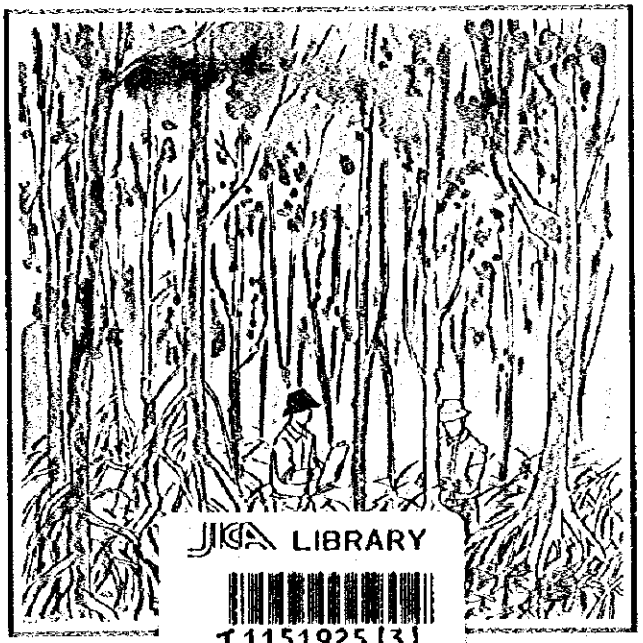
TECHNICAL MANUAL
on
FIELD SURVEY METHOD FOR MANGROVE FOREST



The Study on Mapping and Land Cover Assessment
of Mangrove Areas in the Philippines

July 1999

National Mapping and Resource Information Authority

Japan International Cooperation Agency

Department of Environment And Natural Resourses Republic of the PHILIPPINES

Japan Overseas Forestry Consultants Association

PREFACE

The mangrove forests in the Philippines play an important role in reducing damage by natural disasters and maintaining coastal environments, while also making significant contributions to forestry and fishery production.

However, the total area of mangrove forests in the Philippines has been declining rapidly due to human activities such as the conversion of the forests into fishponds and the increased harvest of trees for firewood, charcoal and other forest products.

Because of this rapid decline, the government of the Philippines has initiated a variety of new programs designed to conserve the mangrove forests. In response to a request from the government of the Philippines, the government of Japan decided to conduct a development study entitled 'The Study on Mapping and Land Cover Assessment of Mangrove Areas' which was entrusted to the Japan International Cooperation Agency (JICA)

The Philippine side is to continue to conduct surveys on mangrove forests in other areas of the Philippines using the survey methods employed in this study. Thus, the study team has prepared this technical manual for the interpretation of the survey methods.

I hope this Manual will contribute to a more comprehensive survey of other mangrove areas in the Philippines and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials of the government of the Philippines for their close cooperation extended to the team.

July, 1999

Kimio Fujita
President
Japan International Cooperation Agency

Table of Contents

Introduction

Appendices

Introduction

This book (hereinafter referred to as "the Manual") comprises one of three (3) volumes produced by "The Study on Mapping and Land Cover Assessment of Mangrove Areas in the Philippines" (hereinafter referred to as "the Study"). The Manual and the other two (2) volumes were prepared in compliance with provisions of the Inception Report for the Study. The consolidated version of the three (3) volumes comprises the Manual for the Survey on Resources of Mangrove Areas.

The Manual was prepared for readers who, now or in the future, will have significant roles in the implementation of field activities in mangroves, including not only government officers but also members of non-governmental organizations (NGOs).

The Manual consists of three parts: (i) methods for implementing transect surveys, (ii) methods for conducting sample plot surveys, and (iii) guidelines for the identification of some mangrove species in the Philippines. The first and second parts are based on standard methods adopted in the Study. But both parts also incorporate minor changes for the improvement of the standard methods based on the results of the implementation of the transect surveys and the sample plot surveys. The third part draws on previously-published botanical data plus useful information obtained in the field while carrying out the Study.

To help ensure that contents of the Manual are easily-understood, it includes as many illustrations and photographs as possible, particularly the third part that deals with identification of mangrove species. Again with the reader's/users convenience in mind, the Manual is printed in a handy-sized, compact book format that will be easy to bring to the field. Furthermore, it is printed on water-proof paper designed to retain both form and contents even if it is accidentally dropped and submerged in seawater.

Hopefully, the Manual will be widely distributed and utilized. Among others, the authors hope that readers will find it worthwhile to refer to and learn from the Manual when examining conditions in other mangrove areas of the Philippines, in addition to those included in the

Study (i.e. Aparri, Lamon Bay and Ulugan Bay). The Manual does not claim to be perfect. Like most other manuals, it should be revised and updated from time-to-time as new knowledge is gained and improved techniques or methods are developed. This indeed is one of the intentions in further implementation of the Study.

I Methods for Implementing Transect Surveys

1. Objectives

Implementation of transect surveys is a standard component of forest inventory work. In mangrove forests, transect surveys are conducted to achieve one of the basic objectives of all forest inventories (i.e. information on species) and also to obtain certain data that specifically applies to mangroves. The reasons for conducting transect surveys in mangrove areas may be summarized as follows:

1) to identify species distribution patterns in the mangrove forests; and
2) to examine the correlation between mangrove association and natural conditions such as tidal level, estuary location, layers of soil sediment, soil ingredients, and micro topography.

2. Selection of the Transect Lines

It is generally recognized that tidal levels have an impact on the distribution of mangrove species. Consequently, it makes sense to select transect survey lines that extend throughout the area affected by tides, from the farthest point seaward that contains mangroves or where mangroves would grow, all the way to the land. The lines should be as straight as possible so that the changing patterns of mangrove vegetation may be observed.

Ideally, the sites for transect surveys should be selected within primary forests. However, under actual conditions in the field it is difficult to find such sites. Therefore, the most practical approach is to choose sites where transect survey lines pass through areas that are the least disturbed or damaged by human activities.

3. The Survey Process

Transect survey methodology for mangroves includes three (3) principal tasks: (i) establishing the level; (ii) tree stand measurement; and (iii) soil survey, all of which are discussed below.

3-1 Establishing the Level

A compass is used to determine the direction (bearing) of the transect line. However, the direction (bearing) should be decided only after reaching the final point in establishing the level as explained below. The procedures for establishing the level are as follows and illustrated on Fig. I-1:

1) Place a stadia rod at the starting point and another stadia rod at a point where there is a change in the micro-topography or mangrove vegetation.
2) Set up a level around mid-point between the two stadia rods. From this point, back-sight along the line and read the scale on the stadia rod placed at the starting point. Then, turn the level 180 degrees, fore-sight along the line and read the scale on the stadia rod at the second point (i.e. where there is a change in the micro-topography or mangrove vegetation).
3) Measure the distance between the two stadia rods.
4) Turn the stadia rod at the second point 180 degrees. Then, transfer the stadia rod previously placed at the starting point to the next point where there is a change in the micro-topography or mangrove vegetation.
5) Repeat steps 2) to 4) above until reaching a point that corresponds to the uppermost limit of the mangrove forest, i.e. where mangrove vegetation no longer grows. This last point usually marks the beginning of the dry land that is no longer affected by the tide.

After completing 1) to 5) above, establish the transect line using a compass so that the bearing may be accurately recorded. Try as much as possible to establish a straight line. However, do not neglect the need to capture changes in micro-topography and mangrove vegetation along the way. In other words, slight deviations from a straight line are acceptable.

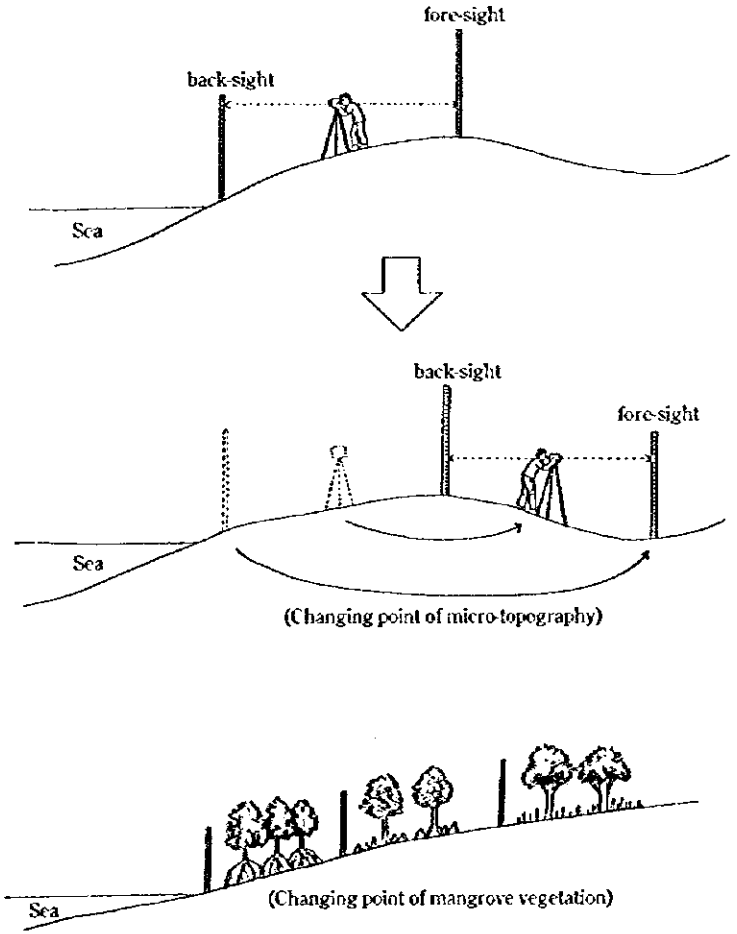


Fig. I-1 Procedure for establishing the level

3-2 Tree Stand Measurement

In this task, all trees above 3 cm DBH should be measured in a belt that is 2 meters wide on one side of the transect line (please see Fig. I-2). The measurements can be made on either the right side or the left side of the

line. However, the work should not shift from one side to another. Work on the same side until reaching the end of the line. The contents to be recorded for the tree stand measurement are species, height, DBH, and location (please see Fig. I-3). The location is indicated by distance from the starting point of the transect line. Stretch a measurement tape along the transect line to facilitate measuring the location and to confirm the line established in task 3-1 mentioned above. When measuring the DBH, round off to the closest 2 cm. For example, DBH between 3 cm and 5 cm should be recorded as 4 cm. In the case of Rhizophora spp., aerial stilt roots often grow to a height greater than DBH (i.e. more than breast height). When this situation is encountered, measure the diameter immediately above the point where the highest stilt roots emerge from the stem (trunk) as shown in Fig. I-3.

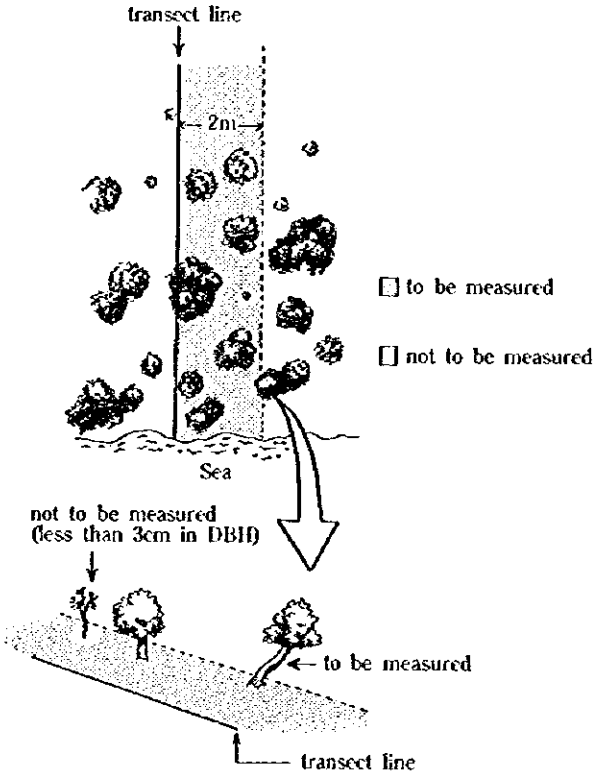


Fig. I-2 Preparation of transect belt and trees to be measured

Two methods of recording should be applied:

1) Enter the species, height, DBH and location (i.e. distance) from the starting point in the field survey sheet (see Appendix 2 as the sample).

2) Prepare a sketch illustrating a rough profile of all trees found in the 2 meter belt on one sides of the transect line. The sketch should be drawn on section paper. As a reference, even trees including seedlings with DBH lower than 3 cm may be included. A sample of a rough profile sketch on section paper in the field is shown in Appendix 1.

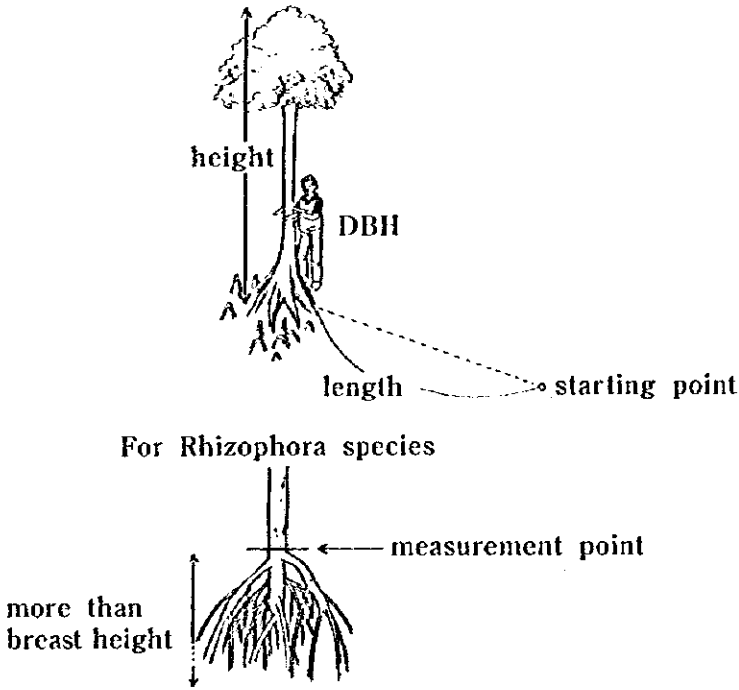


Fig. I-3 Tree measurement method

3-3 Soil Survey

While conducting the work described in I 3-2 above, the soil conditions along the transect line should be examined at the same time. Where different species of mangrove vegetation appear (i.e. when there is a significant change in the species composition) the soil at these points should also be examined in order to reveal any relationship between species composition and soil properties. The following items should be examined in the soil survey:

1) Total soil depth
2) Soil sedimentation at each horizon
3) Color
4) Soil texture
5) Stones, shells and coral
6) Humus
7) Roots

The soil structure profile should be observed so as to examine the items listed above. Core samples should be collected to study the order of soil layers . Since mangrove soil usually consists of soft mud, the pit method for collecting core samples is impractical. Accordingly, a special device called a piston soil sampler should be used. This device is designed to collect samples in soft muddy soil. The piston soil sampler can collect core samples down to a maximum depth of 3 meters with relative ease, except when obstacles such large rocks or thick root systems are encountered.

It is also important to examine water quality, especially salinity. This is because the mixture of sea water and fresh water determines how brackish the water in the soil will become. Therefore, to the extent that it is possible, the following properties of the water should be examined:

1) pH
2) Salinity

For the examinations, a special device for soil water sampling

should be used. For instance, it is a soil water sampler that is designed to collect soil water by applying absorptive pressure 'to the porous cup at the tip of the device.

4. The Survey Materials

The following equipment and materials should be prepared to implement the transect survey;

(1) For establishing the level
Level with a tripod stand
Two stadia rods
20m measurement tape
Hand compass
Field survey notebook to record results (preferably, the notebook should be made of water-proof paper)

(2) For tree stand measurement
Calipers
Diameter tape
Tree height measurement tool
20m measurement tape
Hand compass
Field survey sheets to record results (also made of waterproof paper) (A sample shown in Appendix 2)
Drawing board for rough profile sketch
Section paper
Numbering tapes
Stapler for attaching numbering tape onto tree trunks
Marking tape
Aerial photographs
Map
GPS instruments

(3) For soil survey
Soil sampler
1m scale (folding type is preferable)

Salinometer
Soil color chart
Field survey sheets to record results (made of waterproof paper) (A sample shown in Appendix 3)
Plastic sheet on which to place the soil samples
Litmus paper
Soil water sampler

5. Drawing the Sectional Profile Based on Survey Results

The implementation of surveys should include preparation of sectional profiles since these are very useful in the analysis of results. When preparing the profile the following features should be incorporated:

1) Tree height and ground height should be drawn at different scales. This is important because tree height is clearly noticeable but the change in ground height is not that significant. In the Study, ground height was drawn at a scale ten times greater than the scale used for tree height. Thus, changes in ground height are easy to see on the profile.

2) When drawing the mangroves, it is advisable to indicate the species by using symbol expressing feature of the species.

A sample of the sectional profile is shown in Fig. I-4.

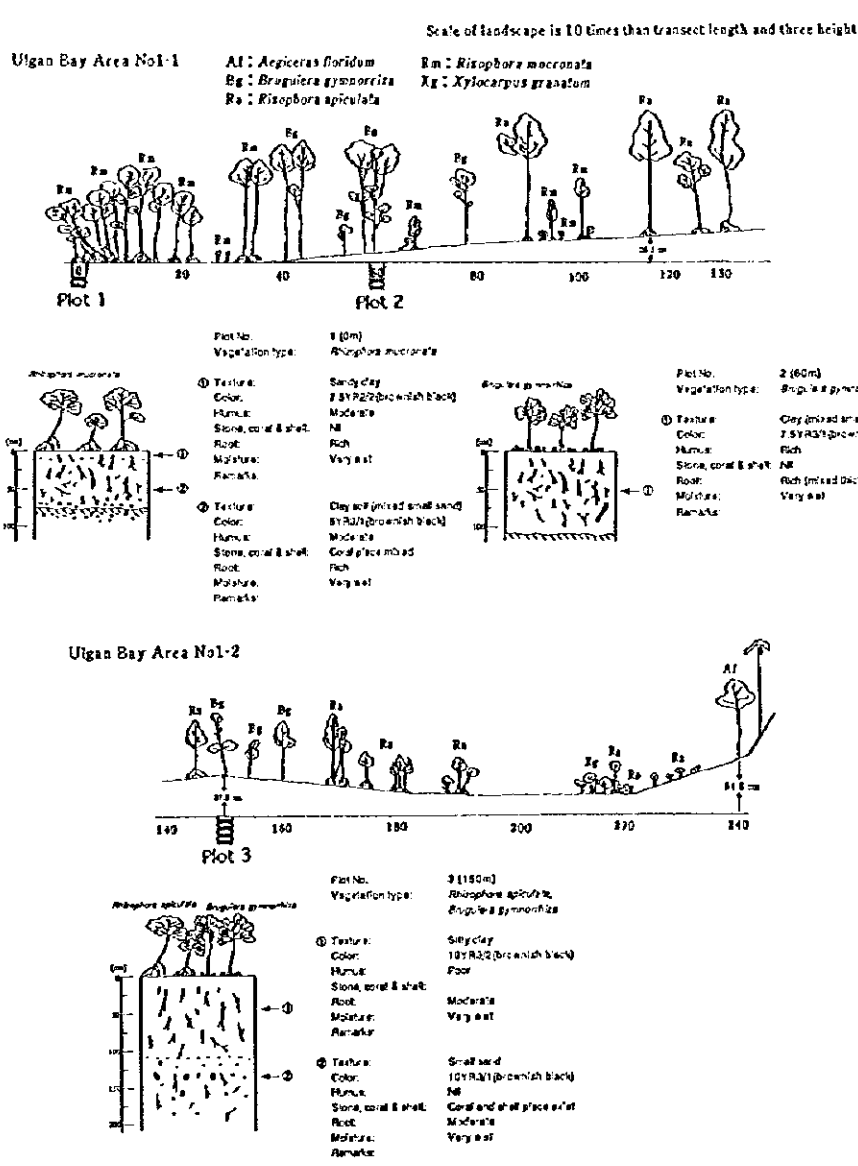


Fig. I-4 A sample of sectional profile by transect survey results

II Methods for Conducting Sample Plot Surveys

1. Objectives

The implementation of sample plot surveys is a standard part of forest inventory work. In the context of mangroves supported by aerial photography, the objectives of this exercise are to:

1) identify stands structure of mangrove forest under different land conditions ; and
2) carry out field verification by comparing data gathered in the field with aerial photograph imagery; in other words a "ground truthing" or "on-site validation" exercise.

