Chapter 3
Mangrove plantation establishment and management

INTRODUCTION

Recently, interest in establishing and maintaining mangrove plantations and in managing natural mangrove forests has increased as people realize the many valuable economic benefits available from these forests. They realize that, in addition to the valuable wood, mangroves provide protection to coastlines by breaking the waves during strong storms, protect seagrass beds and coral reefs from siltation and serve as a food source and nursery for a number of important fish species. All of these can benefit the people especially the coastal dwellers.

This chapter provides POs, COs and NGOs with information on developing and managing mangrove plantations and (natural stand) forests. Historically, mangrove plantations have been relatively small and consisted of one species of *bakauan*. This toolkit advocates planting multiple species, sometimes in pure stands, sometimes in mixed stands, depending on the needs of the PO and the site. In addition, information is provided on how to manage the remaining natural forest stand to maximize the benefit to the coastal ecosystem. We strongly urge POs to consider developing several plantations as their area permits to increase wood, fodder, detritus production, and the protection of shoreline, seagrasses and corals. This chapter was developed from several publications on plantation management written in the Philippines and abroad (Watson 1928; Hamilton and Snedaker 1984; PCARRD 1991; CV-CIRRD 1993; Vande Vusse 1993; Agaloos 1994; Yao 1994, 1997; Chan 1996; ERDS 1996; Field 1996; Hong 1996; Melana and Gonzales 1996; Padron 1996; Qureshi 1996; Saenger 1996; Siddiqi and Khan 1996; Tomlinson 1996; Melana 1998). It also incorporates information from the field.

IDENTIFYING THE PLANTATION MANAGEMENT OBJECTIVES

In establishing any plantation it is important to have well-defined management objectives. In a successful plantation, operation and management reflect the objectives of the PO. Thus, the choices the PO makes about spacing, species and specific silvicultural (tree growing) practices depend on the objectives of the plantation.

Common mangrove plantation objectives/perceived benefits include:

- Firewood/charcoal
- Posts and piles
- Tanbark
- Thatching materials production
- Shoreline protection/productivity of nearby coastal waters
- Timber production

In order for your PO to identify a site and establish, operate and manage the plantation(s), ask yourselves a series of questions:

- Is the area in question for plantation establishment or for enhancement planting?
- If the area is for plantation development, is it for production or forest protection?
- What kinds of production?
  - Firewood or charcoal?
  - Posts?
  - Piles?
  - Tanbark (for *tuba* or other uses)?
  - *Nipa* production?
  - Other uses?
- If for protection, what is the plantation "protecting"?
  - Shoreline or road stabilization?
  - Sediment trapping?
  - Natural fish production?

Depending on the answers to these questions, your PO can decide how to proceed. Next, determine: (1) where to locate the plantation, (2) which species to plant and (3) plantation planning and design.

PLANTATION ESTABLISHMENT

Site Identification and Selection

One of the major reasons of plantation failure is improper siting. Some people believe that all open areas, mudflats and seagrass beds can be turned into mangrove forest plantations, especially for *bakauan*. But this is not true. A number of factors must be considered in selecting an area for plantation. Table 3.1 shows examples of the typical zonation pattern with suggestions for which species should be planted. Site selection is based primarily on these important factors:

- Type of substrate
- Current species present
- Presence or absence of seagrass
- Tidal height
- Extent of wave action
- Presence or absence of pests
- Historical users of the area

Type of substrate—The substrate is an important controlling factor in selecting an area for plantation development. In evaluating the substrate, it is important to realize the limitations that it sets in selecting an area for planting. (Substrates do not always fall into the distinct categories listed below; it can be a combination of two or more types.) Substrates that support mangrove species include:

1. *Mud*—This is best characterized as a soft sediment composed of a combination of organic and inorganic material. It may be as shallow as 2-3 centimeters or as deep as a few meters. A very shallow mud substrate is not recommended for a wood production plantation. In general, mud is a good substrate to plant:

   - *Bakauan babae*
   - *Bakauan lalaki*
   - *Busain*
   - *Tangal*

   Some mud may have a foul smell similar to rot-

Table 3.1. Typical zonation pattern of mangrove species and common names (after Agaloos 1994).

