm. diameter, east bank of river." Each tree designated as corner should be legibly marked in chisel or timber crayon, without causing much injury, indicating the objective of the survey, the corresponding index number and station number as illustrated below:



Ps. - Pasture survey

515 - Survey index number

10 - Station number

Fig. 5: Corner point established on a tree.

This tree has to be marked also with the marking hatchet used by the forest officer performing the survey.

i) "Side - shots":

For accuracy in taking details encountered in the survey, side-shots have to be made. To make a side-shot, occupy a convenient station, then get the bearing and distance of the point being surveyed. Where measuring the distance is too inconvenient or impractical, determine the relative location of that point or feature by "triangulation", which is done by taking the bearings of this point from two stations conveniently located. When the bearings are plotted, the intersection is identical to the point sighted.

j) Large surveys:

As a rule, change the index number and renew the numbering of stations starting again from "1" when the distance surveyed reaches approximately six kilometers, so that the survey when plotted, can be well accommodated in the standard size of plotting paper which is 23 x 30 centimeters. For that matter, several index numbers may be needed to complete a survey project. After plotting, the individual surveys are compiled together in the same sheet of mapping paper of convenient size.

Chapter 2:

MAPPING SCALE, PLOTTING OF FIELD NOTES AND TRACING THE SKETCH

2.1 The Map Scale.

Ground measurements have to be reduced in size or else they cannot be accommodated on paper, hence, the necessity of scale in mapping. The scale shows the map as a projection in proportion to its actual size on the ground. It is only through the reduction at a certain scale that maps of convenient size can be produced.

In forestry the scales most commonly used are 1: 5,000, 1: 10,000 and 1: 20,000. 100 meters in the field are represented on a map:

1:5,000	1:10,000	1:20,000
2 cm	1 cm	0.5 cm

2.2 Plotting of field notes.

For each index number or survey, use 23 x 30 cm cross-section paper. Select an appropriate scale so that when plotted, the survey is well contained on the paper, and all important details can be indicated clearly. The scale of 1:20,000 is generally used in forestry, except in really small surveys where smaller scales have to be used to allow space for important details. The smaller the scale, the bigger the resulting map of a certain ground measurement.

Always consider the top of the plotting paper as north. Place a temporary mark on the upper right hand corner indicating the north and the scale adopted to avoid confusion.

Before starting to plot, examine the field notes and the field sketch to determine the length and the general direction of the survey. This will enable one to plot the sketch more or less at the center of the paper by starting on the side opposite the general direction of the survey.

Mark the station by a dot on the plotting paper. To plot a line with the bearing in the NE or SE direction, place the base line of the protractor towards the East; reverse the position, if the bearing is in the NW of SW direction. Adjust the position so that the intersection of the horizontal o-p-o line and the vertical p-90° line or point p of the protractor coincides with the station marked by a dot on the plotting paper. The graduations of the plotting paper will serve as guide in adjusting the protractor to the desired position.

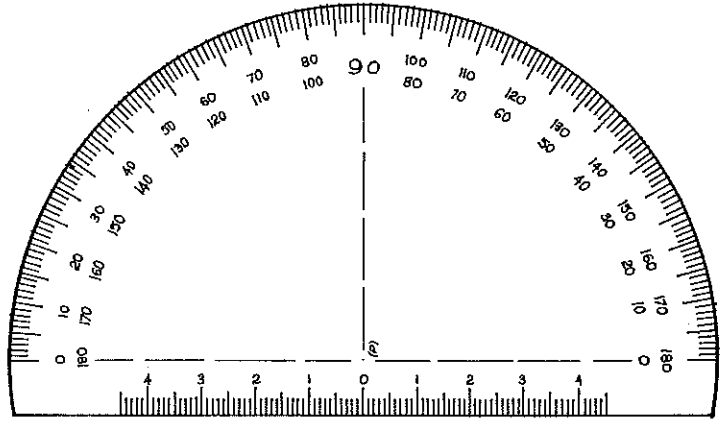


Fig. 6: Protractor

Depending on the general direction of the line to be plotted, read the bearing from the:

1st quadrant	- -	when	in	the	NE	direction	
2nd	"	- -	"	"	"	SE	"
3rd	"	- -	"	"	"	SW	"
4th	"	- -	"	"	"	NW	"

Then mark the reading or bearing by a light dot, called "guide dot". With the "O" graduation of the millimeter scale over station 1, and its edge tangent to the "guide dot", plot the distance between stations "1" and "2" according to the scale adopted. The procedure is repeated until all the stations of the survey are plotted. Indicate the stations established as corners of the area surveyed by enclosing them with squares.

Also plot the tie points, and connect them with tie lines, preferably to the nearest corners of the area surveyed. Indicate their bearings and distances with respect to such corners. If the tie points are too far that plotting them is impractical, show their relative locations by tie lines, also indicating their bearings and distances.