2. Selection of Sample Plots

One of the principal outputs of pre-interpretation of the aerial photographs will be the identification of different patterns based on vegetative features, crown density and landscape conditions. This information should be used in the selection of sample plots. Sample plot locations should be selected based on the different patterns. Thus, results of the plot surveys can be compared with the imagery. In the selection of sample plots, the Study team made sure that the plots chosen should represent all of the different patterns appearing on the imagery. The same care should be exercised in future studies. Target points for sample plot selection should be marked in advance on the aerial photographs. Accessibility should also be considered in the interests of efficiency

Number of plots to be surveyed should be decided based on number of the different patterns in the aerial photograph imagery, budget and term for the survey, the accessibility and so on.

3. The Survey Process

3-1 Composition of the Survey Team

The survey team should consist of two (2) surveyors (officers), one (1) botanist and at least four (4) laborers.

3-2 Procedures for Establishing the Plots

The procedures for establishing the plot are as follows and illustrated on Fig. II- 1:

1) The location of the plots should correspond with the target points marked in advance on the aerial photos. The team should proceed to those target points using a hand compass and handheld GPS instruments to guide them with the greatest possible accuracy to the exact location or as near as possible.

2) The center point of the plot should be decided after reaching the target point for the sample plot survey.

3) Four (4) persons should work together to establish the perimeter of the plot. The size of the plot is determined on the basis of average tree height in the plot. A measuring tape is used to established the perimeter working outward north, south, east and west respectively from the center point as illustrated on Fig. II-1. The standard of the size of the plot is as follows:

   a. If the average tree height in a plot is less than 5 m, the distance from the center point to each corner point should be 10 m. In this case the plot will be a square with approximate dimensions of 14 X 14 meters or about 200m².
   b. If the average tree height in a plot is from 5m to 20m, the distance from the center point to each corner point should be 15 m. In this case the plot will be a square with approximate dimensions of 21 X 21 meters or about 450m².
   c. If the average tree height in a plot is more than 20 m, the distance

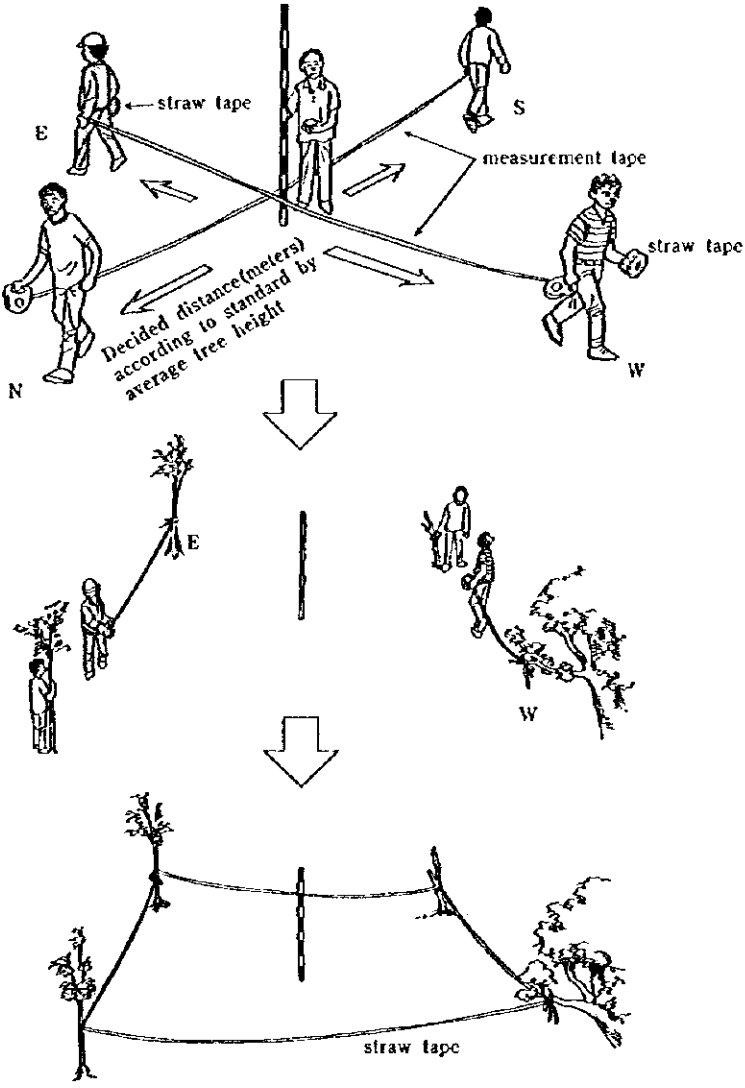


Fig. II- I The Procedures for establishing the plot

from the center point to each comer point should be 20 m. In this case the plot will be a square with approximate dimensions of 28 X 28 meters or about 800m².

4) Each of the four persons should mark their respective corner point with a stake to which they should attach a colored tape.

5) Each person should face the person on his right and stretch a colored nylon tape up to the corner point on his right side. Thus, the perimeter of the plot is surrounded by the tape. Plot survey work may now begin in the area surrounded by the tape.

3-3 Contents of the Plot Survey

The information to be gathered and recorded when conducting the plot survey are (i) tree measurement, (ii) plot position, (iii) GPS reading, (iv) crown density, (v) species dominance, (vi) regeneration and (vii) land use conditions as a result of human activities. Additionally, the survey team should prepare a stand distribution sketch, a land feature sketch and a brief description of the mangrove forest. The team should also take photographs of the plot. These several tasks are discussed below.

(1) Tree Measurement

The purpose of tree measurement is to record species, height, and DBH. The tree measurement activity should record all trees in the plot with DBH of 3 cm and above. As mentioned earlier in paragraph I 3-2, the DBH should be rounded off to the closest 2 cm; i.e. DBH between 3 cm and 5 cm should be recorded as 4 cm. As mentioned in paragraph I 3-2, the DBH of Rhizophora species should be measured immediately above the point where the highest stilt roots emerge from the stem (trunk) .

(2) Plot Position

Plot position refers to where the plot is situated in relation to tidal level and estuarine location. Tidal level determines how long the roots of mangrove species will be submerged in seawater within a day. Estuarine location influences the degree of salinity in the plot. Both

factors (tidal level/estuarine location) should be recorded. There are three (3) categories of tidal level (low, middle, high) and four (4) categories of estuarine location (downstream, intermediate, upstream, others). The tidal level category should be decided in consideration of the fact that the low tidal level generally corresponds with long submergence, the high tidal level generally corresponds with short submergence, and the middle tidal level falls somewhere in between. The estuarine location category should be ordinary decided in consideration of fact that the order from downstream to upstream generally corresponds with high salinity to low salinity, respectively. In case that there is no estuarine location in the site of the plot due to absence of any river, etc., the category of "others" should be selected.

(3) GPS Reading

GPS should be used to determine the geographic location of each sample plot. This information is needed in order to mark the plot location on a map after completing the sample plot study exercise. However, it not always possible to take GPS readings. Sometimes, due to canopy cover, there is not enough open space to catch the signals from satellites. In this case, the GPS reading may be taken at an open space nearby which is as close as possible to the plot.

(4) Crown Density

The crown density should be estimated in each canopy layer-upper, middle and lower. The upper layer of the canopy refers to trees more than 15 meters high. The middle layer comprises trees in the 10-15 meter height range. The lower layer means the trees less than 10 meters high. The estimate for each canopy layer should be expressed in percentage (%) from 0% to a maximum of 100%.

(5) Dominance

The degree of dominance of each mangrove species should be evaluated and recorded in each canopy layer (upper, middle and lower). It should be categorized in six (6) classes. The symbol "5" means that the degree of dominance of a species is about 70 %. The symbol "4" means a degree of dominance of about 50 %. If the degree of dominance is about 25%, this should be indicated by the symbol "3". The symbol "2" means a degree of dominance of about 10 %, and the symbol "1" a degree of about 5 %. The

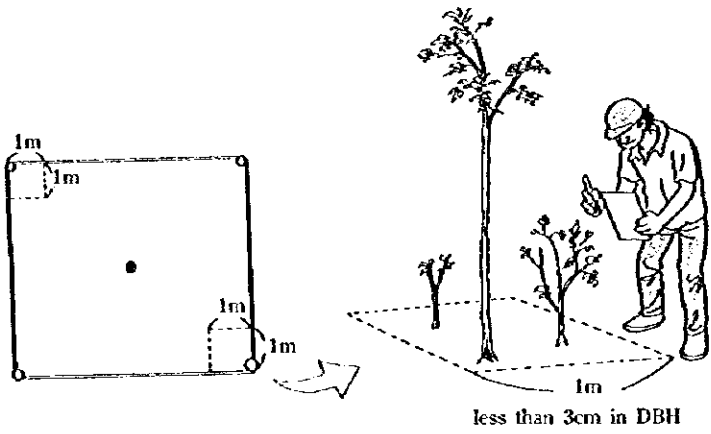


Fig. II-2 Method of measurement for regeneration

symbol "+" indicates the existence of a species but further indicates that it is not dominant and symbol "1" can not be given.

(6) Regeneration

Regeneration refers to all of the mangrove vegetation found in the sample plot with less than 3 cm DBH (i.e. seedlings and saplings). Since it is impractical to count all the seedlings/saplings in the plot, examination of the regeneration is done in small sample areas within the plot. The amount of regeneration is assessed and recorded as explained below, and as shown in Fig. II-2 .

1) Measure two sample areas, each 1m × 1m quadrat, in two corners of the sample plot.

2) Toss a coin to decide whether the sample areas should be located in the east and west corners of the plot or in the north and south corners.

3) Identify the species and count the number of seedlings /saplings for each species in three height classes-less than 1m, from 1m to 3 m, and 3 m or more. Then, record all of this information.

4) Finally, make a sketch showing the distribution of seedlings/saplings.

(7) Land Use Condition as a Result of Human Activities

The information gathered in this regard is descriptive. The procedure is simply to observe and assess conditions, and then to evaluate the extent to which these conditions relate to human disturbance. For example, there may be stumps that indicate recent or previous gathering of fuelwood. The results of observation/assessment should be described in the field notebook.

(8) Stand Distribution Sketch

This task involves preparation of a sketch that illustrates the vegetation in the sample plot. Canopy classes, breadth of the crowns and spacing (density) of trees in the plot should be shown clearly on the sketch. Symbols may be used to indicate species.

(9) Sketching the Landscape

Landscape in this instance refers to the features of the land in the sample plot. For instance, there may be a small channel (canal) running through the plot. Or, the plot may contain a puddle(s), rock (s), mud mound(s) or perhaps some stumps. There might be gaps in the plot caused by felling of trees. Nipa may be growing in some of the plots. In brief, any and all significant or unique features of the landscape should be noted and included in the sketch. When conducting observations as basis for preparing the sketch, it is important to keep in mind that species composition, growth and stand distribution frequently correspond with features of the land in the plot.

(10) Brief Description of the Mangrove Forest

In addition to the topics just discussed, there may be other conditions, situations or features unique to the plot. If so, these should be described as brief comments recorded in the notebook.

(11) Taking Photographs

It is important to take photographs of the mangrove forest in the plot. The photographs should be inserted in the GIS database. The photographs should be numbered for purposes of identification to ensure that each photograph corresponds to a specific plot.

3-4 Personnel and Responsibilities

1) A surveyor (officer) should carry out tree measurement and GPS reading, assisted by a botanist and two laborers. He/she should also take the photographs.

2) Another surveyor (officer) should carry out the other plot survey tasks discussed above, with the assistance of a botanist.

4. Survey Equipment and Supplies

The following equipment and supplies should be made available for the sample plot surveys.

Caliper
Diameter tape
Tree height measurement tool
Two 50m measurement tapes
Hand compass
Two field survey sheets to record results (water-proofed paper is better) (Appendices 4 and 5 show samples of two kinds of field survey sheets)
Numbering tapes
Stapler to attach numbering tape on tree trunks
Straw tapes
Aerial photographs
Map
GPS instruments

5. Orderly Presentation of the Survey Results

The survey results should be carefully analyzed and presented in a neat, and orderly manner. For this purpose, it is advisable to prepare sheets that can be used to facilitate correlation of the field data and the interpretation of aerial photographs. In the Study, results of the plot sampling survey were entered on a Mangrove Plot Survey Sheet, a sample of which is presented in Appendix 6. Hereunder are some recommendations to consider when preparing the sheet.

1) Use visual materials to the maximum extent possible. Thus, reports presenting the results should contain photographs, sketches and copies of aerial photographs.

2) Regarding estimation of stand volume in the plots, it is advisable to refer to information found in "The Philippine Recommends for Mangrove Production and Harvesting, 1991, Philippines Recommends Series No.74" published by the Philippine Council For Agriculture, Forestry and Natural Resources Research and Development (PCARRD). The relevant sections of that document which were utilized in preparation of this Manual are shown in Appendix 7. It should be noted, however, that information in the PCARRD publication refers to timber volume, in the context of timber production as studied in Palawan, covering only seven (7) species: *Rhizophora apiculata, Rhizophora mucronata, Bruguiera cylindrica, Bruguiera gymnorrhiza, Lumnitzera littorea, Xylocarpus granatum,* and *Scyphiphora hydrophyllacea.* At the present time, the timber volume tables found in the PCARRD publication are the only officially-published source of data that may be used as basis for estimating stand volume in the plots. It should also be noted that the PCARRD publication might not include data on some of the species that will be found in the survey sites. A survey team might, therefore, apply the volume figures for some of the seven (7) species just mentioned as the basis for estimating stand volume of species with similar characteristics that will be found at the survey sites.

III Guidelines for Identification of Some Mangrove Species in the Philippines

1. Objectives and Contents of This Chapter

Species identification is a fundamental component of mangrove studies. It is also one of the most difficult. This chapter seeks to assist teams and individuals that are conducting mangrove studies in the Philippines by providing guidelines that will help facilitate species identification. Towards this end, it includes numerous photographs of mangroves illustrating the different parts of this interesting flora such as leaf, flower, fruits and bark. In all, twenty-six (26) mangrove species are covered in this chapter, with as many photographs as possible displayed for examination and for comparison with specimens collected in the field. Based on results of the Study, the authors anticipate that this chapter covers most, if not all, of the species that the teams will find in their work.

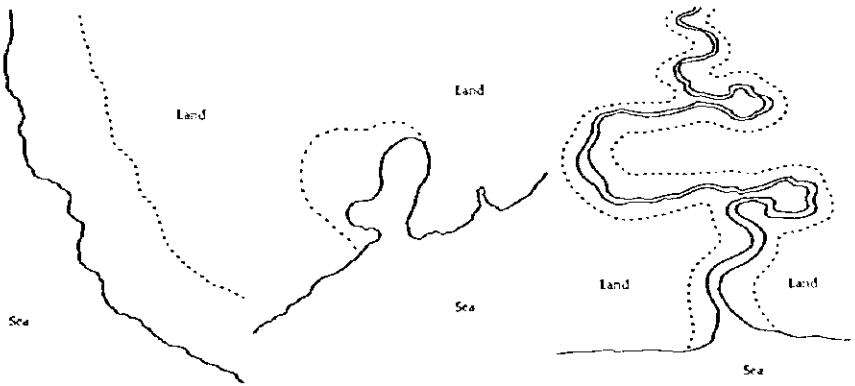
Wherever possible, simple terms are used to describe the characteristics of the species such as shape, color, size, surface, etc. of plant parts such as leaf, flower, fruits, etc. However, the use of technical terms is often unavoidable. Therefore, when encountering technical terms that are not familiar, the reader may refer to the glossary in Appendix 8 for clarification.

Specific features usually make it possible to distinguish one species in a genus from other species in the same genus. This differentiation is especially useful in respect of genus that have more than two (2) species. This chapter of the Manual has two facing pages for each species. Near the bottom of some of the pages there is a line entitled "Specific features for comparison with other species in the same genus". Immediately below this line there are a few comments that firstly : (i) identify a species of the same genus for comparison purposes, and secondly (ii) identify the specific features of the species on the page for comparison such as size of the leaves or fruit, color of

the bark, etc. The comparisons (differences with the species above (i)) are placed in parenthesis, for example - color of bark (darker). Thus, for further clarification, the reader may refer to each characteristic of the species cited on the same two facing pages.

At the bottom of each page after the word "Location", there are a few comments that indicate where the species described on the page usually grows. In addition to these comments, there are also illustrations that indicate the usual habitat of the species within the following three patterns based on topographical factors: (i) seaside flat area; (ii) tidal flat area in small bay; and (iii) river mouth flat area. The typical illustrations of the three patterns used on each page are indicated in Fig. III-1. Three image illustrations presented in Fig. III-2 correspond to each illustration of the three patterns in Fig. III-1 so as to facilitate a more clear understanding of the three patterns. The locations usually inhabited by the mangrove species are painted in dark green color for high frequency and light green color for low frequency. However, the locations explained in the comments and illustrated on the figures do not cover all of the habitat conditions. Therefore, it is noted that there are numerous exceptions due to site-specific factors.

The term "inter-tidal position" used in this chapter has practically the same meaning as the term "tide level" which was used frequently in the preceding chapter. Both terms refer to the correlation between tide and species distribution.



(i) Seaside flat area (ii) Tidal flat area in small bay (iii) River mouth flat area

Fig. III-1 Typical Illustrations of the Three Location Patterns

(i) Seaside flat area (ii) Tidal flat area in small bay (iii) River mouth flat area

Fig. III-2 Image Illustrations with Mangrove Vegetation Corresponding to Three Typical Illustrations in Fig. III-1

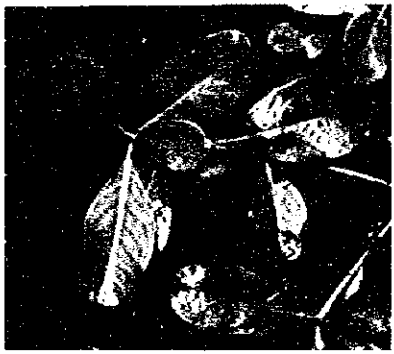
2. Descriptions of Some Mangrove Species

The following pages of this chapter provide descriptions of the main 26 species found during the study.