Zone	Tidal regime	Soil types	Species and common names	Good species for planting
Seaward	Daily, including neap tides	Coral rubble, sandy, sandy loam	*Avicennia marina (bungalon); Sonneratia alba (pagatpat); Rhizophora stylosa (bakauan bato); R. apiculata (bakauan lalaki)*	*Rhizophora stylosa* (coral rubble or sand); *Rhizophora apiculata* (sandy loam, silty)
Middle	Daily, except during neap tides	Silty to silty clay	*Avicennia alba (bungalon puti); A. officinalis (api-api); Rhizophora apiculata (bakauan lalaki); R. mucronata (bakauan babae); Aegiceras floridum (saging-saging); A. corniculatum (busain); Bruguiera cylindrica (pototan lalaki); Bruguiera gymnorrhiza (busain)*	
Landward	Inundated only during spring tides	Silty to silty-clay to clay	*B. sexangula (pototan); Ceriops tagal (tangal); C. decandra (malatangal); Excoecaria agallocha (buta-buta); Lumnitzera racemosa (kulasi); Nypa fruticans (nipa)*	*Ceriops tagal* (silty to silty clay) *Nypa fruticans* (silty to silty clay, only where there is fresh water intrusion)
Riverine: (Rivermouth and upstream forebank/ backbank)	Variable inundation brackish/ freshwater influence	Sandy to silty clay	Rivermouth: *Avicennia marina; A. officinalis; Aegiceras floridum (saging-saging); A. corniculatum; Rhizophora mucronata; R. apiculata; R. stylosa* Upstream: *Avicennia alba; A. officinalis; Aegiceras floridum; A. corniculatum; Bruguiera cylindrica; B. gymnorrhiza; Nypa fruticans; Rhizophora mucronata; R. apiculata*	*Rhizophora stylosa* (sandy, rivermouth) *R. apiculata* (silty to silty clay, rivermouth and upstream backbank) *R. mucronata* (silty to silty clay, rivermouth and upstream forebank) *Nypa fruticans* (silty to silty clay, brackish water)

ten eggs. Avoid planting in these areas because the soil may be very acidic and the likelihood of plant diebacks is high. The consistency of mud can vary from a fairly firm substrate that easily supports the weight of a walker to very thin where a walker is quickly up to the knees. Avoid very thin areas because here the survival of plants is not high while the amount of work to plant and manage a plantation in such a location is quite high.

2. *Rocky or coralline*—This substrate may best be described as hard shelves where small or thin pockets of softer sediment are found. Rocky or coralline areas are not recommended for production forests because of relatively low soil fertility. But for protection and other ecological purposes the following species are recommended in these areas:

   - *Bakauan bato*
   - *Bakauan lalaki*
   - *Pagatpat*

3. *Sandy substrate*—Well known to most people, sandy substrate consists of very small grains of sediment (often coral) usually less than 2 millimeters in diameter. There is no organic matter to speak of, although it may overlay mud or muck. Like mud, sand may be as shallow as 2-3 centimeters or as deep as several meters. In situations where this substrate is very shallow, it is not recommended for wood production efforts. As with rocky or coralline substrate, the following species do well in sandy substrate:

   - *Bakauan bato*
   - *Bakauan lalaki*
   - *Pagatpat*

4. *Muck*—Similar to mud except that it contains a large amount of plant debris (its organic matter content is higher than mud). It also tends to be deeper starting at more than 10 centimeters thick up to a few meters. Like mud, muck may have the same foul, rotten egg smell; if so, planting should not be attempted. In general, muck is a good substrate to plant:

   - *Bakauan babae*
   - *Busain*
   - *Tangal*

The type and thickness of substrate present will help to decide which species of mangrove is best to plant in any given area. It is important to investigate an area thoroughly and to avoid blindly deciding to plant a certain species. It is important that the PO maintains flexibility about what it wants to do in particular places.