In indicating the important details traversed by the survey, refer to the sketches at the back of the field notes. Show the different vegetative covers by light lines and identify them by abbreviations in accordance with the standard conventional signs. Never use colored pencils on the plotting paper.

Place the title of the survey at a convenient space, preferably on the upper right hand corner of the plotting paper.

D-16, Forest Station _____ Index No. _____
Survey of _____
_____
_____
Located in So. _____, Bo. _____
Mun. _____, Prov. _____
Surveyed by _____, _____
(Name & Title) (Date)
Plotted by _____, _____
(Name & Title) (Date)
Traced by _____, _____
(Name & Title) (Date)
Instrument used: _____
Distances by: _____
No. of Kilometers surveyed: _____
Scale: _____
Area in Hectares: _____

Under "Legend" indicate the different vegetative covers and natural land marks or improvements shown in the sketch, in accordance with the standard conventional signs adopted by the Bureau of Forest Development.

2.3 Tracing the sketch

Use a tracing paper of the same size as the cross-section paper used in plotting. Trace the sketch exactly as plotted with all the details, except that the vegetative covers have now to be indicated by colored pencils in accordance with the standard conventional signs adopted by the Bureau of Forest Development as follows:

- Commercial Forest - green diagonal lines, approximately 45° from SW to NE;
- Non-Commercial Forest - blue diagonal lines, approximately 45° from NW to SE;
- Cultivated land - red vertical lines;
- Grass, cogon or open land - yellow horizontal lines;
- Non-commercial forest
  mixed with brushland
  or pure brushland - blue diagonal broken lines, approximately 45° from NW to SE
- Marsh or Swamp - green horizontal broken lines,
- Kaingin - red broken lines at random

If the survey is made in a reforestation project or on a forest station level, at least 3 copies of the tracing have to be prepared and submitted as follows: the original together with the field notes to the Central Office; one duplicate copy to the Regional Office and the District Office concerned. One copy is retained for the records of the project office or the forest station.

Chapter 3:

THE CLOSE TRAVERSE

If the survey made to delimit a tract of land ends at the same point where it started, the resultant survey line or loop produced is called a close traverse. A close traverse survey is made to determine the actual shape, size and extent of an area, as well as its relative location with respect to points or important land marks known in the map for various purposes.

3.1 The sketch with technical description

Aside from the sketch produced by tracing the plotting, a sketch with technical description has to be prepared for each close traverse survey. The technical description is a tabular statement consisting of the bearings and distances between corners, description of corners, as well as the bearings, distances and description of tie points. While the tracing of the sketch as plotted goes with the field notes, each copy of the report on the close traverse must be accompanied by a sketch with technical description. This sketch is the main basis of the report.

The following items must be considered in the sketch to show the relative location of the area:

- The nearest forest zone or land classification (L.C.) corners;
- Adjacent or nearby areas under forestry permits or leases, or at least some of their corners,
- In delicate cases, the ordinate and coordinate lines under which the area falls.

SKETCH SHOWING

The area under Ps. A. No. 116 of Mr. Alfonso Rodriguez

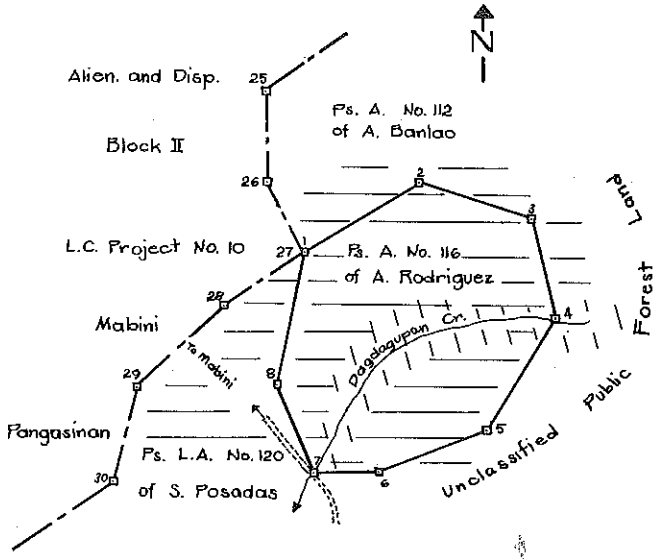
Located in:

Sitio: Dagdagupan
Barrio: Villacorta
Municipality: Mabini
Province: Pangasinan

Surveyed by: For. J. Mariano Date: Jan. 4-5, 1972
Plotted by: For. J. Mariano Date: Jan. 8, 1972
Compiled/Traced by: For. J. Mariano Date: Jan. 8-9, 1972

P.M.D. Used: Index No. 515, Mabini Reforestation Project, Mabini, Pangasinan

Scale: 1:10,000
Approx. Area: 19 Has.