Aegiceras corniculatum / Family : MYRSINACEAE/

Leaf

Unit : simple
Arrangement : alternate
Blade shape : obovate to elliptical
Apex shape : rounded to emarginate
Color : green both side
Size : 4-11cm long by 3-6cm wide
Others : glands on the leaves for secreting salt, and surface glabrous but with minute pustules turning black with age



Bark

dark gray, smooth

Roots

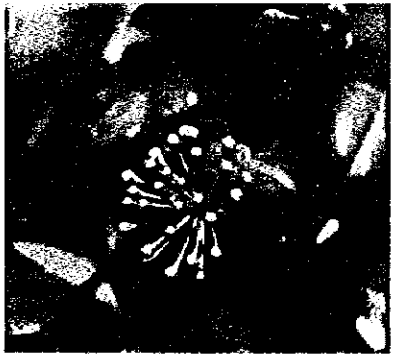
no prominent aerial roots

Flower

Inflorescence : umbel, terminal
Petal : five (5) and white
Calyx : five (5) lobes and green
Size : 0.4-0.5cm in diameter and 0.5-0.6 cm in length
Others : fragrant (sweet-scented) smell, peduncle up to 0.5 cm

Fruit

Shape : cylindrical, hanging, strongly curved like a miniature banana, and pointed tip
Size : up to 7cm in length
Color : green to yellowish brown
Surface : smooth
Others : not hypocotyl



flower buds

Official common name : Saging-saging /Minor mangrove elements

Seed type

cryptoviviparous

Other features

Usually isolated shrub growing to a height of 6m, not forming a conspicuous part of the community

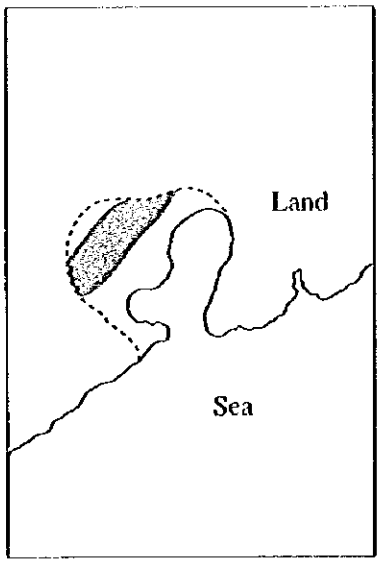
Specific features for comparison with other species in the same genus

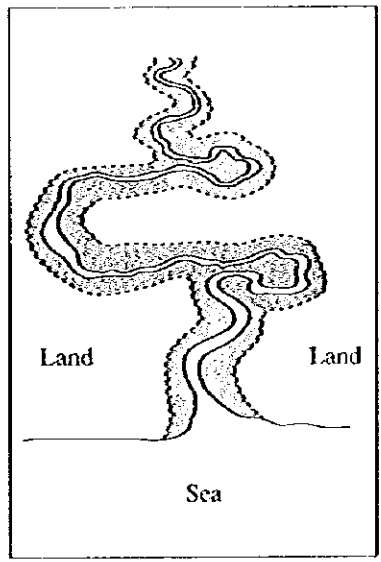
Comparing with

A. floridum **:** Leaves and fruits (larger) and the bark is (darker) .

Location

Found on river banks over a wide range of salinities, along the water channels in the inner part of the swamp, less sandy spots





Aegiceras floridum /Family: MYRSINACEAE/

Leaf

Unit : simple
Arrangement : alternate
Blade shape : obovate
Apex shape : rounded to emarginate
Color : green both side
Size : 3 - 6 cm long by 3 cm wide
Others : glands on the leaves for secreting salt, glabrous surface

Bark

brown, rough

Roots

no prominent aerial roots

Flower

Inflorescence : racemose, terminal
Petal : five (5) and white
Calyx : five (5) lobes and green
Size : 0.4 cm in length
Others : sour-smelling, peduncle up to 2 cm

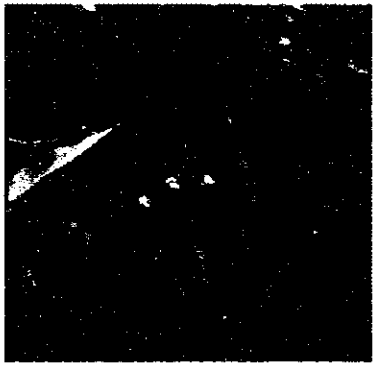
Fruit

Shape : cylindrical, short, erect, slightly curved
Size : up to 3 cm in length
Color : yellowish brown to brownish red in maturation
Surface : smooth
Others : not hypocotyl

Seed type

cryptoviviparous

Official common name : Tinduk-tindukan /Minor mangrove elements



Other features

Multi-branched shrub growing to a height of 6 m

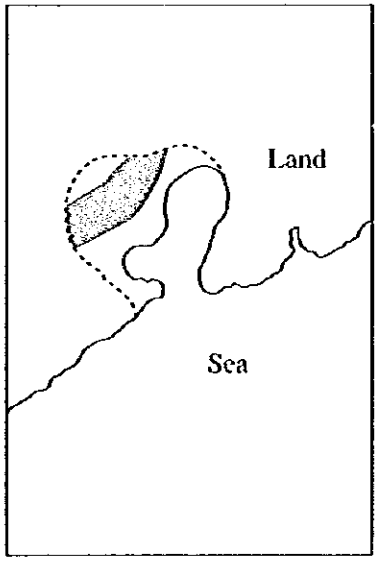
Specific features for comparison with other species in the same genus

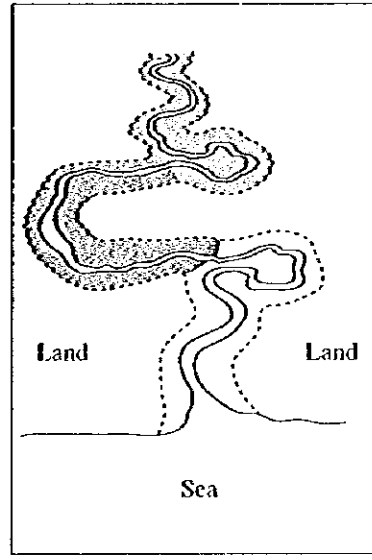
Comparing with

A. corniculatum: The leaves and fruits are (smaller) and the bark is (lighter) colored

Location

Along the water channels in the inner part of the swamp, rocky and sandy soil





Avicennia lanata /Family : AVICENNIACEAE/

Leaf

Unit : simple
Arrangement : opposite
Blade shape : elliptical
Apex shape : rounded to acute
Color : upper surface dark green, undersurface yellowish brown or white
Size : 5 - 9 cm long by 4 cm wide
Others : with salt glands, undersurface with hairy, leaf margins not reflexed, petiole 1.5 to 3 cm long

Bark

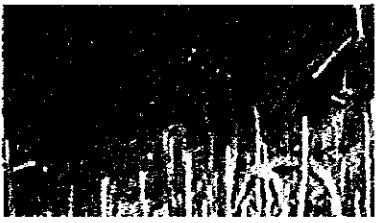
brown to dark gray, smooth, slightly fissured, not flaking

Roots

pneumatophores, pencil-like

Flower

Inflorescence : 8 - 14 flowered, dense spike, 1 - 2 cm long, terminal or axillary on distal shoots
Petal : four (4), orange to yellow
Calyx : five (5) lobes, shape recurved (not erect)
Stamens : four (4)
Size : 0.3 - 0.5 mm in diameter when expanded
Others : style very short center of the flower



Fruit

Shape : bean-like fruits, fruit rounded apically or with a short beak
Size : 1.5 - 2.0 cm in width, 1.5 - 2.5 cm in length
Color : pale green or bronze
Surface : with a white woolly or hairy covering

Seed type

cryptoviviparous

Other features

Crown is whitish because of white wooly indumentum that covers leaves and younger stem part. Tree can grow up to 24 m

Specific features for comparison with other species in the same genus:

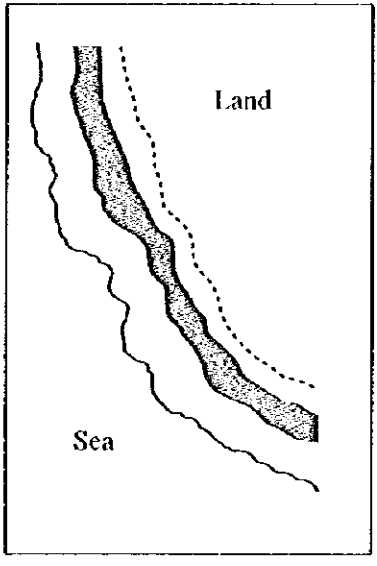
Comparing with

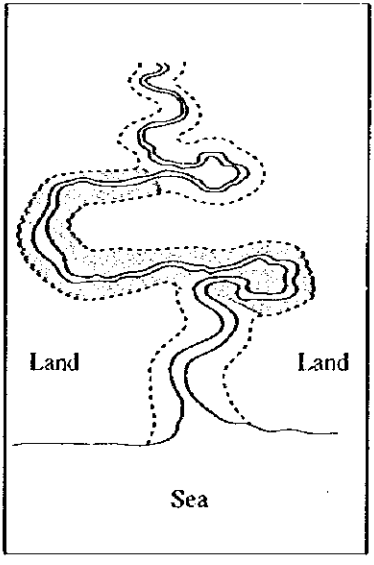
A. officinalis: Shape of calyx lobes (recurved) and color on undersurface of leaves (more greenish)

A. marina: Bark (more brownish and slightly fissured) and existence of (hairy) undersurface of leaves

Location

sandy substratum, normal tidal range, usually in back mangrove

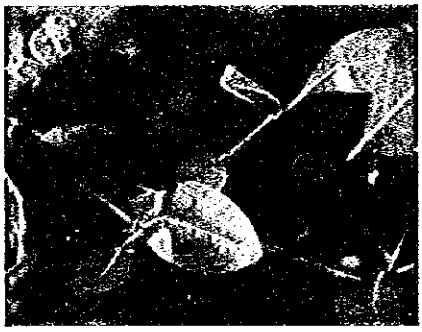




Avicennia marina /family: AVICENNIACEAE/

Leaf

Unit : simple
Arrangement : opposite
Blade shape : elliptical
Apex shape : acute to rounded
Color : upper surface light green, undersurface greenish white
Size : 5 - 9 cm long by 3.5 cm wide
Others: underside of the leaf with special glands for secreting excess salt, undersurface is not hairy, leaf margins reflexed



Bark

greenish yellow, smooth, thin, peeling off in patches

Roots

pneumatophores, pencil-like

Flower

Inflorescence : 8 - 14 flowered, dense spike, 1 - 2 cm long, terminal or axillary on distal shoots
Petal : four (4), yellow to orange
Calyx : five (5) lobes
Stamens : four (4)
Size : 0.3 - 0.5 mm in diameter when expanded
Others : style very short, center of the flower

Fruit

Shape : bean-like fruits, fruit rounded or at most shortly beaked which is almost completely obscure in the mature
Size : 1.5 - 2.0 cm in width, 1.5 - 2.5 cm in length
Color : grayish green, never yellowish
Surface : slightly hairy

Official common name : Bungalon /Major mangrove elements

Seed type

cryptoviviparous

Other features

pioneer species, high tolerance of hyper-saline condition, tree can grow up to 12 m

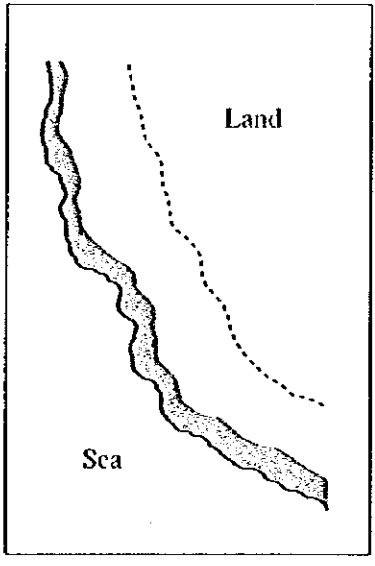
Specific features for comparison with other species in the same genus

Comparing with

A. officinalis and *A. lanata*: Bark (mottled greenish yellow and peeling in patches) and undersurface of leaves (not hairy)

Location

abundant on exposed area facing the sea, rarely far from the sea



Avicennia officinalis / Family : AVICENNIACEAE /

Leaf

Unit : simple
Arrangement : opposite
Blade shape : obovate to elliptical
Apex shape : rounded
Color : upper surface shiny dark green, undersurface golden-brown or white
Size : 5 - 10 cm long by 5 cm wide
Others : With salt glands, undersurface hairy, leaf margins slightly reflexed


upper surface


under surface

Bark

gray to brown, smooth, slightly fissured, not flaking

Roots

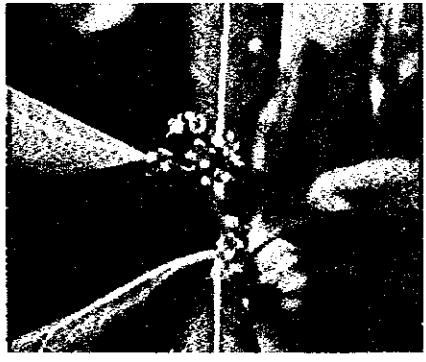
pneumatophores, pencil-like

Flower

Inflorescence: 7 - 10 flowers, dense spike (somewhat capitate), terminal or axillary on distal shoots
Petal : four (4), orange yellow
Calyx : five (5) lobes, shape erect
Stamens : four (4)
Size : 0.6 - 15 mm in diameter when expanded
Others: style very prominent, oblique or slanting, not in the center of the flower

Fruit

Shape : bean-like fruits, heart-shaped fruit, abruptly narrowed to a short beak
Size : 2.0 - 2.5 cm in width, 2.5 - 3.0 cm in length
Color : green or brown
Surface : densely hairy, wrinkled



Seed type

cryptoviviparous

Other features

mature tree forms a columnar shrub or tree up to 15 m

Specific features for comparison with other species in the same genus:

Comparing with

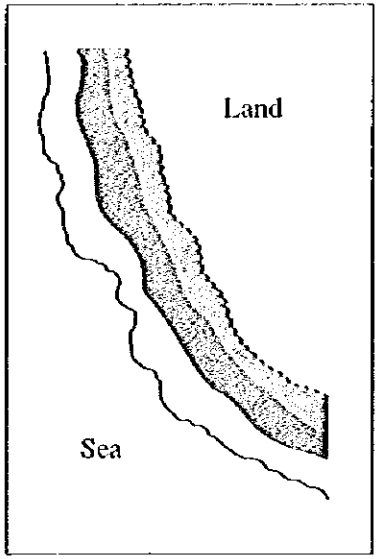
A. lanata:Shape of calyx lobes (erect) and color on undersurface of leaves (more whitish)

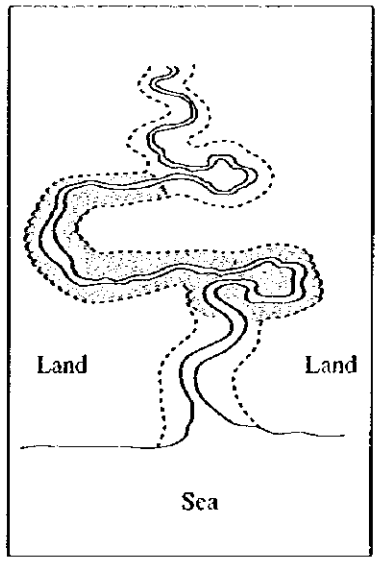
A. marina:Bark (more brownish and slightly fissured). Undersurface of leaf is (more hairy)

Other *Avicennia spp.*: Size of flower and fruits (larger)

Location

sporadic on the banks of rivers and on firm mud, prefers clay soil, usually inland, rare on





Bruguiera cylindrica /Family : RHIZOPHORACEAE/

Leaf

Unit : simple
Arrangement : opposite
Blade shape : elliptical
Apex shape : acuminate
Color : upper surface dark green, undersurface light green
Size : 9 - 16 cm long by 4 - 7 cm wide

Bark

gray and dark brown, with white patches, relatively smooth

Roots

knee-roots and buttress

Flower

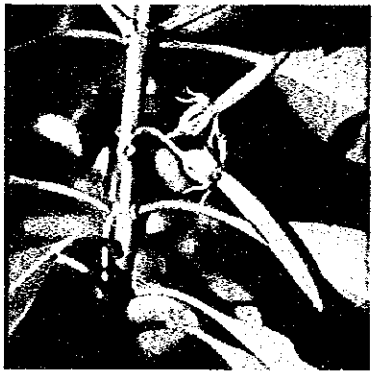
Inflorescence : usually 3 flowerd, cyme, axillary, peduncle 1 cm long
Petal : white
Calyx: 8 lobes, yellowish green, calyx tube 4 to 6 mm long, 2 mm in diameter, calyx lobes stout and reflexed in fruit
Size : 0.8 - 1.2 cm in length
Others : flower erect at anthesis

Fruit

Shape : cylindrical, slightly curved
Size : up to 15 cm long, less than 1 cm diameter
Color : green to purplish green
Surface : smooth
Others : grooved, detached with calyx, buoyant, dispersed by currents

Seed type

viviparous



young fruit

Other features

usually grows like a small tree but up to 20 m in height

Specific features for comparison with other species in the same genus

Comparing with

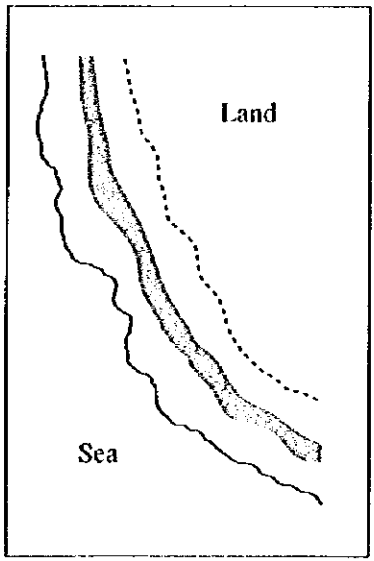
B. gymnorrhiza and *B. sexangula* : color of calyx (yellowish green) and size of flower (smaller)

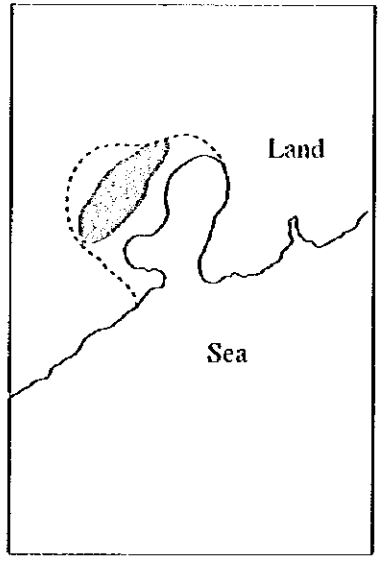
Other *Bruguiera spp.*: Bark (white patches)

B. parviflora : size of leaves (relatively longer and wider) and length of calyx (shorter)

Location

Usually found gregariously in the inner mangroves, on newly established substrates, stiff clay. Rather rare.