Common species present—One of the best ways to determine which mangroves will succeed in a particular area is to look at which species are currently thriving there. If the area once supported a mangrove forest, people living near may know which species were there. Not surprisingly, local people indicate that many forests now composed of *api-api* and *pagatpat* were once composed primarily of *bakauan lalaki* or some other *bakauan* species.

Think carefully about planting species that are not found in the area. It is likely that nature has already tried to establish those species and failed.

The presence or absence of seagrass—Many people believe that seagrass beds are very good sites for mangrove plantation, but that is not the case. It is not a

Knowing which species were historically found in an area is a very good way of determining what species are likely to thrive there now. This information can be obtained by asking the local people or by identifying stumps in the area. If that is not possible, observe the current composition of species near or in the plantation area for a good idea of which mangrove species are likely to succeed.

good idea to plant mangroves in seagrass beds because there are many species of coastal animals that live in these habitats; if their habitat is altered they will die. Simply replacing one habitat with another does not help to manage and enhance the coastal environment.

Do not put mangrove plantations on top of what are now stable seagrass beds!!

Tidal height—Like substrate, tidal height is an important biophysical control affecting plantation success. It is important to know if the average daily water depth of the area identified for planting will in fact support growth. In order to determine the height of the average and highest low and high tides see the detailed discussion in Chapter 6, *Resource Mapping of Mangroves*.

Planting is generally done on bare substrates during the low tide of neap tide, especially for small seedlings and propagules (such as *bungalon* and *pototan lalaki*). In some cases, big or long propagules may be planted in areas when the water depth is as high as 10 centimeters at low tide. (This is routinely done at the *bakauan bato* plantation in Banacon Island, Getafe, Bohol.)

Tidal height also affects growth and survival. In Banacon, a seedling planted at a low tide depth less than 30 centimeters has a much higher survival than those planted at 40 centimeters.

Areas constantly battered by waves especially during stormy days are critical for planting. As much as possible, avoid these areas and endeavor to plant in good sites. Table 3.2 shows suggested soils for some mangrove species.

Presence or absence of pests—Another major factor in plantation success is the absence of pest species such as barnacles and crabs. All of these species can cause problems to young plants. If there are large numbers of these pests in the area, look elsewhere. Another pest that people often overlook is filamentous algae. This algae can pile up against the young plants and knock them over by their sheer weight. If your PO decides that an area with these problems is the one that must be used, then you must prepare for a significant amount of extra work to remove them periodically.

Traditional users of the area—All traditional users of the area should be identified and allowed an opportunity to join the PO and share the benefits of the CBFMA. If that has been done, there should be little problem with gaining their acceptance of the plantation. It is important to plan the plantation with them so their needs regarding boat traffic, shell gathering and other issues are included in the plan. (This is even more important in cases where these users did not join the PO.)

When the historical users of an area are not consulted about a proposed new use for it, such as a plantation, they often become very unfriendly towards the promoters and can even go so far as to destroy seedlings and the new plantation area.

There are a number of factors that contribute to identifying a successful plantation location. Good planting sites include:

- Well protected areas away from strong waves like coves, lagoons, bays and abandoned and reverted fishponds
- Open areas along rivers
- Gaps within natural stands
- Stable mudflats with barrier islands
- Barnacle free areas
- Logged-over areas

Choice of Species

Plantation success largely depends on the choice of species. Determining which species to plant is a complex decision that is based on the plantation's purpose (whether production or protection) and the biophysical characteristics of the selected area. In the long run, it is the biophysical characteristics that will determine the

Table 3.2. Suggested soils for selected species of mangroves (after Watson 1928)