Legend:

Cogon land
Brushland
Logging road
Creek

Fig. 7: Field Sketch (Technical description next page)

LINE	BEARING & DIST.	CORNER No.	CORNER MARK	DESCRIPTION of CORNERS
1-2	N 55° E, 250 Ms.	1	515/1	Molave, 30 cms., Cor. 27, A&D Blk.II L.C. Proj. 10 Mabini Pang.
2-3	S 75° E, 210 Ms.	2	515/2	Akleng Parang, 20 cms., Cor 8 Fs. A. No. 112 of A. Banlao
3-4	S 10° E, 180 Ms.	3	515/3	Duhat, 20 cms., Cor. 7, Fs. A. No. 112 of A. Banlao
4-5	S. 32° W, 245 Ms.	4	515/4	Kalumpit, 40 cms., North bank of Creek
5-6	S. 70° W, 215 Ms.	5	515/6	Banayoyo, 25 cms., on foot of hill
6-7	D- W 120 Ms.	6	515/8	Palosapis, 50 cms., Cor. 10, Fs. L.A No. 120 of S. Posadas
7-8	N 22° W 175 Ms.	7	515/9	Sakat, 35 cms., junction of Creek and logging road
8-1	N 11° E 250 Ms.	8	515/10	Dita, 30 cms., Cor. 8 Fs. L.A. No.120 of S. Posadas

Corner 1 is identical with corner 27, A & D Block II L.C. project No. 10 of Mabini, Pangasinan

Fig. 7 (continued): Technical description of survey.

Adjust the boundary of the sketch if the following conditions exist:

- If a portion of the close traverse falls inside an alienable and disposable block, or when in conflict with existing forestry permit or lease; and
- If the area happens to be close to an alienable and disposable block or to areas under forestry permit or lease, to avoid narrow strips or small patches of vacant areas.

The boundary can be adjusted simply by selecting common corners with the adjoining alienable and disposible block or areas covered by a permit or lease.

Indicate the details and legends in the same manner as in the tracing of the original plotting.

3.2 Correcting error of closure

When plotted, a close traverse seldom closes due to errors in taking the bearings and in measuring the distances between stations. The gap or difference in distance and direction produced after plotting the survey is called the error of closure.

Figure 8 below is the sketch of a proposed pasture area which did not close by a distance represented by x.

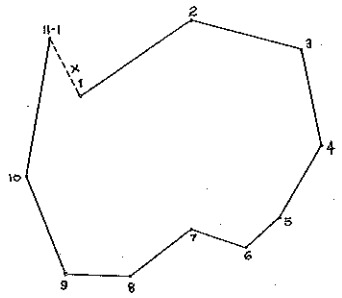


Fig. 8: A close traverse survey with error of closure

In correcting the error of closure, station 1 remains a fixed point because in a survey, there is normally no error of closure incurred at the point of beginning. The rest of the stations will have to be adjusted either forward or backward depending on whether the last station falls short of, or overshots the first station when plotted. In the foregoing illustration, stations 2 to 11 will have to be moved backward. The error of closure in each station maybe determined either by the diagram method or by computation.

a) <u>The Diagram Method</u>

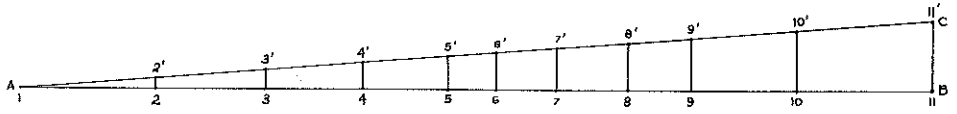


Fig. 9: The correction diagram

With the same scale used in plotting, draw a straight horizontal line AB, the length of which equals the total length of the traverse. Points A and B, therefore, correspond to stations 1 to 11, respectively. On this line, lay off stations 2 to 10, from point A at intervals equal to their respective distances as plotted. At point B, errect a perpendicular line

equal in length to the error of closure, X in Fig. 8. In the diagram this is line BC or 11-11'.

Then draw line AC. From points 2, 3, 4, 5, 6, 7, 8, 9, and 10, errect perpendicular lines up to line AC. These lines, e.g. 2-2', 3-3', etc., determine the distances at which the stations will have to be adjusted in order to close the traverse.

b) By computation

Multiply the error of closure by the distance of a particular station from station 1, then divide the product by the total length of the close traverse. The quotient equals the error of closure in such a station, or the distance at which it has to be adjusted.

Example: A close traverse has a total length of 2,500 meters. When plotted, it did not close by 50 meters. Compute for the error of closure in station 5, assuming the distance is 800 meters from station 1.