Bruguiera gymnorrhiza/Family : RHIZOPHORACEAE

Leaf

Unit : simple
Arrangement : opposite
Blade shape : elliptical
Apex shape : acuminate
Color : upper surface dark green, undersurface yellowish green
Size : 9 - 22 cm long by 5 - 9 cm wide
Others : leathery, undersurface without black dots

Bark

few pustules, young bark-smooth and brown, old bark-rough, black and fissured

Roots

knee-roots and short buttresses originating stilt-like roots

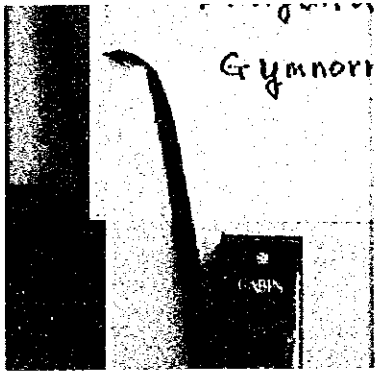
Flower

Inflorescence : large flower, usually single, axillary
Petal : brown, tip of petal lobes acute, each extended into 3 filaments
Calyx : 10 - 14 lobes, red, 4 cm long, bell-shaped leathery in texture
Size : 3 - 5 cm in length
Others : usually the flower, stipules and midrib, undersurface reddish

Fruit

Shape : cylindrical, cigar-shaped, blunt apically
Size : 20 - 30 cm long, 1 - 2 cm diameter
Color : dark green to purple tinted brown
Surface : smooth, ribbed
Others : detached with calyx, buoyant, dispersed by currents

flower buds



Seed type

viviparous

Other features

tree grows up to 30 m or more in height, twigs, petioles and young stems covered with a fine white covering that rubs off

Specific features for comparison with other species in the same genus

Comparing with

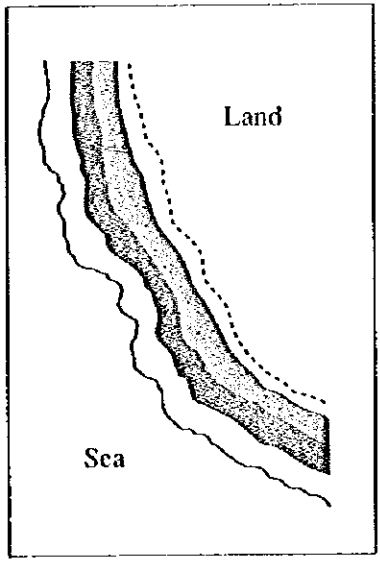
Other *Bruguiera spp.*: color of calyx (red), size of leaves (largest)

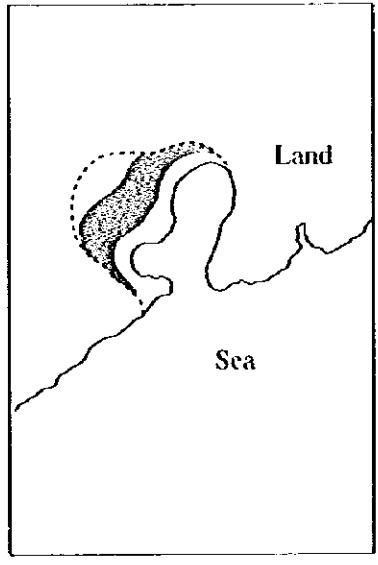
B. sexangula : bark (less pustule) and twigs and petioles (white waxy covering)

B. parviflora and *B. cylindrica*: size of flower (larger)

Location

usually found in the middle mangroves extending into the landward area, stiff clay





Bruguiera parviflora / Family :RHIZOPHORACEAE /

Leaf

Unit : simple
Arrangement : opposite
Blade shape : elliptical
Apex shape : acuminate
Color : yellowish green
Size : 7 - 13 cm long by 2 - 4 cm wide
Others : upper surface shiny, undersurface dull

Bark

gray and dark brown

Roots

knee-roots and small buttress

Flower

Inflorescence : 3 - 4 flowerd, cyme, axillary, peduncle 2 cm long
Petal : white to yellowish
Calyx: 8 lobes slender less than 3 cm long erect or slightly spreading in fruit, yellowish green
Size : 0.6 - 1.0 cm in length
Others : flower erect at anthesis

Fruit

Shape : cylindrical
Size : up to 15 cm long, less than 0.5 cm in diameter
Color : yellowish green
Surface : smooth
Others : detached with calyx, buoyant, dispersed by currents

flower buds

Seed type

viviparous

Other features

tree grow up to 20 m in height

Specific features for comparison with other species in the same genus

Comparing with

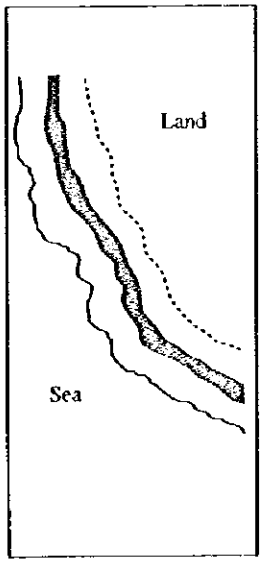
B. gymnorrhiza and *B. sexangula*: color of calyx (yellowish green) and size of flower (smaller)

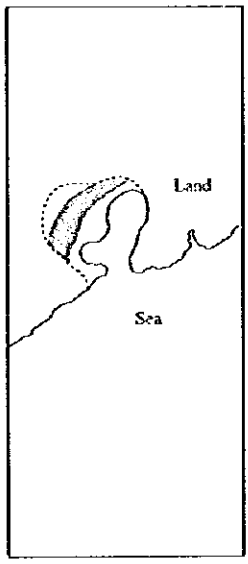
Other *Bruguiera spp.*: size of leaves (smallest)

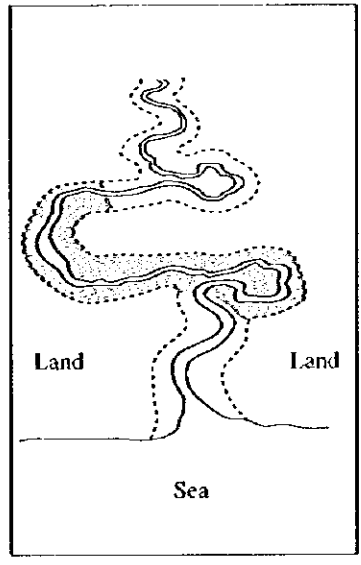
B. cylindrica: bark (without white patches) and length of calyx (longer)

Location

found in the inner mangroves on the firm mud flat, along river banks







Bruguiera sexangula /Family : RHIZOPHORACEAE/

Leaf

Unit : simple
Arrangement : opposite
Blade shape : elliptical
Apex shape : acuminate
Color : dark green
Size : 8 - 16 cm long by 3 - 6 cm wide
Others : leathery

Bark

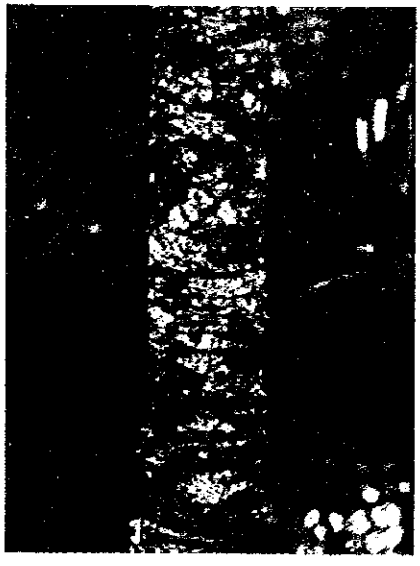
many pustules, young bark- smooth and brown, old bark-rough, black and fissured

Roots

knee-roots and short buttress

Flower

Inflorescence : large flower, usually single, axillary
Petal : white to brown, tip of petal lobes blunt without filaments
Calyx : 10 - 14 lobes, yellow or tinged with red (orange), 2.5 cm long, bell-shaped, leathery in texture
Size : 3 - 4 cm in length



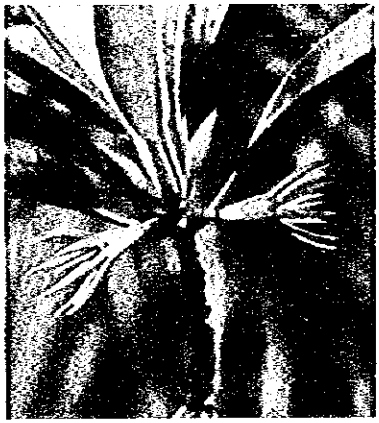
Fruit

Shape : cylindrical, cigar-shaped, blunt apically
Size : less than 15 cm long, 1 - 2 cm in diameter
Color : green to purple tinted brown
Surface : little rough to touch
Others : detached with calyx, buoyant, dispersed by currents

Seed type

viviparous

Official common name : **Pototan /Major mangrove elements**



Other features

tree grows up to 30 m or more in height, white covering absent

Specific features for comparison with other species in the same genus

Comparing with

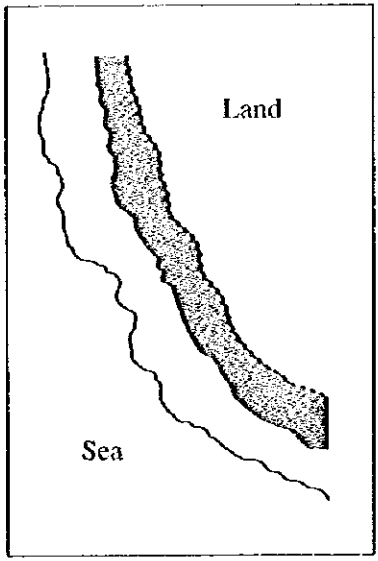
Other *Bruguiera spp.*:color of calyx (yellow or tinged with red (orange))

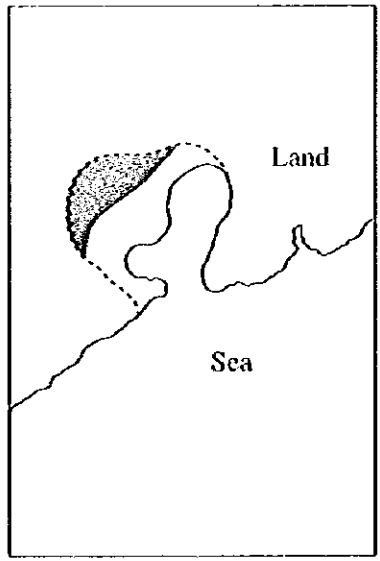
B. gymnorrhiza: bark (more pustule) and twigs and petioles (lacks the white waxy covering)

B. parviflora and *B. cylindrica* : size of flower (larger)

Location

usually found in the middle mangroves community and extends into the landward area, on firm mud





Camptostemon philippinensis / Family : BOMBACACE

Leaf

Unit : simple
Arrangement : alternate
Blade shape : oval to obovate
Apex shape : rounded
Color : light green
Size : 8 - 10 cm long by 3 - 4 cm wide
Others : small scales on both surfaces, spirally arranged

Bark

brown, unfissured

Roots

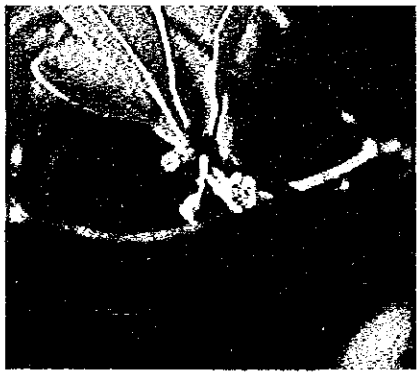
plank-root

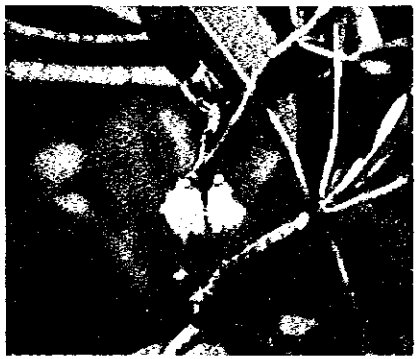
Flower

Inflorescence : axillary, cyme
Petal : five (5) and white
Size : 0.5 cm in length
Others : 5 stamens, with cotton-like hairs

Fruit

Shape : pear-shaped capsule
Size : 1.5 cm long by 0.8 cm
Color : green
Surface : covered with small and round scales
Others : scaly laterally flattened, few seeds covered with cotton-like substance





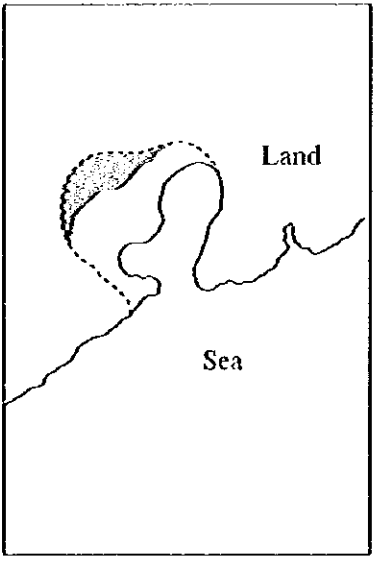
after flower before fruit

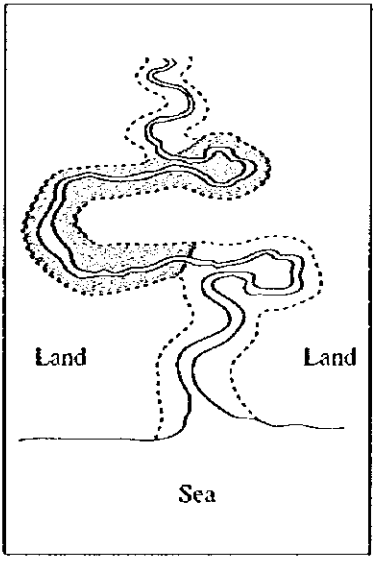
AE / Official common name : Gapas-gapas /Minor mangrove elements

Seed type
cryptoviviparous

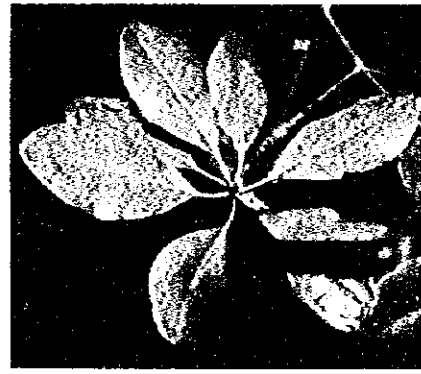
Other features
tree grows up to 10 m or more in height

Location
usually observed on inner edges of the mangrove forest and along river banks





Ceriops decandra / Family: RHIZOPHORACEAE /



Leaf

Unit : simple
Arrangement : opposite
Blade shape : oval to obovate
Apex shape : emarginate to rounded
Color : glossy yellowish green
Size : 7 - 12 cm long by 3 - 5 cm wide
Others : leathery

Bark

pale grayish brown, smooth, slightly fissured, inclined to flake

Roots

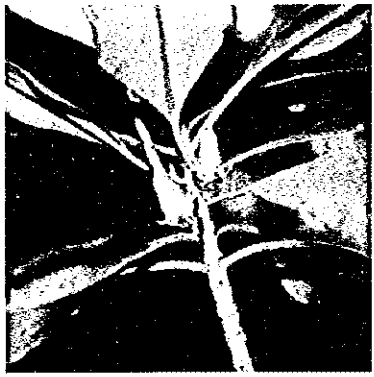
buttress originating stilt-like roots

Flower

Inflorescence : 5 - 10 flowered, condensed cyme, axillary
Petal : 5, white, not enclosing the stamens at anthesis
Calyx : 5 lobes, light greenish yellow, 5 mm long, somewhat pointed
Size : 0.4 - 0.5 cm in diameter
Others: flower on short stout peduncle (less than 10 mm long by 3 - 4 mm diameter)

Fruit

Shape : cylindrical, blunt apex
Size : 9 - 15 cm long, 0.8 - 1.2 cm diameter
Color : green to brown (hypocotyle), dark red when mature (cotyledonary)
Surface : relatively smooth, warty toward apex, ridge-shaped and grooved
Others : calyx lobes erect in fruit, buoyant, dispersed by currents



young fruit

Seed type

viviparous

Other features

small to moderately tall tree up to 20 m in height, usually a bushy shrub or dwarf tree

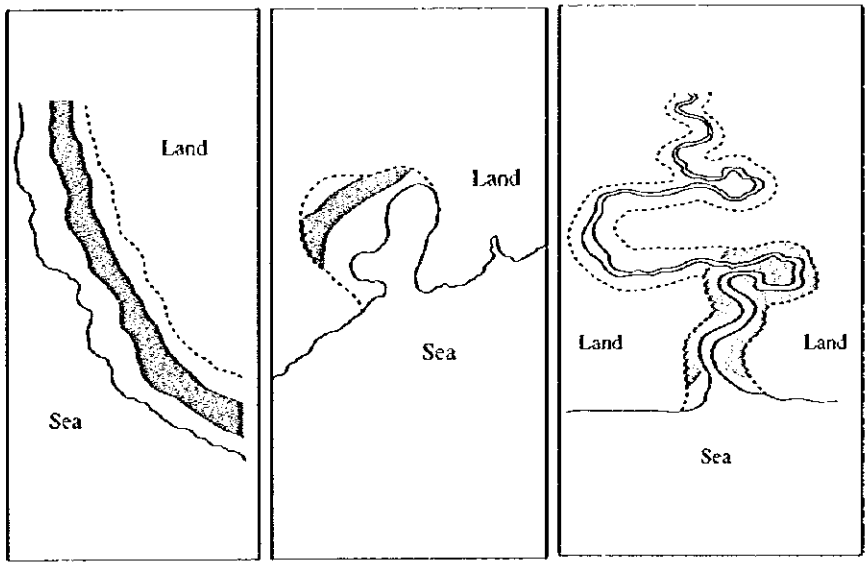
Specific features for comparison with other species in the same genus

Comparing with

C. tagal: bark (dark color, less flaky), fruit (shorter, blunt apex), calyx lobes in fruit (erect), peduncle (short stout), stamens at anthesis (not enclosing)

Location

within the tidal zone mixed with other Rhizophoraceae, mouth of tidal stream, muddy soil inland, but less common than *C. tagal*.



Ceriops tagal / Family : RHIZOPHORACEAE /

Leaf

Unit : simple
Arrangement : opposite
Blade shape : oval to obovate
Apex shape : emarginate to rounded
Color : glossy yellowish green
Size : 7 - 12 cm long by 3 - 5 cm wide
Others : leathery

Bark

pale grayish white with a red tinge, smooth slightly fissured, peeling in thick strips from the buttressed portion

Roots

buttress originating stilt-like roots

Flower

Inflorescence : 5 - 10 flowered, hanging cyme, axillary
Petal : 5, white, enclosing the stamens in pairs at anthesis
Calyx : 5 lobes, light greenish yellow, 6 mm long, oblong and somewhat blunt
Size : 0.4 - 0.5 cm in diameter
Others : flower on long slender peduncle (10 - 20 mm long by 2 mm diameter)

Fruit

Shape : cylindrical, sharply pointed apex
Size : 16 - 30 cm long, 0.8 - 1.2 cm diameter
Color : green to brown (hypocotyle), yellow when mature (cotyledonary)
Surface : relatively smooth, warty throughout, slightly ridged and grooved
Others : calyx lobes spread or reflexed in fruit, buoyant, dispersed by currents

Official common name : Tangal /Major mangrove elements

Seed type

viviparous

Other features

small to moderately tall tree up to 20 m in height, usually a bushy shrub or dwarf tree in unfavorable localities

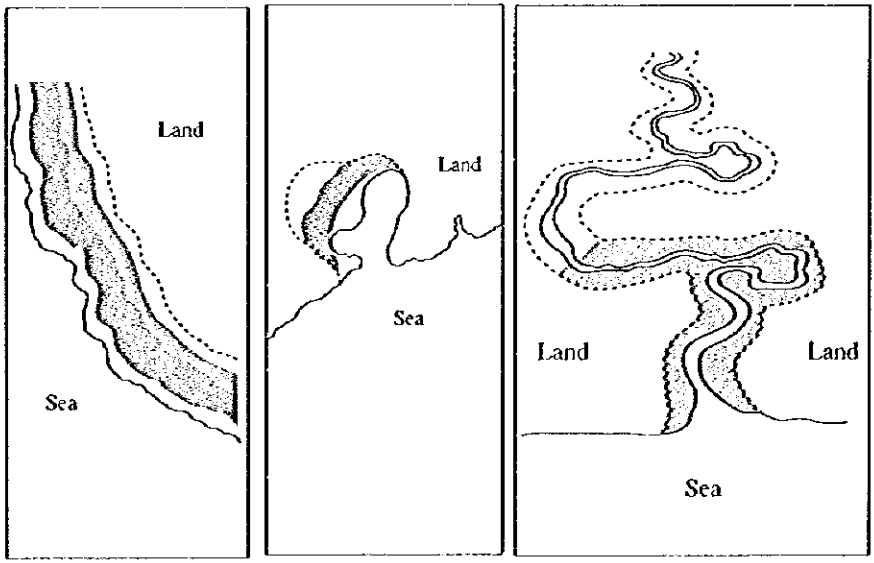
Specific features for comparison with other species in the same genus

Comparing with

C. decandra: bark (light color, more flaky), fruit (longer, pointed apex), calyx lobes in fruit (spread or reflexed), peduncle (long slender), stamens at anthesis (enclosing)

Location

Rather more common than C. decandra in the same habitat especially inner mangroves on well drained soil.