Name	Common name	Soil and location
1. *Acanthus ebractcatus*	*Diluario*	Loam or clay on river banks and clearings
2. *Acanthus ilicifolius*	*Tingloy*	Loam or clay on river banks and clearings
3. *Acrostichum aureum*	*Lagolo*	Almost everywhere if light
4. *Avicennia alba*	*Bungalon puti*	Deep mud within the influence of rivers
5. *Avicennia lanata*	*Piapi*	Sandy mud not far from sea; Singapore and East Coast
6. *Avicennia officinalis*	*Api-api*	Stiff soil on river banks
7. *Bruguiera gymnorrhiza*	*Busain*	Loam or sandy mud. Gregarious in drier areas
8. *Bruguiera parviflora*	*Langarai*	Will grow almost anywhere in mangrove if well drained
9. *Excoecaria agallocha*	*Buta-buta*	Clay, often behind 11
10. *Heritiera littoralis*	*Dungon-lati*	Sandy loam, river banks and inland edge of mangrove
11. *Lumnitzera racemosa*	*Kulasi*	Clay. Sometimes behind 11
12. *Nypa fruticans*	*Nipa*	River banks within the influence of fresh water
13. *Rhizophora mucronata*	*Bakauan babae*	Deep mud within the influence of rivers. Not on sea face
14. *Scyphiphora hydrophyllacea*	*Nilad*	Loam or sandy mud on river banks and open spaces
15. *Sonneratia alba* (Gedabu)	*Pagatpat*	Loam, often some distance from river banks

success of the plantation; it is up to the PO to decide which species to plant after considering all the factors discussed above.

Table 3.3 presents the major commercial mangrove species. Using these data with the information above, determine which species are best suited to your plantable area.

Plantation Establishment Techniques

After identifying the planting site, the socio- and biophysical attributes, management objectives and choosing the mangrove species, proceed with establishment:

- ***Determining what needs to be done to prepare the site***—The plantation sites often need some preparation prior to planting. The people in charge of the plantation should walk over the entire area and determine what needs to be done. This may include clearing areas of *Achrosticum* fern or other brush, removing standing dead wood that will shade out the area and removing debris. In this phase, it is important to determine both what needs to be done and when it will be completed. If a completion time is not included, the tasks are not likely to be finished in time for planting.
- ***Planting organization, areas and spacing***—When people are walking through the area during site preparation they can also evaluate it for planting block size, keeping a sharp eye out for areas where people or boats commonly transit.

Table 3.3. Commercial uses of various mangrove species.

Species	Uses
Bakauan bato, babae and *lalaki*	Piles or poles, firewood or charcoal
Busain group	Piles or poles, firewood or charcoal
Tangal	Tanbark (*tungog*) for *tuba* industry, poles
Pagatpat	Timber and lumber, firewood or fodder
Bungalon	Firewood, fodder
Api-api and *piapi*	Timber, poles, firewood, charcoal
Tabigi	Timber and lumber, firewood or tanbark
Piagau	Timber and lumber
Tabau	Posts and poles
Dungon-lati	Timber
Nipa	Shingles, alcohol, wine

This information will contribute to developing a sketch map of the area.

Several organizational ideas can be used in planting:

- An inverted V shape spacing with the point of the V facing the sea to deflect wave impact. Spacing should be less than 0.5 meter.
- In Cuba, planting has been done in triangle formation with one of the corners of the triangle pointing seaward. Spacing is less than 1 meter.
- Cluster planting, as practiced in Bohol, may also be done in other areas. It is done to act as a wave break. To maximize survival, spacing is much closer (25 x 25 centimeters). After 3-5 years, when the clusters are fully established, the gaps in back of the clusters can be planted at a wider spacing, as the area will be more or less protected by the clusters.
- Strip planting—the same principle applied in strip planting. Strips (10 or 20 x 100 or 150 meters) are established 100-200 meters from the shore at very close spacing to withstand strong waves. Once established, the open areas between the *bakauan* strips and shoreline may now be planted at a wider spacing.
- ***Seedling density or spacing***—Spacing can range from 16 individuals per square meter to one individual per 1 square meter. The closer the spacing, the greater the ability of the propagules to withstand wave impact. This explains the local tradition of closer spacing (0.25 x 0.25 centimeter) in spite of DENR's recommended spacing of four individuals per square meter. Generally, wider spacing is employed when bigger trees are needed. The wider spacing reduces competition for sunlight and nutrients. Deciding on the spacing will help to determine what the total requirement for your seedlings will be.
- ***Sketch map***—This map forms the backbone of the plan. While it does not have to be scaled precisely, it should be clear enough to provide users with guidance on the location of passages, blocks and seedling density. Figure 3.1 shows an example sketch map.