Solution: $\frac{50 \text{ ms.} \times 800 \text{ ms.}}{2{,}500 \text{ ms.}} = 16$ meters - Error of closure in station 5

The process is repeated with the rest of the stations, except the first and the last stations.

c) Correction of plotted traverse:

The figure in solid line below is a reproduction of the traverse as plotted. From stations 2, 3, 4, 5, 6, 7, 8, 9, and 10, draw downward, light lines parallel to line X, the line representing the error of closure. Along these parallel lines, the stations are moved backward according to their respective correction distances as determined in the correction diagram or as computed. The adjusted stations, points 2', 3,' etc. in the figure below, are then connected by a broken line which now represents the close traverse as corrected.

The corrected traverse is the basis in making the sketch with technical description. However, stations not considered as corners are omitted.

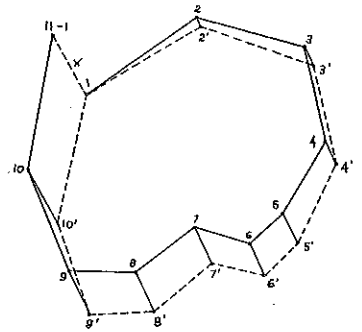


Fig. 10: Correcting the error of closure

3.3 Area determination of a close traverse.

a) Planimeter method: A planimeter is a mathematical engineering instrument for the rapid determination of areas of plane surfaces. It consists mainly of three parts: a ploe arm, a tracer arm and a carriage which supports a vertical wheel equipped with a graduated scale and a vernier and a registering dial. It works by setting and adjusting the instrument besides the sketch and tracing the boundary of the traverse by the tracer point. The reading at the registering dial is multiplied by a constant conversion factor depending on the scale to obtain the area of the close traverse.

b) Determination of area by computation: This method is convenient when the traverse has the shape of square, rectangle or triangle and the area can be computed with the help of the standard formulas. A polygonal traverse has to be subdivided into more simple geometrical forms to which the standard formulas can be applied.

c) By counting the squares on cross-section paper: The field notes are plotted on standard size cross-section paper at a scale of 1:5,000 or 1:2,000 depending on the importance of details. If the scale is 1:5,000 and the size of the squares is 0.5 by 0.5 cm, 16 squares would make one hectare. Then portions of squares are estimated and their aggregate area is computed and added to the area of the whole squares to compute the entire area of the traverse. This method of area computation is most commonly used in forest surveys in the Philippines.

Appendix

Conventional abbreviations used in field sketches.

TRIANGULATION POINT ------ Art.

HOMESTEAD APPLICATION UNDER PUBLIC LAND ACT--------- H.A.

LEASE APPLICATION UNDER PUBLIC LAND ACT--------- L.A.

SALE APPLICATION UNDER PUBLIC LAND ACT--------- S.A.

FREE PATENT APPLICATION---F.P.A.

FOREST CLAIM---------- F.C.

PRIVATE WOODLAND REGISTRATION APPLICATION----P.W.R.A.

PRIVATE WOODLAND REGISTRATION---------- P.W.R.

BATHING ESTABLISHMENT---- Be.

COMMUNICATION STATION SITE-Cs.

COMM. SITE FOR RADIO, WIRELESS OR TELEVISION STA.---------- Cs.-Rd.

COMM. SITE FOR TELEPHONE STA.-------- Cs.-Te

KAINGIN---------- Kgn.

LIME and CHARCOAL KILN-- Lck.

LOG POND ---------- Lp.

LOGGING CAMP SITE ------ Lc.

LUMBER YARD ---------- Ly.

RIGHT-OF-WAY---------- Rw.

TREE FARM---------- Tf.

TREE FARM-COFFEE PLANTATION----Tf.-Cp

TREE FARM - LUMBANG PLANTATION--Tf.-Lmp.

TREE FARM - CITRUS PLANTATION--Tf.-Ct.

TREE FARM - MEDICINAL PLANTATION--Tf.-Mp

TREE FARM - RUBBER PLANTATION--Tf.-Rp

TREE FARM - CACAO PLANTATION--Tf.-Cc

VEGETABLE GARDEN----------Vg.

WOODLAND LEASE ----------Wl.

RESIDENCE ----------Rs.

SANATORIUM ----------Sn.

PRIVATE CAMP ----------Pc.

TIMBER DEPOT ----------Td.

SAWMILL SITE ----------Ss.

HOTEL SITE ----------Hs.

SALT WORKS ----------S.w.

PASTURE ----------Ps.

NIPA-BACAUAN PLANTATION---Nb.

FISHPOND ----------Fp.

LICENCES ----------L.

TIMBER LICENCE AGREEMENT ----------T.L.A.

ORDINARY TIMBER LICENCE-O.T.L.

ORDINARY MINOR LICENCE--O.M.L

COMMUNAL FOREST ----------Cn.F.

COMMUNAL PASTURE ----------Cn.Ps.