Excoecaria agallocha / Family : EUPHORBIACEAE /

Leaf

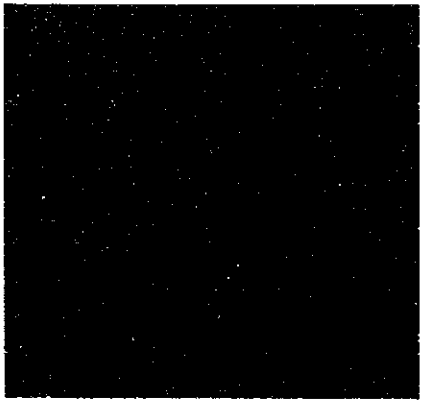
Unit : simple
Arrangement : alternate
Blade shape : elliptical
Apex shape : acute
Color : green and shiny
Size : up to 9 cm long and 6 cm wide
Others : spirally arranged, leaf margin slightly wavy

Bark

gray with diagonal marking, rough

Roots

no prominent aerial roots



flower

Flower

Inflorescence : male catkin or spike, female raceme, axillary
Petal : green and white
Calyx : yellowish green

Size : male 5 - 10 cm long, female 2 - 3 cm long
Others : unisexual inflorescence, 3 yellow stamens

Fruit

Shape : combined 3 balls (3 lobes)
Size : 0.5 - 0.7 cm in diameter
Color : green
Surface : smooth, leathery

Seed type

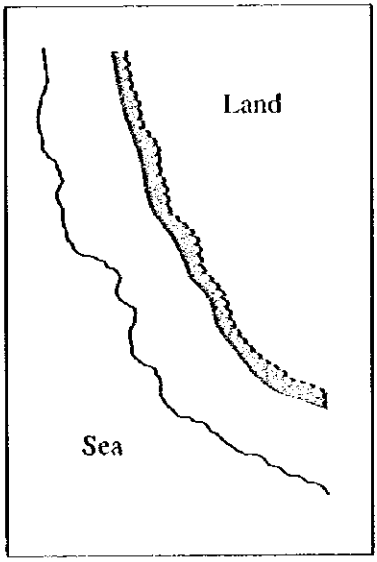
normal seed, black 3 mm in diameter

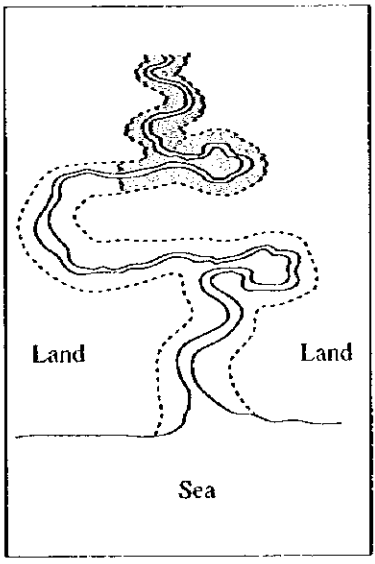
Other features

abundant white and milky latex, irritating can cause blisters or temporary blindness if in contact with eyes and skin

Location

open site, landward edge of mangrove, at or just above the high tide mark, dry area on firm mud or sand, common along bank of tidal streams and rivers.





Heritiera littoralis / Family: STERCULIACEAE /

Leaf

Unit : simple
Arrangement : alternate
Blade shape : elliptical to obovate
Apex shape : acute
Color : upper surface dark green, undersurface grayish white
Size : usually 10 - 20 cm long by 5 - 10 cm wide (but up to 30 cm by 15 - 18 cm wide)

Bark

dark gray, fissured

Roots

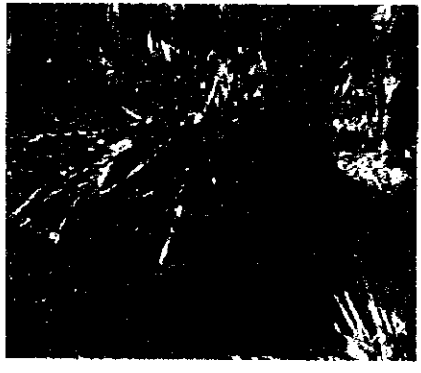
buttress well developed, plank-roots

Flower

Inflorescence : loose panicle, axillary or terminal
Petal : purple and brown
Calyx : 4 - 5 (- 6) lobes, cup-shaped, reddish
Size : female 0.4 - 0.5 cm long, 0.3 - 0.4 mm in diameter
Others : unisexual flower, densely hairy

Fruit

Shape : oval ball with ridge on outer edge resembles a chicken's comb
Size : 5 - 7 cm long
Color : green to brown
Surface : smooth
Others : buoyant, dispersed by currents

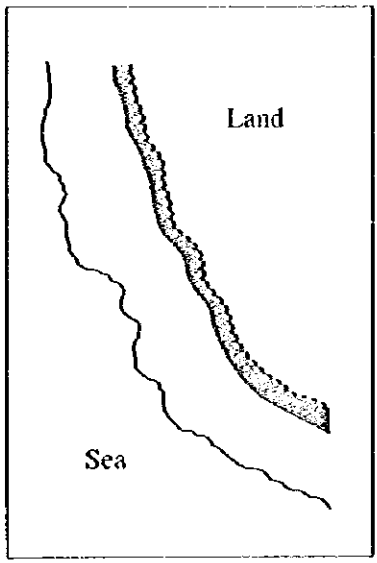


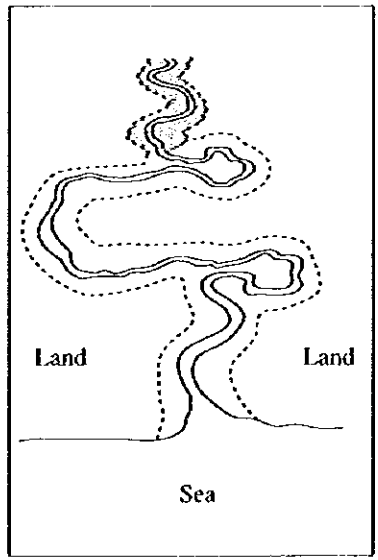
Official common name : Dungon-late /Minor mangrove elements

Seed type
normal seed

Other features
height up to 25 m, intolerant of high salinity

Location
landward edge of mangrove, along upstream of rivers





Lumnitzera littorea /Family: COMBRETACEAE/

Leaf

Unit : simple
Arrangement : alternate
Blade shape : obovate
Apex shape : round to emarginate
Color : green
Size : 4 - 8 cm long
Others: very thick, both surfaces are almost the same, fleshy leaves with an indentation at the end, glabrous

Bark

gray to dark brown, sometimes has pustules, grooved, rough, fissured along the long axis of the trunk

Roots

small buttress and looped laterals that protrude up to 10 cm above the substrate

Flower

Inflorescence : spike, terminal, 2 - 3 cm long
Petal : 5, bright red
Calyx : 5 lobes, green
Size : 1.6 - 1.8 cm long, 0.5 - 0.7 cm in diameter
Others : less than 10 stamens much longer than the petals

Fruit

Shape : vase-shaped
Size : 1.5 - 2.5 cm long
Color : green tinged with red
Surface : glossy
Others:narrowed at each end with a persistent calyx, buoyant, dispersed by currents

Seed type

normal seed (single)

Official common name : Tabau /Major mangrove elements

Other features

usually small multi-branched shrubs with red twigs, tree can grow up to 35 m

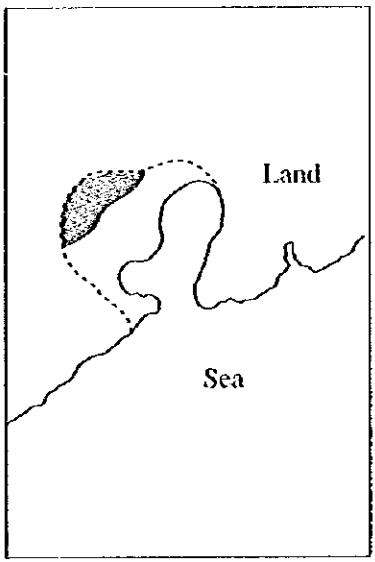
Specific features for comparison with other species in the same genus

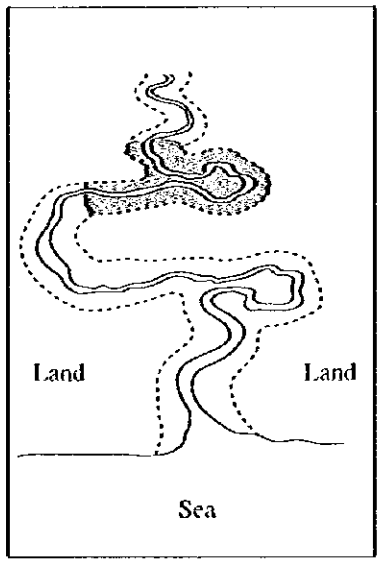
Comparing with

L. racemosa: color of flower (red), color and size of fruit (green tinged with red, longer), leaf blade when young (glabrous), leaf (slightly larger and thicker), bark (slightly less fissured)

Location

landward fringe, along river banks, less saline areas, well-drained sites





Lumnitzera racemosa / Family : COMBRETACEAE /

Leaf

Unit : simple
Arrangement : alternate
Blade shape : obovate
Apex shape : round to emarginate
Color : green
Size : 3 - 7 cm long
Others : very thick, both surfaces are almost the same, sometimes hairy when young

Bark

gray to dark brown, grooved, rough, fibrous fissured longitudinally

Roots

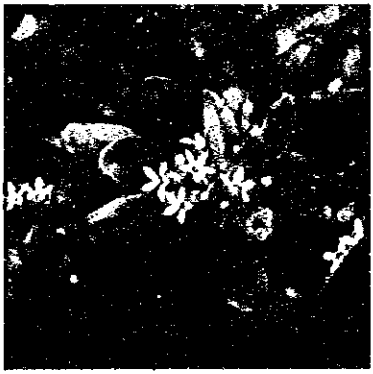
small buttress, looping lateral roots sometimes develop, but less commonly than in *L. littorea*

Flower

Inflorescence : spike, axillary or terminal, 1 - 2 cm long
Petal : 5, white
Calyx : 5 lobes, green
Size : 0.7 - 0.8 cm long, 0.4 - 0.5 cm in diameter
Others : less than 10 stamens as long as the petals

Fruit

Shape : vase-shaped
Size : 1.0 - 1.5 cm long
Color : green
Surface : glossy
Others : narrowed at each end with a persistent calyx, buoyant, dispersed by currents



Seed type

normal seed (single)

Other features

usually small multi-branched shrubs with brown twigs, rarely growing more than 6 m

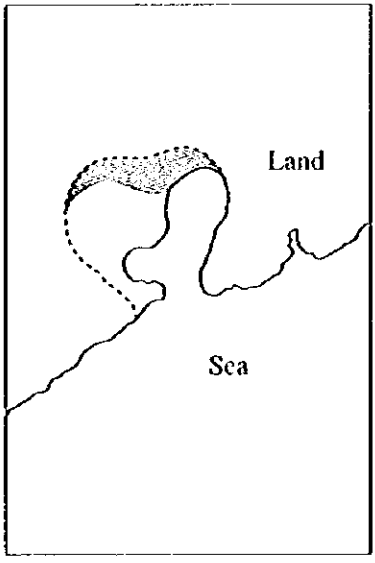
Specific features for comparison with other species in the same genus

Comparing with

L. littorea:color of flower (white), color and size of fruit (green, shorter), leaf blade when young (sometimes hairy), leaf (slightly smaller and thinner), bark (slightly more fissured)

Location

landward fringe, saline areas, dry part or sandy portions.



Nypa fruticans /Family : PALMAE /

Leaf

Arrangement : palm leaf
Blade shape : lanceolate (leaflet)
Apex shape : acute (leaflet)
Color : green
Size : leaf unit 4 - 9 m long
Others : shinning, smooth and no spines

Bark

smooth, green and light brown at the base

Roots

no prominent aerial roots

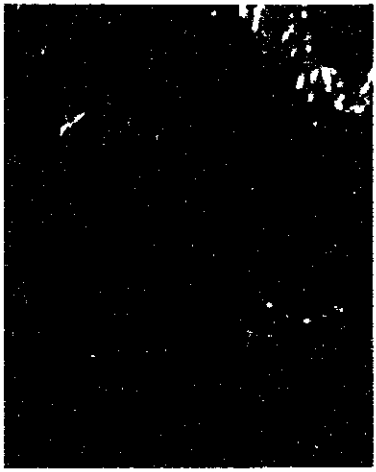
Flower

Inflorescence : on a long peduncle, at its tip circular cluster of flowers of two forms male and female
Size : 25 cm (female)
Others : female, globose-like head, male, catkin-like, orange to yellow in color

Fruit

Shape : globose, similar to pandanus
Size : circular fruiting head 30 cm or more in diameter
Color : young green, mature brown
Others : on a special erect stout stalk

Official common name : Nipa /Major mangrove elements



fruit

Seed type

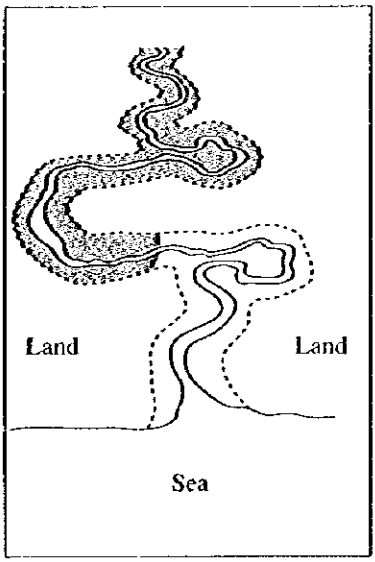
cryptoviviparous

Other features

a shrubby stout palm with thick short horizontal stem that is buried in the mud, forms large colonies

Location

along the river banks where there is freshwater and saltwater influence



Osbornia octodonta / Family : MYRTACEAE /

Leaf

Unit : simple
Arrangement : opposite
Blade shape : obovate
Apex shape : rounded
Color : green
Size : 2 - 6 cm long by 2 cm wide
Others:petiole tinged with red, aromatic when crushed, both surfaces are almost the same, have oil glands (translucent dots)

Bark

gray or reddish brown, spongy flaking, fibrous

Roots

no prominent aerial roots, sometimes obscure buttress

Flower

Inflorescence : 1 - 3 flowered cyme, axillary
Calyx : bell-shaped or berry-like with 8 lobes,

yellowish green, dense hairy
Size : 0.5 - 0.7 cm in length
Others : numerous stamens (up to 48), white to yellow

Fruit

Shape : spherical
Size : 0.7 cm long, 0.5 cm diameter
Color : yellowish green
Surface : densely hairy, leathery in texture
Others : one or two seeds

Seed type

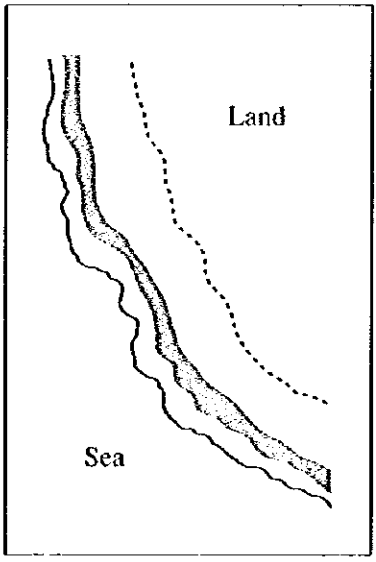
normal seed

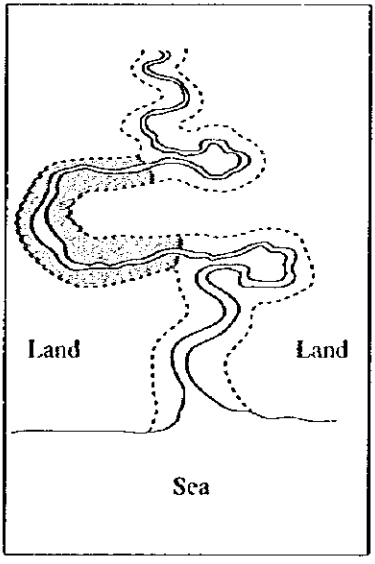
Other features

low shrub or small bushy tree

Location

Usually on more exposed sites in association with mangroves, on sandy or gravelly shores. It is not abundant.





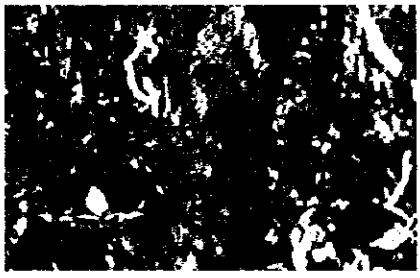
Rhizophora apiculata / Family : RHIZOPHORACEAE /

Leaf

Unit : simple
Arrangement : opposite
Blade shape : narrowly elliptical
Apex shape : apiculate (with an abrupt slender tip)
Color : upper surface dark glossy green, undersurface pale green
Size : 6 - 18 cm long by 2 - 6 cm wide
Others : undersurface has small black dots, scattered sometimes indistinct

Bark

young tree- light gray and smooth; mature tree - gray to dark gray, vertical fissure and tesselated



Roots

stilt-roots

Flower

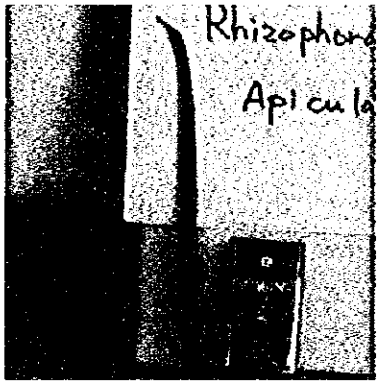
Inflorescence : 2 flowered, cyme, axillary
Petal : 4, white, glabrous
Calyx : 4 lobes, golden yellow to pale yellow, 2.0 - 3.0 cm when spread
Others : flowers in pairs on a short, stout and stiffened peduncle about 1.0 cm shorter than the petiole, usually 12 stamens, with brown style 1 mm long

Fruit

Shape : cylindrical fruit, frequently curved
Size : 20 - 30 cm long, 1 - 2 cm diameter
Color : green tinged with red
Surface : warty (relatively smooth)
Others : hypocotyl, detaches from under cotyledonary collar, buoyant, dispersed by currents

Seed type

viviparous



Other features

shoot, stipule, petiole, midrib, and terminal bud reddish, trees can grow up to 30 m

Specific features for comparison with other species in the same genus

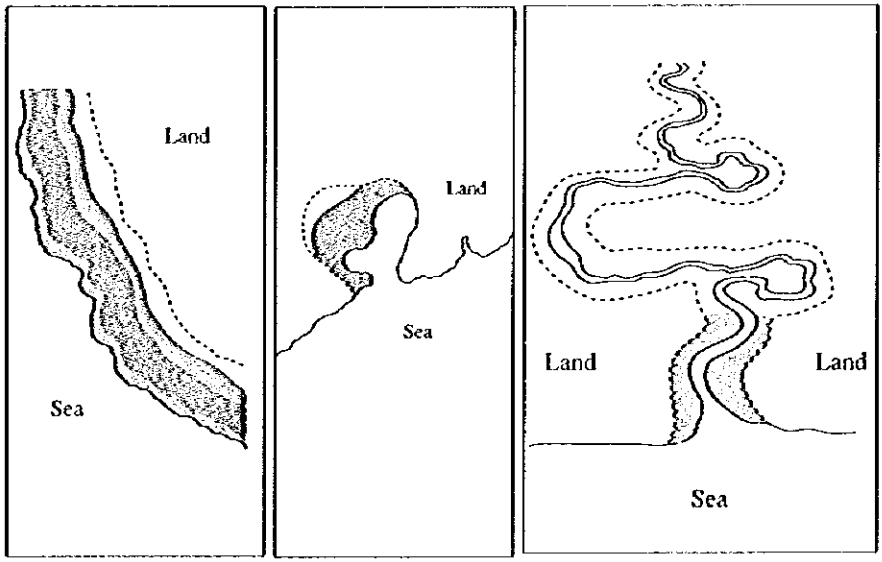
Comparing with

Other *Rhizophora spp.*: color of shoot and terminal bud etc. (reddish), number of flowers (two), length of peduncle (shorter), surface of petal (glabrous)

R. mucronata: size of leaf (narrower), surface of bark (not so rough), length of fruit (shorter)

Location

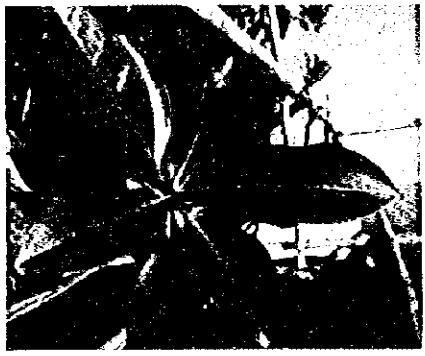
this species is usually found low in the intertidal zone with soft mangrove mud, on estuaries normally flooded by the tides.