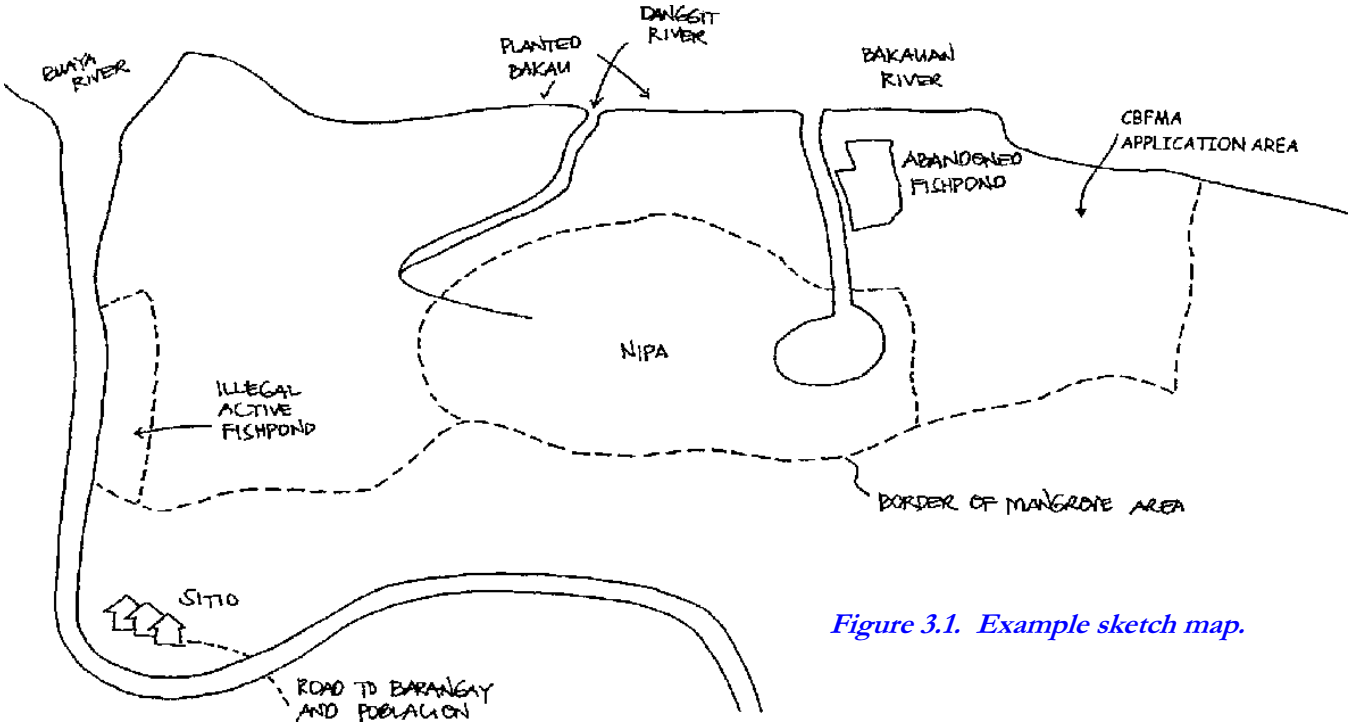

Figure 3.1. Example sketch map.

Figure 3.2. Undergrowth vegetation like the mangrove fern* (lagolo)*, herbs and vines are removed to prepare the site for planting.