Rhizophora mucronata / Family : RHIZOPHORACEAE

Leaf

Unit : simple
Arrangement : opposite
Blade shape : elliptical
Apex shape : apiculate (with an abrupt tooth-like tip)
Color : upper surface dark green, undersurface light green
Size : 8 - 23 cm long by 5 - 13 cm wide
Others : undersurface has small black dots, scattered sometimes indistinct



Bark

young tree- light gray and smooth; mature tree - gray to dark gray, rough, horizontal fissure and tessellated

Roots

stilt-roots, crooked with extensively arching aerial stilt-roots

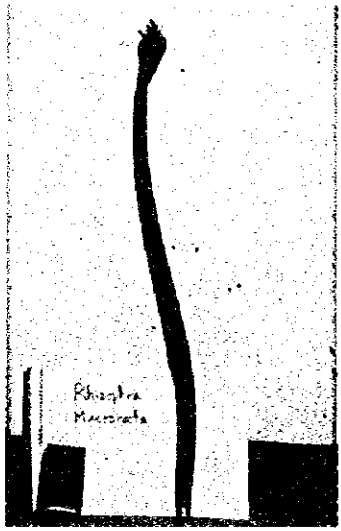
Flower

Inflorescence : 4 or more flowered, dichotomous cyme, axillary
Petal : 4, white, hairy
Calyx : 4 lobes, creamy yellow to yellowish green
Size : 1.5 - 2.0 cm in length, 3 - 4 cm in diameter
Others : peduncle in 2.5 - 4.0 cm, 8 stamens, style 1 mm long

Fruit

Shape : cylindrical fruit, gradually tapering to a hard sharp point
Size : 50 - 100 cm in propagule-length, 1 - 2 cm diameter
Color : green to yellowish green
Surface : warty, rough
Others : hypocotyl, detaches from under cotyledonary collar, buoyant, dispersed by currents

/ Official common name : Bakauan-babae /Major mangrove elements

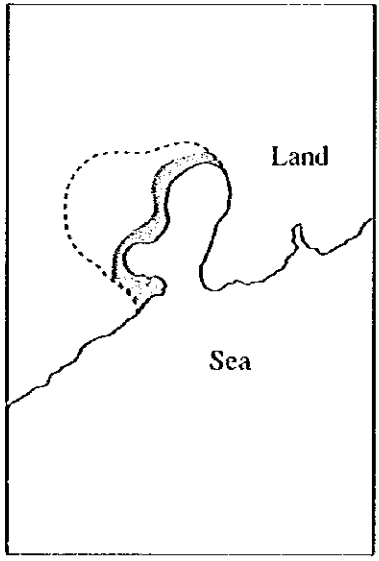


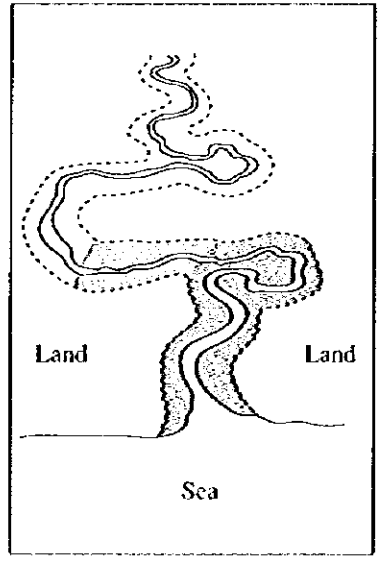
Seed type
viviparous

Other features
shoot, stipule, petiole, midrib, and terminal bud greenish or whitish, trees can grow up to 25 m

Specific features for comparison with other species in the same genus
Comparing with
R. apiculata:color of shoot and terminal bud etc. (greenish or whitish), number of flowers (4 or more), length of peduncle (longer), surface of petal (hairy)
Other *Rhizophora spp.*: size of leaf (broader), and surface of bark (rough), length of fruit (longer)
Rhizophora stylosa: length of style (shorter)

Location
in the tidal stream, river banks and estuaries





Rhizophora stylosa / Family : RHIZOPHORACEAE /

Leaf

Unit : simple
Arrangement : opposite
Blade shape : elliptical
Apex shape : apiculate (with an abrupt tooth-like tip)
Color : upper surface dark green, undersurface pale green
Size : 7 - 20 cm long by 4 - 7 cm wide
Others : undersurface has small, scattered black dots, sometimes indistinct

Bark

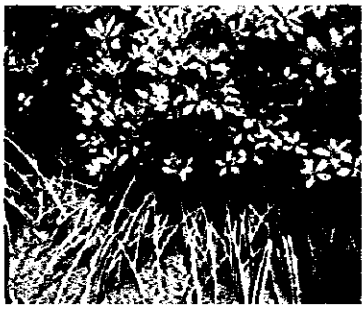
young tree - light gray and smooth; mature tree - gray to black, rough, fissure and tessellated

Roots

stilt-roots

Flower

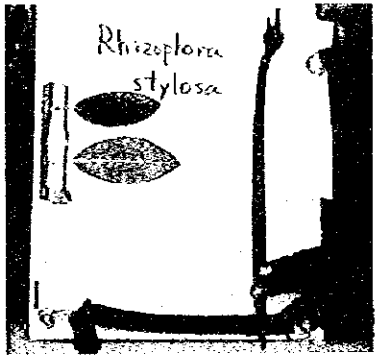
Inflorescence : 4 or more flowered, dichotomous cyme, axillary
Petal : 4, white, hairy
Calyx : 4 lobes, creamy yellow to yellowish green
Size : 1.5 - 2.0 cm in length, 2.5 - 3.5 cm in diameter
Others : peduncle in 2.5 - 4.0 cm, 8 stamens, style 0.4 - 0.6 mm long



Fruit

Shape : cylindrical fruit, pointed
Size : 20 - 30cm in propagule-length, 1 - 2 cm diameter
Color : green to yellowish green
Surface : warty (relatively smooth)
Others : hypocotyl, detaches from under cotyledonary collar, buoyant, dispersed by currents

Official common name : Bakauan-bato /Major mangrove elements



Seed type

viviparous

Other features

shoot, stipule, petiole, midrib, and terminal bud greenish or whitish, trees can grow up to 20 m

Specific features for comparison with other species in the same genus

Comparing with

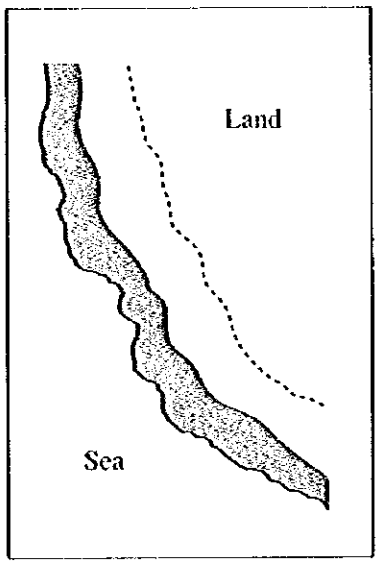
R. apiculata : color of shoot and terminal bud etc. (greenish or whitish), number of flowers (4 or more), length of peduncle (longer), surface of petal (hairy)

R. mucronata: size of leaf (narrower), surface of bark (not so rough), length of fruit (shorter)

Other *Rhizophora spp.*:length of style (longer)

Location

seaward, low in the intertidal zone, sandy shores, coralline substrate, rocky coastline



Scyphiphora hydrophyllacea / Family : RUBIACEAE /

Leaf

Unit : simple
Arrangement : opposite
Blade shape : obovate
Apex shape : rounded
Color : very shiny green
Size : 4 - 7 cm long by 2 - 4 cm wide
Others : petiole tinged with red, leathery and glabrous surface, two terminal leaves are covered with sticky substance and are closely pressed together

Bark

rough, brown

Roots

no prominent aerial roots, occasionally has stilt-roots

Flower

Inflorescence : 3 - 7 flowered, condensed cyme, axillary
Petal : 4 or 5, white tinged with pinkish or red
Calyx : 4 or 5 obscure lobes, 0.4 cm long
Size : 3 - 5 cm in length
Others : peduncles with 0.2 - 1.5 cm, 4 - 5 stamens

Fruit

Shape : barrel shaped, small gear-like (8 to 10 longitudinal grooves)
Size : less than 1 cm in length, 0.4 - 0.5 cm

Official common name : **Nilad /Major mangrove elements**

diameter

Color : green to brown

Surface : glabrous

Seed type

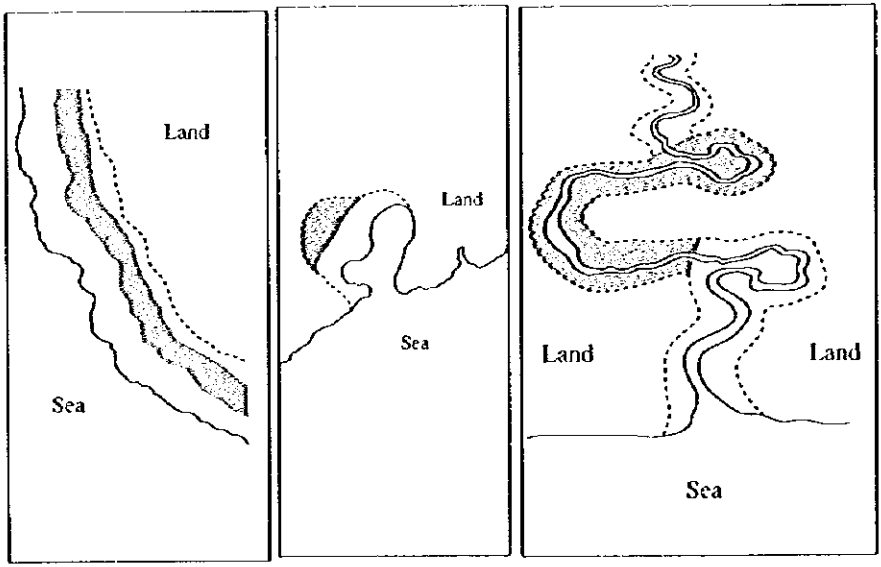
normal seed

Other features

petioles and young shoots sticky to touch, height up to 3 m

Location

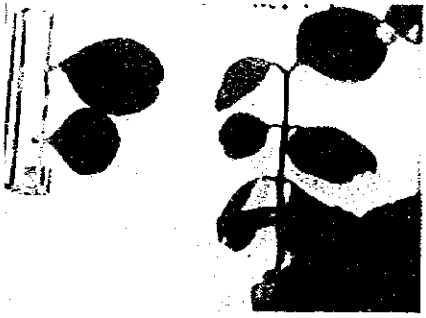
inner mangrove area, banks of tidal streams, along river banks, firm mud or sandy soil



Sonneratia alba /Family : SONNERATIACEAE/

Leaf

Unit : simple
Arrangement : opposite
Blade shape : oblong to obovate
Apex shape : rounded to emarginate
Color : dark green both surface
Size : 5 - 10 cm long by 4 - 5 cm wide
Others:both surfaces are almost the same, fleshy, juvenile leaf petiole is yellow



Bark

light or dark brown, irregularly fissured, smooth with fine

Roots

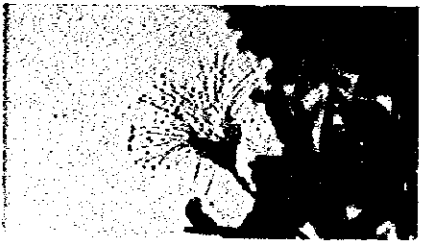
pneumatophores, conical

Flower

Inflorescence : 1 to a few flowered, cyme, terminal or branchlet
Petal : white
Calyx : 6 - 8 lobes, green, inner side pale yellow partly pinkish, plenty of nectar in the tube
Size : 5 - 8 cm in diameter
Others : numerous stamens with white, flower ephemeral, opening in late evening and lasting one night

Fruit

Shape : cylindrical (large base and short length)
Size : 3.5 - 7 cm in diameter
Color : green
Surface : smooth
Others : seated on flat or reflexed calyx, apex not depressed at base of style, calyx cup shaped enclosing the base of fruit



Official common name : Pagatpat /Major mangrove elements

Seed type

normal seed, contains 150 - 200 seeds in a fruit

Other features

bole crooked rarely straight, height up to 20 m

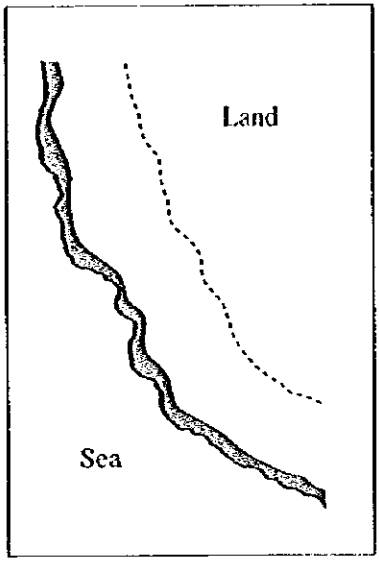
Specific features for comparison with other species in the same genus

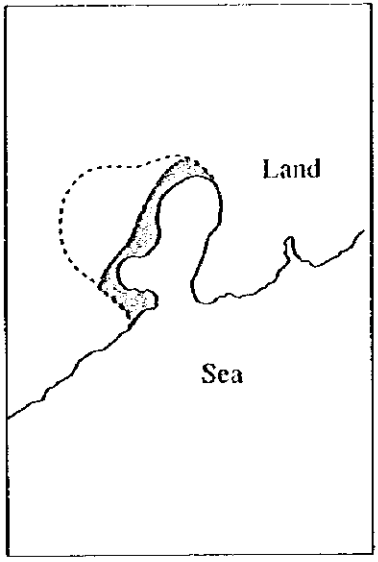
Comparing with

S. caseolaris: shape of leaf (sometimes obovate and emarginate), color of juvenile leaf petiole (yellow), location (often seaward fringe)

Location

newly-formed sandy mud flats in sheltered situations, often found in seaward fringe, estuaries with stagnant or slow moving water, tolerates saline areas





Sonneratia caseolaris / Family : SONNERATIACEAE /

Leaf

Unit : simple
Arrangement : opposite
Blade shape : elliptic - oblong or oval - obovate
Apex shape : rounded with prominent recurved tip
Color : green both surface
Size : 5 - 13 cm long by 2 - 5 cm wide
Others : both surfaces are almost the same, fleshy adult leaf, less fleshy juvenile leaf with petiole red in color

Bark

dark gray, fissured

Roots

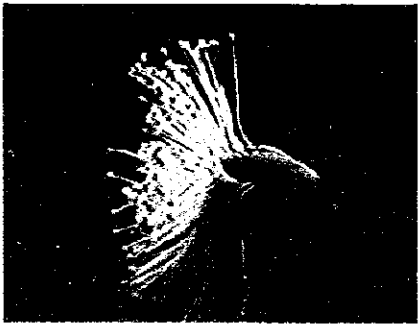
pneumatophores, conical up to more than 1 m

Flower

Inflorescence : 1 to a few flowered, cyme, terminal
Petal : red
Calyx : 6 - 8 lobes, green, inner side reddish, plenty of nectar in the tube
Size : 8 - 10 cm in diameter
Others : numerous stamens with white and red, flower ephemeral, opening in late evening and lasting one night

Fruit

Shape : cylindrical (large base and short length)
Size : 5 - 8 cm in diameter
Color : green
Surface : smooth, glossy
Others : surrounded by spreading star-shaped red-throated calyx tube, calyx flat and horizontal not enclosing the ripe fruit



Seed type

normal seed, contains 800 - 1200 seeds in a fruit

Other features

bole crooked, rarely straight, height up to 15 m

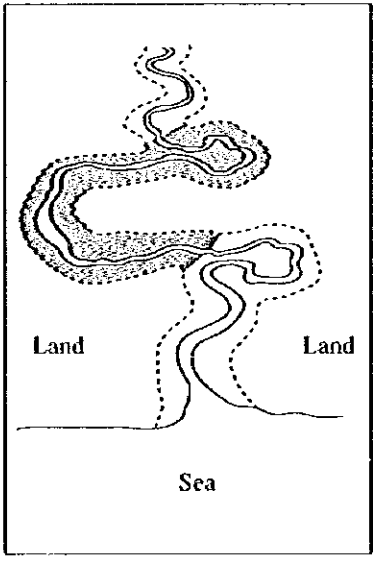
Specific features for comparison with other species in the same genus

Comparing with

S. alba : shape of leaf (sometimes elliptic - oblong and rounded), color of juvenile leaf petiole (red), location (river banks)

Location

estuarine river banks, prefers less saline areas, rocky, sandy or muddy soil



Xylocarpus granatum /Family : MELIACEAE/

Leaf

Unit : compound (pinnate)
Arrangement : alternate, usually 4 or 6 leaflets (opposite)
Blade shape : oval to obovate (leaflet)
Apex shape : rounded (leaflet)
Color : green
Size : 7 - 12 cm long by 4 - 6 cm wide (leaflet)
Others : leathery surface, thick

Bark

yellowish-brown, paper-like flake fall off exposing the inner green bark, smooth

Roots

buttress and plank root

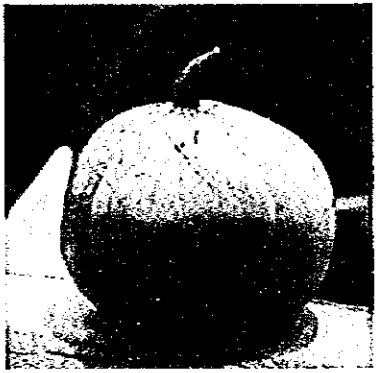
Flower

Inflorescence : 8 - 20 flowered, panicle, mainly axillary
Petal : 4, creamy to pinkish white
Calyx : 4 lobes, yellowish green
Size : 0.5 cm in length, 1.0 - 1.3 cm in diameter
Others : unisexual flower, creamy white stamens fused into tubes, scented

Fruit

Shape : ball (spherical melon)
Size : 15 - 25 cm in diameter
Color : yellowish brown
Surface : leathery
Others : with corky leathery cover, buoyant, dispersed by currents, heavy (1 - 2 kg), contains 6 - 18 seeds

Official common name : Tabigi /Minor mangrove elements



Seed type

normal seed

Other features

grows up to 25 m, stem usually contorted often hollow, crooked and branched with a short bole

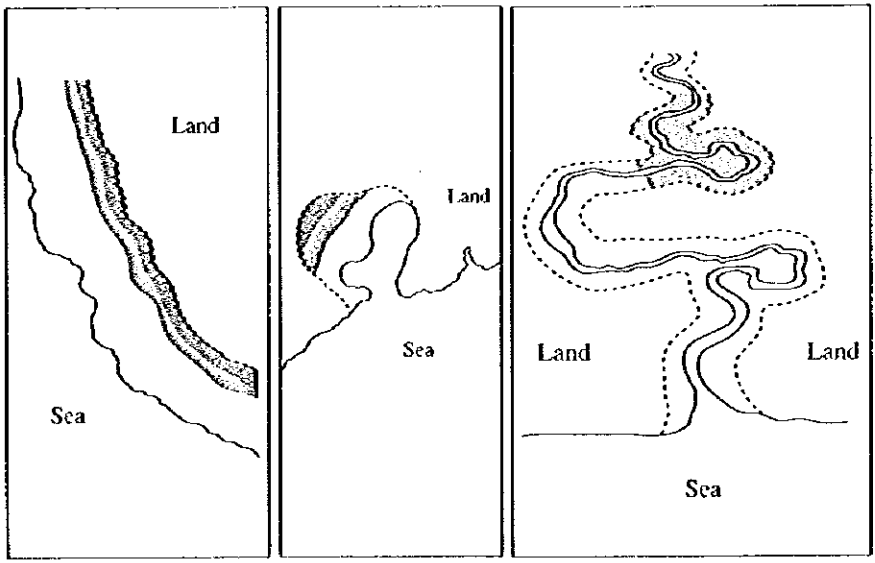
Specific features for comparison with other species in the same genus

Comparing with

X. moluccensis: size of fruit (larger), color and surface of bark (light brown, flaky and smooth), thickness and surface of leaflet (thick and leathery)

Location

Landward edge of mangrove area, upper portion of river banks, common on dry grounds, inner low-salinity areas, sandy, rocky



Xylocarpus moluccensis / Family : MELIACEAE /

Leaf

Unit : compound (pinnate)
Arrangement : alternate, usually 4 or 6 leaflet (opposite)
Blade shape : oval to elliptical (leaflet)
Apex shape : acute to rounded (leaflet)
Color : green
Size : 5 - 10 cm long by 3 - 5 cm wide (leaflet)
Others : less leathery surface, thin

Bark

dark gray or dark brown, rough, longitudinally fissured

Roots

short buttress

Flower

Inflorescence : 10 - 35 flowered, panicle, mainly axillary
Petal : 4, creamy to pinkish white
Calyx : 4 lobes, yellowish green
Size : 0.5 cm in length, 0.8 - 1.3 cm in diameter
Others : unisexual flower, creamy white stamens fused into tubes, scented

Fruit

Shape : ball (spherical melon)
Size : up to 10 cm in diameter
Color : green, dark brown when ripe
Surface : leathery
Others : with corky leathery cover, buoyant, dispersed by currents, contains 4 - 16 seeds

Seed type

normal seed

Official common name : Piagau /Minor mangrove elements

Other features

grow up to 25 m, stem cylindrical with a good straight bole

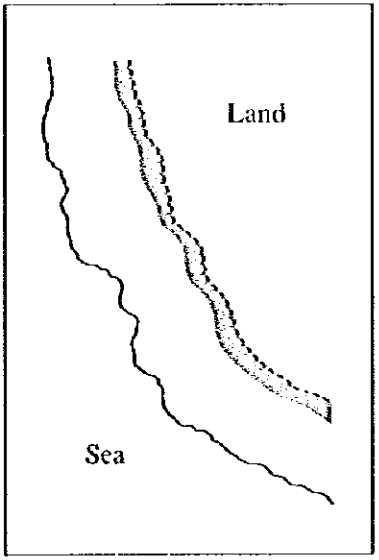
Specific features for comparison with other species in the same genus

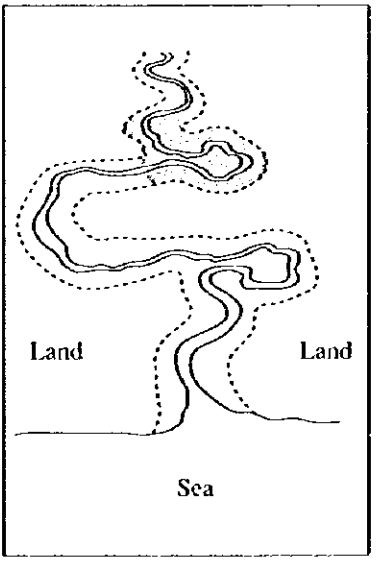
Comparing with

X. moluccensis: size of fruit (smaller), color and surface of bark (dark gray, not flaky and rough), thickness and surface of leaflet (thin and less leathery)

Location

upper portion of river banks, inner low-salinity areas, common on dry grounds, sandy, rocky





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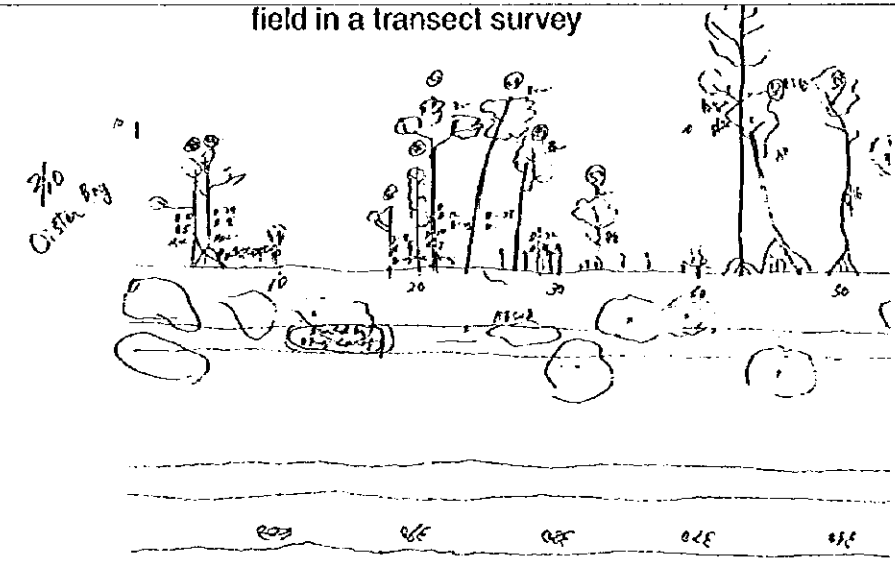
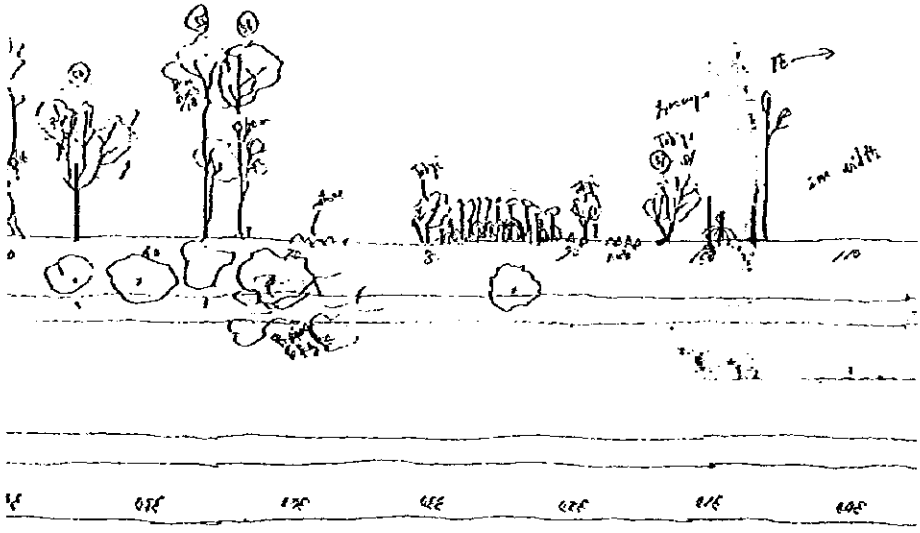
Appendices

Appendix 1 Sample of rough profile sketch drawn on the field in a transect survey





Appendix 2 Field sheet for tree measurement in the transect survey

Tree Measurement Sheet No. _____

Transect No. _____ Survey Place _____

Area ___ X ___ (ha) Time _____ ~ _____ Date / /1999

Tape No.	Tree Species	Diameter (cm)	Hight (m)	Location (m)	Remarks

Appendix 3 Field sheet for soil survey in the transect survey

Field Note for Soil Survey

Sketch on the ground

Date / / Name of Place

Vegetation Length from seaward (m)

Surface water

pH Salinity

Soil water in f 1cm in depth

pH Salinity

Soil water in s 1cm in depth

pH Salinity

Soil water in t 1cm in depth

pH Salinity

0cm

Sketch of soil profile (under ground)

25cm

50cm

75cm

100cm

125cm

150cm

175cm

200cm

Condition on soil layers Depth of soil	Soil Texture	Soil Color	Humus	Condition on gravel, shell, coral pieces and roots	Remarks

Appendix 4 Field sheet for tree measurement in sample plot survey

Tree Measurement Sheet No. _____

Plot No. _____ Survey Place _____

Area _____ X _____ (ha) Time ___ : ___ ~ ___ : ___ Date / /1999

No.	Tree Species	Diameter (cm)	Hight (m)	Remarks

Appendix 5 Field sheet for sample plot survey

Date / /1999 Plot No. _____

Name of Surveyor _____

Area _____ Zone _____

Compartment _____ Sub-Compartment _____

1. Plot Position Tidal level L, M, H

Estuarine location D, I, U, O

2. Crown Density

Upper layer _____ %

Middle layer _____ %

Lower layer _____ %

3. GPS reading

N _____

E _____

4. Dominance (Class 5, 4, 3, 2, 1, +)

Species	Upper	Middle	Lower

5. Regeneration

Sample 1

Species	Number		
	<1m	1~3m	3m≦

Sample 2

Species	Number		
	<1m	1~3m	3m≦

Sample Plot Survey Sheet No.2

Date / /1999 Plot No. _____

6. Land use condition or affection of human activities

7. Stands distribution sketch

8. Land feature sketch

9. Seedling distribution sketch

Sample 1

Sample 2

10. Brief description of the Mangrove Forest

Appendix 6 Sample of "Philippine Mangrove Plot Survey Sheet"

Plot No.45

Area : Ulugan Bay
Zone : Macarascasn
Compartment : 302
Sub-compartment : M9

Location Map

GPS data was not available because the satellites could not be caught

Brief Description of the Mangrove Forest

This plot has land condition of seaside wider flat and is located at middle tidal level and downstream estuarine place. The mangrove forest in the plot is composed of Ra with upper layer crown of old growth and Bg with lower layers crown and almost primary forest. The forest has stand volume of approx. 265cubic meters per ha. Regeneration in the forest is very plenty.

1. Mangrove Stands Condition

a. Number of Stands

b. Dominance

	By Layer						Dominance			Remarks
	Real			Per ha						
Species	U	M	L	U	M	L	U	M	L	
Ra	13	4		289	89		4	3		
Bg		2	15		44	333		+	2	
Total	13	6	15	269	133	333				755 stands / ha

c. Crown Density

Upper layer : 60 %
Middle layer : 20 %
Lower layer : 20 %

d. Land use condition or affection of human activities

Small stumps of Ra show that the forest was utilized by local people. According to the people, trees in the area were cut for charcoal ten years ago.

e. Regeneration
Seedling number by species (Per ha)

Species	number
Ra	85,000
Bg	10,000
Total	95,000

Page 2 (Plot No.45)

2. Stands list (significant volume stands)

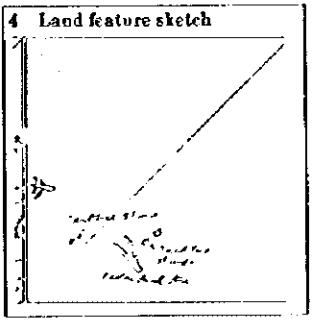
No	Tape No	Species	DBH cm	Height m	Volume M^3
1	921	Ra	30	17	0.661
2	924	Ra	38	18	1.003
3	926	Ra	38	17	1.003
4	927	Ra	30	15	0.572
5	928	Ra	32	17	0.768
6	929	Ra	14	10	0.107
7	930	Ra	32	17	0.768
8	931	Ra	28	15	0.486
9	932	Ra	32	16	0.661
10	934	Ra	28	15	0.486
11	935	Ra	30	16	0.572
12	939	Bg	16	9	0.124
13	940	Ra	30	17	0.661
14	942	Ra	28	19	0.562
15	943	Bg	14	13	0.124
16	948	Ra	26	20	1.003
17	949	Ra	32	18	0.768
18	950	Ra	30	16	0.572
19	951	Bg	14	10	0.124
20	953	Ra	38	18	1.003

3. Stands distribution sketch

Total volume 12.031 cubic meter
267.33 cubic meter per ha

5. Photograph (stand condition of the plot)

4 Land feature sketch



Growth and Yield

Volume Functions

The only available data on mangrove growth and yield are those from studies in Palawan gathered by the Natural Resources Management Center (Cabahug et al. 1983). The derived volume functions in equation form for common mangrove tree species are as follows:

1. *Rhizophora apiculata* Blume (bakauan-lalake)
   $\text{Log } V_1 = -4.029663 + 1.837598 \text{ Log } D + 0.929837 \text{ Log } H$
   $\text{Log } V_2 = -4.791066 + 1.901799 \text{ Log } D + 1.085533 \text{ Log } H + 0.834127 \text{ FF}$

2. *Rhizophora mucronata* Lam. (bakauan-babae)
   $\text{Log } V_1 = -3.788613 + 1.473822 \text{ Log } D + 1.120277 \text{ Log } H$
   $\text{Log } V_2 = -4.667635 + 1.887656 \text{ Log } D + 1.037529 \text{ Log } H + 0.742427 \text{ FF}$

3. *Bruguiera cylindrica* (L.) Blume (pototan lalake)
   $\text{Log } V_1 = -3.814477 + 1.565084 \text{ Log } D + 1.035151 \text{ Log } H$
   $\text{Log } V_2 = -4.680300 + 1.867159 \text{ Log } D + 1.067606 \text{ Log } H + 0.76183 \text{ FF}$

4. *Bruguiera gymnorrhiza* (L.) Lam. (busain)
   $\text{Log } V_1 = -3.629746 + 1.337198 \text{ Log } D + 1.56924 \text{ Log } H$
   $\text{Log } V_2 = -4.771440 + 1.980607 \text{ Log } D + 0.9991424 \text{ Log } H + 0.7803200 \text{ FF}$

5. *Lumnitzera littorea* (Jack) Voight (tabau)
   $\text{Log } V_1 = -3.977934 + 1.621413 \text{ Log } D + 0.9805590 \text{ Log } H$

   $\text{Log } V_2 = -4.557025 + 1.859857 \text{ Log } D + 1.002259 \text{ Log } H + 0.673728 \text{ FF}$

6. *Xylocarpus granatum* Koen. (tabigi)

   $\text{Log } V_1 = -3.942941 + 1.676631 \text{ Log } D + 1.016875 \text{ Log } H$

   $\text{Log } V_2 = -4.878811 + 2.043152 \text{ Log } D + 0.967386 \text{ Log } H + 0.862088 \text{ FF}$

7. *Scyphiphora hydrophyllacea* Gaerth. (nilad)

$$\text{Log } V_1 = -3.316593 + 1.422360 \text{ Log } D + 0.5913420 \text{ Log } H$$

$$\text{Log } V_2 = -3.834415 + 1.653389 \text{ Log } D + 0.704516 \text{ Log } H + 0.245311 \text{ FF}$$

Where: V = volume in cubic meter

D = diameter at breast height

FF = form factor

The form factor (FF) was computed using the formula adopted by Lamwilai (1973):

$$\text{Form Factor} = \frac{\text{Wood Volume of the tree}}{\text{Cylindrical volume corresponding to diameter at big end at same length}}$$

The ranges of form factors of mangrove tree species are shown in Table 3.

Table 3. Range of form factors by species.

Species	Form Factor		
1. *Rhizophora apiculata*	0.3952	to	0.6973
2. *Rhizophora mucronata*	0.3266	to	0.6834
3. *Bruguiera cylindrica*	0.3190	to	0.6783
4. *Bruguiera gymnorrhiza*	0.3545	to	0.6783
5. *Lumnitzera littorea*	0.3342	to	0.6570
6. *Xylocarpus granatum*	0.3645	to	0.6908
7. *Scyphiphora hydrophyllacea*	0.3985	to	0.6946

Form factors vary according to species and dbh or dab. Form factor increases correspondingly as the diameter increases.

The volume table for each species were computed using the selected 2-Index Variable equations. Both volume functions either in equational or tabular form, yield tree volume in cubic meters.

The DBH ranges from 10 to 35, 60, 70 and 75 cm for nilad; pototan and tabigi; busain; bakauan and tabau, respectively at 2.5 cm interval. The tree height range from 2.5 to 15, 17.5, 27.5, and 30 m for nilad; tabigi; busain; pototan and tabau; and bakauan, respectively at 2.5 m interval.

The equations derived should be used normally within these ranges and extrapolation should be done with caution.

Appendix 9 presents the volume tables for *Rhizophora apiculata, R. mucronata, Bruguiera cylindrica, B. gymnorrhiza, Lumnitzera littorea, Xylocarpus granatum,* and *Scyphiphora hydrophyllacea.*

Cubic meter volume for timber-producing mangrove species in Palawan for *Rhizophora apiculata.*

DBH	HEIGHT IN METERS											
(cm)	2.5	5.0	7.5	10.0	12.5	15.0	17.5	20.0	22.5	25.0	27.5	30.0
10.0	0.014	0.026	0.038	0.050	0.062							
12.5	0.021	0.040	0.058	0.076	0.094							
15.0	0.029	0.056	0.082	0.107	0.132							
17.5	0.039	0.075	0.109	0.143	0.176	0.209						
20.0	0.050	0.096	0.140	0.183	0.226	0.268						
22.5	0.062	0.199	0.174	0.229	0.282	0.334						
25.0	0.076	0.145	0.212	0.278	0.343	0.407						
27.5	0.091	0.174	0.254	0.332	0.410	0.486	0.562					
30.0	0.107	0.204	0.299	0.391	0.482	0.572	0.661					
32.5	0.124	0.237	0.347	0.454	0.560	0.664	0.768					
35.0	0.142	0.272	0.398	0.521	0.643	0.763	0.881					
37.5	0.162	0.310	0.453	0.593	0.731	0.868	1.003	1.136	1.269			
40.0	0.182	0.349	0.511	0.669	0.825	0.979	1.131	1.282	1.432			
42.5	0.204	0.391	0.572	0.749	0.924	1.096	1.267	1.436	1.603			
45.0	0.227	0.435	0.637	0.834	1.028	1.220	1.409	1.597	1.784			
47.5	0.251	0.481	0.704	0.922	1.137	1.349	1.559	1.767	1.974	2.179		
50.0	0.277	0.530	0.775	1.015	1.251	1.485	1.716	1.945	1.172	2.398		
52.5	0.303	0.580	0.849	1.112	1.371	1.626	1.879	2.130	2.379	2.626		
55.0	0.330	0.633	0.926	1.213	1.495	1.774	2.050	2.324	2.595	2.865		
57.5	0.359	0.688	1.006	1.318	1.625	1.928	2.227	2.525	2.820	3.112	3.404	
60.0	0.389	0.745	1.089	1.421	1.759	2.087	2.412	2.734	3.053	3.370	3.685	
62.5	0.420	0.804	1.176	1.540	1.898	2.252	2.603	2.950	3.295	3.637	3.977	
65.0	0.451	0.865	1.265	1.657	2.043	2.424	2.801	3.174	3.545	3.913	4.279	
67.5	0.484	0.928	1.357	1.778	2.192	2.601	3.005	3.406	3.804	4.199	4.592	4.982
70.0	0.518	0.993	1.453	1.903	2.345	2.783	3.216	3.645	4.071	4.494	4.914	5.332
72.5	0.554	1.060	1.551	2.032	2.505	2.972	3.434	3.892	4.347	4.798	5.247	5.693
75.0	0.590	1.130	1.653	2.164	2.668	3.166	3.658	4.147	4.631	5.112	5.590	6.065

Cubic meter volume for timber-producing mangrove species in Palawan for *Bruguiera cylindrica.*