Plan implementation—After planning, it is time to prepare the site for planting. Examples of the work that might be needed include:

Brushing the area— This refers to the removal of undergrowth such as mangrove fern (*lagolo)* as in Figure 3.2 and spiny woody vine (*diluario*) prior to planting. Brushing can be approached in several ways:

- *Total brushing*—removes all of the undergrowth from the area. This is an extremely difficult task in areas of heavy undergrowth and is generally unnecessary.
- *Strip brushing*—removes undergrowth along pre-determined strips, generally 1 meter in width. These strips may be hundreds of meters long depending on the size of the area; they make for easier maintenance of the plantation over time.
- *Spot brushing*—removes undergrowth in a 1-meter radius around the point where plants will be placed. A stake of at least 1-meter height is necessary to be able to locate the seedlings until they become larger. Spot

brushing is the easiest of the three approaches.

- If the area is invaded by *lagolo*, use a blunt bolo or spade to uproot the ferns as if it was *cogon* grass. Cutting off the stems will not eliminate weeds, it is necessary to remove their roots. Because these areas can be so large, spot brushing is recommended to minimize effort and still provide the best environment for the seedlings.
- If it is a logged-over area, any remaining logging debris (branches, for example) will need to be taken out.
- If the area contains brush, vines or low-lying vegetation, it will be necessary to cut it down and remove it.
- With enrichment planting it may be necessary to prune branches and remove dead trees to provide light and space for the new seedlings.
- Breaking fishpond dikes and filling in internal canals. (This is discussed in more detail in Chapter 5, *Fishpond Restoration*.)
- Finally, if seedlings or wildlings are being planted, it will be necessary to dig holes in order to place the seedlings. The holes need not be deeper than the size of the rootball. Begin planting at the seaward side of the plantation at low tide.

While this list cannot cover every possible example, it does provide a number of good site preparation activities for the PO.

Warning

For other activities whose legal sanction is not certain, it is best to consult the local DENR office/officer.

There are also some things a PO should *not* attempt to do as part of site preparation:

- Trying to change the depth of the area by excavating or adding soil.
- Trying to change the soil type by adding soil.
- Completely cutting down one type of tree to replace it with another. (This is particularly true in cases where the PO wants to replace large areas of forest with *nipa* palms.)
- Removing fishing traps or mooring areas of any kind without the prior approval of those involved.

Planting

There are several planting methods. The method used depends on the type of stock and species being planted, whether seed, seedling, propagule or wildling. Common methods include:

Direct planting—Propagules of *bakauan, pototan* and *tangal* are planted directly on the ground. Other species with large seeds like *dungon-lati*, the *tabigi* group and to some extent the *bungalon* group, can also be directly seeded. (*Nipa* too is commonly sown directly in the field.) This method is economical with a high percentage of survival. Figure 3.3 shows an example of direct planting.

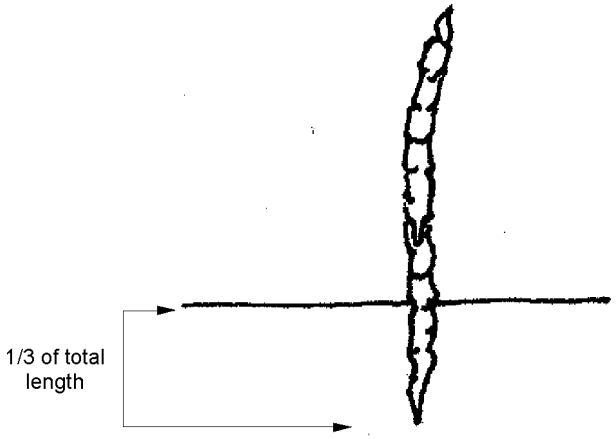

Figure 3.3. Direct planting of propagules (1/3 of length buried).

Potted seedlings—Used for trees with tiny seeds that are difficult to sow directly in the field, the *pagatpat* group, for example. Seedlings from the *bakauan* group also can be raised in the nursery and planted in this manner for specific sites such as open areas with unstable substrates where there is concern about the early survival of the seedlings. Potted seedlings involve considerably more cost and should only be done when it is the only option. Figure 3.4 shows an example of potted seedlings.