DBH	HEIGHT IN METERS											
(cm)	2.5	5.0	7.5	10.0	12.5	15.0	17.5	20.0	22.5	25.0	27.5	30.0
10.0	0.015	0.030	0.045	0.061								
12.5	0.021	0.042	0.064	0.087								
15.0	0.027	0.056	0.086	0.115								
17.5	0.035	0.072	0.109	0.147	0.185							
20.0	0.043	0.089	0.134	0.181	0.228							
22.5	0.052	0.106	0.161	0.217	0.274							
25.0	0.061	0.125	0.190	0.256	0.323							
27.5	0.071	0.145	0.221	0.298	0.375	0.453						
30.0	0.081	0.166	0.253	0.341	0.430	0.519						
32.5	0.092	0.188	0.287	0.386	0.487	0.588						
35.0	0.103	0.212	0.322	0.434	0.547	0.660						
37.5	0.115	0.236	0.359	0.483	0.609	0.736	0.863					
40.0	0.127	0.261	0.397	0.535	0.674	0.814	0.955					
42.5	0.140	0.287	0.437	0.588	0.741	0.895	1.050					
45.0	0.153	0.314	0.477	0.643	0.810	0.979	1.148	1.319				
47.5	0.166	0.341	0.520	0.700	0.882	1.065	1.250	1.435				
50.0	0.180	0.370	0.563	0.758	0.956	1.154	1.354	1.555				
52.5	0.195	0.399	0.608	0.819	1.031	1.245	1.462	1.678	1.896	2.115		
55.0	0.209	0.429	0.654	0.880	1.109	1.340	1.572	1.805	2.039	2.275		
57.5	0.225	0.460	0.701	0.944	1.189	1.436	1.685	1.935	2.186	2.438		
60.0	0.240	0.492	0.749	1.009	1.271	1.535	1.801	2.068	2.337	2.606		
62.5	0.256	0.525	0.798	1.075	1.355	1.637	1.920	2.205	2.491	2.778	3.067	
65.0	0.272	0.558	0.849	1.144	1.441	1.740	2.042	2.345	2.649	2.954	3.261	
67.5	0.289	0.592	0.900	1.213	1.529	1.846	2.166	2.487	2.810	3.134	3.459	
70.0	0.305	0.626	0.953	1.284	1.618	1.954	2.293	2.633	2.975	3.318	3.662	

Cubic meter volume for timber-producing mangrove species in Palawan for *R. mucronata.*

DBH	HEIGHT IN METERS											
(cm)	2.5	5.0	7.5	10.0	12.5	15.0	17.5	20.0	22.5	25.0	27.5	30.0
10.0	0.014	0.029	0.045	0.064	0.082							
12.5	0.019	0.041	0.064	0.089	0.114							
15.0	0.025	0.053	0.084	0.166	0.149							
17.5	0.031	0.067	0.106	0.146	0.187	0.230						
20.0	0.038	0.082	0.129	0.177	0.228	0.280						
22.5	0.045	0.097	0.153	0.211	0.271	0.333						
25.0	0.052	0.113	0.179	0.247	0.317	0.388						
27.5	0.600	0.131	0.206	0.284	0.364	0.447	0.531					
30.0	0.068	0.148	0.234	0.329	0.414	0.508	0.604					
32.5	0.077	0.167	0.263	0.363	0.466	0.572	0.679					
35.0	0.086	0.186	0.293	0.405	0.520	0.638	0.758					
37.5	0.095	0.206	0.325	0.448	0.576	0.706	0.839	0.974	1.112			
40.0	0.104	0.227	0.357	0.493	0.633	0.776	0.923	1.072	1.223			
42.5	0.114	0.248	0.391	0.539	0.692	0.849	1.009	1.172	1.337			
45.0	0.124	0.270	0.425	0.586	0.753	0.924	1.098	1.275	1.455			
47.5	0.134	0.292	0.460	0.635	0.815	1.000	1.189	1.381	1.575	1.773		
50.0	0.145	0.315	0.496	0.685	0.879	1.079	1.282	1.489	1.699	1.912		
52.5	0.156	0.339	0.533	0.736	0.945	1.159	1.378	1.600	1.826	2.054		
55.0	0.167	0.363	0.571	0.788	1.012	1.241	1.475	1.713	1.955	2.200		
57.5	0.178	0.387	0.610	0.842	1.081	1.325	1.575	1.830	2.088	2.349	2.614	
60.0	0.190	0.412	0.649	0.896	1.151	1.411	1.677	1.948	2.223	2.501	2.783	
62.5	0.201	0.439	0.689	0.952	1.222	1.499	1.781	2.069	2.361	2.656	2.956	
65.0	0.213	0.464	0.730	1.008	1.295	1.588	1.887	2.192	2.501	2.814	3.131	
67.5	0.226	0.490	0.772	1.066	1.369	1.679	1.995	2.317	2.644	2.975	3.311	3.650
70.0	0.238	0.517	0.815	1.125	1.444	1.771	2.105	2.445	2.790	3.139	3.493	3.850
72.5	0.251	0.545	0.858	1.184	1.521	1.865	2.217	2.575	2.938	3.306	3.678	4.055
75.0	0.263	0.573	0.902	1.245	1.599	1.961	2.330	2.705	3.088	3.475	3.867	4.263

Cubic meter volume for timber-producing mangrove species in Palawan for *Bruguiera gymnorrhiza*.

DBH	HEIGHT IN METERS										
(cm)	2.5	5.0	7.5	10.0	12.5	15.0	17.5	20.0	22.5	25.0	27.5
10.0	0.014	0.030	0.045	0.064							
12.5	0.021	0.043	0.067	0.092							
15.0	0.028	0.057	0.089	0.124							
17.5	0.035	0.073	0.113	0.157	0.204						
20.0	0.043	0.089	0.138	0.191	0.245						
22.5	0.050	0.105	0.163	0.225	0.292						
25.0	0.058	0.120	0.187	0.259	0.336						
27.5	0.065	0.136	0.211	0.292	0.379	0.473					
30.0	0.073	0.151	0.235	0.325	0.421	0.524					
32.5	0.080	0.165	0.257	0.355	0.461	0.574					
35.0	0.086	0.178	0.278	0.384	0.499	0.621					
37.5	0.092	0.191	0.297	0.412	0.534	0.665	0.805				
40.0	0.098	0.203	0.316	0.437	0.567	0.706	0.855				
42.5	0.103	0.214	0.333	0.460	0.597	0.743	0.900				
45.0	0.108	0.223	0.348	0.481	0.624	0.778	0.942	1.117			
47.5	0.112	0.232	0.362	0.500	0.649	0.808	0.979	1.161			
50.0	0.116	0.240	0.374	0.517	0.671	0.836	1.012	1.201			
52.5	0.119	0.247	0.385	0.532	0.691	0.860	1.041	1.235	1.442	1.654	
55.0	0.122	0.253	0.394	0.545	0.707	0.881	1.067	1.265	1.477	1.704	
57.5	0.124	0.258	0.402	0.555	0.721	0.899	1.088	1.291	1.507	1.738	
60.0	0.126	0.262	0.408	0.565	0.733	0.913	1.106	1.312	1.531	1.766	
62.5	0.128	0.266	0.414	0.572	0.742	0.925	1.120	1.328	1.551	1.789	2.042
65.0	0.129	0.268	0.418	0.578	0.750	0.934	1.130	1.341	1.566	1.806	2.062
67.5	0.130	0.270	0.420	0.582	0.755	0.940	1.138	1.350	1.576	1.818	2.075
70.0	0.131	0.271	0.422	0.584	0.757	0.943	1.142	1.355	1.582	1.825	2.083

Cubic meter volume for timber-producing mangrove species in Palawan for *Xylocarpus granatum*.

DBH	HEIGHT IN METERS											
(cm)	2.5	5.0	7.5	10.0	12.5	15.0	17.5	20.0	22.5	25.0	27.5	30.0
10.0	0.014	0.028										
12.5	0.020	0.041										
15.0	0.027	0.055										
17.5	0.035	0.071										
20.0	0.044	0.089	0.135									
22.5	0.054	0.109	0.164									
25.0	0.064	0.130	0.195									
27.5	0.075	0.152	0.230									
30.0	0.087	0.176	0.266	0.356								
32.5	0.099	0.201	0.304	0.407								
35.0	0.113	0.228	0.344	0.461								
37.5	0.126	0.256	0.386	0.517								
40.0	0.141	0.285	0.430	0.577								
42.5	0.156	0.315	0.476	0.638	0.801							
45.0	0.172	0.347	0.524	0.703	0.881							
47.5	0.188	0.380	0.574	0.769	0.965							
50.0	0.205	0.414	0.626	0.838	0.052							
52.5	0.222	0.450	0.679	0.910	1.141							
55.0	0.240	0.486	0.734	0.984	1.234							
57.5	0.259	0.524	0.791	1.060	1.330							
60.0	0.278	0.562	0.849	1.138	1.428							

Cubic meter volume for timber-producing mangrove species in Palawan for *L.littorea*

DBH	HEIGHT IN METERS											
(cm)	2.5	5.0	7.5	10.0	12.5	15.0	17.5	20.0	22.5	25.0	27.5	30.0
10.0	0.016	0.031	0.046									
12.5	0.022	0.043	0.065									
15.0	0.029	0.057	0.085	0.113								
17.5	0.036	0.072	0.107	0.143								
20.0	0.044	0.086	0.131	0.174								
22.5	0.053	0.105	0.157	0.208	0.260							
25.0	0.062	0.123	0.183	0.224	0.304							
27.5	0.071	0.142	0.212	0.281	0.351							
30.0	0.081	0.161	0.241	0.321	0.400	0.479						
32.5	0.092	0.182	0.272	0.361	0.451	0.540						
35.0	0.102	0.203	0.304	0.404	0.504	0.604						
37.5	0.113	0.225	0.337	0.448	0.559	0.670	0.780					
40.0	0.125	0.248	0.371	0.494	0.616	0.738	0.860					
42.5	0.137	0.272	0.407	0.541	0.674	0.808	0.941					
45.0	0.149	0.296	0.443	0.589	0.735	0.880	1.026					
47.5	0.162	0.321	0.480	0.639	0.797	0.955	1.112	1.270				
50.0	0.175	0.347	0.519	0.690	0.861	1.031	1.201	1.371				
52.5	0.188	0.374	0.558	0.743	0.926	1.110	1.293	1.476				
55.0	0.202	0.401	0.599	0.796	0.993	1.190	1.386	1.582	1.778			
57.5	0.215	0.428	0.640	0.851	1.062	1.272	1.482	1.692	1.901			
60.0	0.230	0.457	0.682	0.907	1.132	1.356	1.580	1.803	2.026			
62.5	0.244	0.485	0.725	0.965	1.203	1.442	1.680	1.917	2.154	2.392		
65.0	0.259	0.515	0.769	1.203	1.276	1.529	1.781	2.033	2.285	2.537		
67.5	0.274	0.545	0.814	1.803	1.351	1.618	1.885	2.152	2.418	2.684		
70.0	0.290	0.575	0.850	1.143	1.426	1.709	1.991	2.273	2.554	2.835	3.116	
72.5	0.305	0.606	0.906	1.205	1.504	1.801	2.093	2.936	2.692	2.988	3.284	
75.0	0.321	0.638	0.954	1.268	1.582	1.895	2.208	2.521	2.833	3.144	3.456	

Cubic meter volume for timber-producing mangrove species in Palawan for *Scyphiphora hydrophyllacea*.

DBH	HEIGHT IN METERS											
(cm)	2.5	5.0	7.5	10.0	12.5	15.0	17.5	20.0	22.5	25.0	27.5	30.0
10.0	0.021	0.031										
12.5	0.029	0.044										
15.0	0.039	0.059										
17.5	0.049	0.075	0.093									
20.0	0.060	0.091	0.113									
22.5	0.071	0.109	0.135									

Appendix 8

Glossary

Acuminate:	tapering to the apex, the sides more or less pinched in before reaching the tip; compare with acute
Acute:	pointed tip, tapering to the apex with the sides straight or nearly so; usually less tapering than acuminate; compare with acuminate
Alternate :	only one leaf inserted at a node
Ament :	same as catkin
Anther :	the pollen-bearing part of the stamen
Anthesis:	the time when the flower opens; more strictly the time during which pollination can take place
Apex :	the growing point of any structure, same as tip
Apical :	at the point of any structure, belonging to the tip
Apiculate :	ending as an abrupt slender or tooth-like tip which is not stiff; compare with aristate
Appendages :	an attached secondary part to a main structure
Aristate :	with an awn or stiff bristle, usually at the apex; compare with apiculate
Axil :	the angle formed by the upper side of a leaf and the stem
Axillary :	arising from the axil
Axis :	the main or central line of development of a plant or organ
Beaked :	used for fruits ending in an elongated narrow tip
Blade :	the expanded part of a leaf or petal
Bole :	trunk of tree
Buttress	: downward sloping radial projection from lower trunk of tree
Calyx :	the outer envelopes of the flower, consisting of sepals, free or united
Capitate :	in a globular or head-shaped cluster
Capsule:	a dry dehiscent fruit made of more than 1 carpel (segment)
Catkin :	a spike or spike-like of small, close growing flowers often

shredding when mature, usually pendulous inflorescence of unisexual flowers

Club-shaped : slender below and thickened on the upper end

Clustered : collected in a compact bunch

Columnar : shape like a column or pillar

Compound : having definite and distinct segments (2 or more leaflets) from the stem to the apex

Cordate : heart-shaped, as seen at the base of a deeply-notched leaf, connected at its broader end

Corolla : collection of petals

Crown : top portion of the tree consisting of leaves, branches and twigs

Corymb: a flat-topped or convex open inflorescence; technically a contracted raceme, can be compound, indeterminate type

Cotyledon : the embryo leaf in a seed, often functioning as the first leaf of a seedling

Cryptoviviparous (cryproviviparity): seed germinated in the fruits but covered with their pericarp (fruit skin) before detaching from the parent tree

Cyme : a flower cluster, often convex or flat-topped, various shapes or degrees of branching but oldest flower is always at the end of the branch, determinate type

Dehiscent : opening spontaneously to release the seeds of the fruit

Determinate : inflorescence in which the oldest flower is at the end of the main axis with the younger flowers arising from below. The cyme is the only example of this type

Dichotomous : branching by repeated division into two equal parts

Distal : situated farthest from the place of attachment

Ecosystem : the complex of a biological community and its environment functioning as an ecological unit in nature, with exchange of matter and energy amongst members of the community and with the environment

Elliptic (al) : broadest at the middle, both ends rather equal, the

	length is at least twice the width
Emarginate :	with a shallow notch at the apex
Entire :	leaf with a continuous margin never toothed, notched or divided
Epidermis :	the outer layer of tissues
Exsert (ed) :	protruded beyond, as stamens beyond the tube of the corolla
Family :	a group of related genera
Female :	a flower or plant bearing only pistils
Filament :	any thread-like body; used especially for that part of the stamen that supports the anther
Frond (fern) :	leaf of a fern
Fruit:	the matured ovary and all it contains
Genus (genera) :	a group of related species
Glabrous :	no hairs present; also used to mean smooth
Gland :	a secreting surface or structure, or an appendage havingthe general appearance and function of such an organ
Globose:	spherical or nearly so
Habit :	the general appearance/form of plant
Herb :	a plant with no persistent woody stem above ground; also a plant used in seasoning and medicine
Hypocotyl :	portion of seedling between stem and root; in some plants important for storage of starch and other reserve materials
Indeterminate :	inflorescence in which the youngest flower is always at the end of the main axis or in the center of the inflorescence; new flowers can continue developing at the tip. The panicle, spike, raceme, and umble are the examples of this type
Inflorescence :	the arrangement of flowers on the floral axis; a flower-cluster
knee roots :	horizontal roots like bending knees above the ground, looping up and down with knob-like structure at the top
Lanceolate :	lance-shaped; several times longer than wide, broadest

	toward the base and tapering to apex
Latex :	the milky juice of some plants like Excoecaria agallocha
Leaflet :	one of the divisions of a compound leaf
Lenticel:	pocket of corky cells on woody stem or root allowing exchange of gases between interior of plant and atmosphere
Lobe :	any segment of an organ especially if rounded
Leatherly :	tough and leather-like
Male :	flowers having stamens but no pistil
Midrib :	the middle rib or vein of a leaf
Mucro (nate) :	a short, small abrupt tooth-like tip; loosely used but not very sharp at extreme apex
Node :	the point on the stem or branch at which a leaf or lateral branch arises
Oblique:	slanting
Oblong :	shape that is two to four times longer than wide and the sides parallel or nearly so
Obovate :	egg-shaped in outline, attached at the narrow end, inverse of ovate
Opposite :	2 leaves inserted opposite to each other on the stem
Oval :	loosely used for a broadly elliptical shape, the width over 1/2 the length; some authors have used it as the same as ovate;
Ovary :	female organ of flower, situated in center of the flower and developing into the fruit containing seeds
Ovate :	egg-shaped in outline, attached at the wide end
Ovoid :	a 3-dimensional figure, ovate in outline
Panicle :	a compound inflorescence with the younger flowers at the apex or center; a compound raceme or corymb, comprising spike or raceme, etc. indeterminate type
Pedicel :	stalk of each individual flower of an inflorescence
Peduncle :	the stalk of a solitary flower or of an inflorescence; compare pedicel
Peduncle :	a flower stalk
Perennial :	a plant lasting for 3 or more years; a stem not dying

	back over the dry season
Persistent :	remaining beyond the period when such parts commonly fall
Pericarp :	the wall of the ripened ovary and therefore the wall of the fruit
Petal :	one of the individual parts of the corolla, used particularly for a polypetalous corolla in designating one unit
Petiole :	the stalk of a leaf blade or of a compound leaf
Petiole :	stalk of leaf
Phenology :	the complex annual course of flushing, quiescence, flowering, fruiting and leaf fall in a given environment
Pinnate :	a compound leaf in which the leaflets are arranged along the sides of a common petiole
Pistil :	the seed-producing organ, consisting usually of ovary, style and stigma
Plank roots :	horizontal ribbon-like roots that elaborate above the ground, undulating and winding laterally like a snake
Pneumatophore :	pencil-like or conical roots protruding upward from horizontal root extensions
Raceme :	an inflorescence with pedicelled flowers borne along a more or less elongated axis with the younger flowers nearest the apex, indeterminate type
Racemose :	raceme-like or bearing racemes
Radicle :	the rudimentary root formed within the seed
Reflexed :	bent outward or backward
Russet :	purple tinted brown
Schizocarp :	a dry fruit of 2 or more carpels, splitting up at maturity into 2 or more one seeded, indehiscent segments
Sepal :	a division of calyx, outermost part of flower; usually green
Sessile :	without any stalk
Shrub :	a woody perennial plant smaller than a tree and usually with several basal stems, less than 4 to 5 m in height

Simple (leaf) : only one definite segment present between the stem and the end of the blade. although sometimes lobed or toothed.

Solitary : single

Species : a term for all the individuals of one kind

Spherical : globose, a 3-dimensional solid, round in outline, like the earth

Spike : an inflorescence with the flowers sessile on a more or less elongated axis with the younger flowers at the apex, indeterminate type. Here including dense, capitate-like type

Spore (fern) : reproductive body of lower plants, usually single cell

Stalk : the stem, petiole, peduncle etc.

Stamen : male organ of flower, consisting of filament (stalk) and anther containing pollen

Stem : the main trunk of a plant

Sterile : infertile and unproductive, as a flower without a pistil, a stamen without an anther or a leafy shoot without flowers

Stigma : sticky or feathery area above ovary, receiving pollen at pollination

Stilt-root : looping aerial roots exposed to the air, arising from the trunk and lower branches and extending outward and downward into the soil

Stipule : leafy outgrowth, often paired, arising at the base of the leaf stalk

Style : the usually stalk-like part of a pistil connecting the ovary and stigma

Substrate : material in or on which plant is growing, e.g., soil, rock,

sand

Terminal : borne at or arising from the end or apex of the stem

Tessellate : checkered, mosaic-like

Tree : a woody plant exceeding 5 to 6 m in height with a distinct trunk

Umbel : inflorescence of stalked flowers all arising from same point, indeterminate type

Unisexual : of one sex, having either stamens or pistils, not both

Viviparous (viviparity):
germinating or sprouting from seed or bud in the fruit and protruding and expanding hypocotyl of seedling from fruit while attached to the parent plant

Warted (warty) : covered with firm roundish excrescences on the stem / fruits