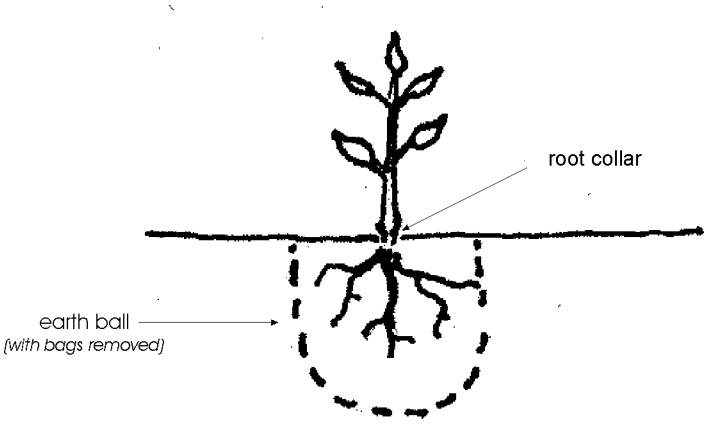

Figure 3.4. Field planting of potted seedlings (root collar at ground level).

One common practice responsible for high mortality rates in mangrove planting is the sowing of propagules more than half their length in the soil. This was done because people believed that waves would dislodge the propagules if planted too shallow. Propagules, however, are covered with lenticels that they use to exchange air while developing roots. Burying propagules too deep will render the lenticels useless, causing a slow death to plants. Generally propagules are sown one-third of their length in firm substrate and one-half of the length in soft substrate. Other types of seeds should be sown just below the substrate including the* tabigi *and* tinduk-tindukan*.

Wildlings—Where there are not enough seeds or propagules, wildlings may be potted and hardened in the nursery for a month. In uprooting/collecting wildlings, extra care must be taken not to damage the root system. For some species, wildlings can be directly planted provided the soil around the roots is intact. Figure 3.5 shows collected and potted *bakauan* wildlings. Planting wildlings requires extra care to protect against damage on the roots, one of the natural adaptive structures of mangrove to tolerate a saline environment.

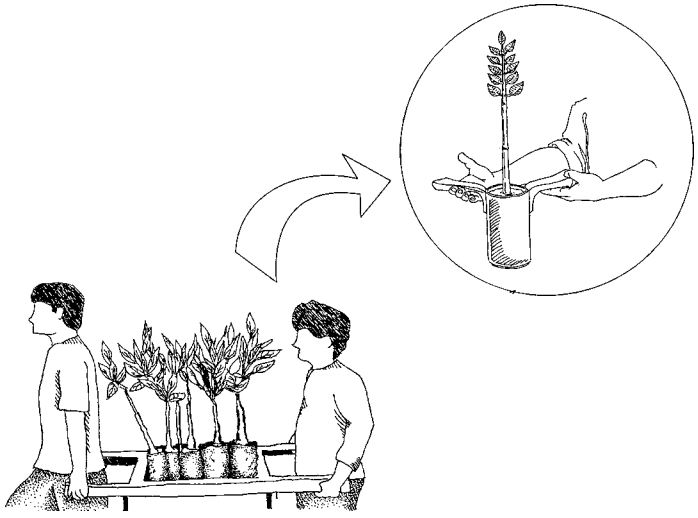

Figure 3.5. Potted* bakauan *wildlings.

Care and Maintenance of Plantations

Plantations are cared for in several stages depending on their age, species and rate of growth. For example, *bakauan bato* is best harvested in its 12th year. However, if it grows well it can be harvested in 10 years (or in its 15th year if it grows poorly). Below are the major phases of care for plantations and natural forests:

- Like any newborn, the first 2 years after their establishment are probably the most intense phase of care for plantations.
- Generally, from the 3rd through the 4th years the level of care is somewhat less.
- The 5th year sees an increase in care because this is the first thinning if growth has been normal and the economic size of desired products is attained.
- The 6th through the 14th years see a period of relatively low maintenance in longer maturing species. (In *bakauan bato*, depending on growth rate, harvesting can begin anywhere from the 10th and probably should be completed by the 20th year.)
- In most other longer maturing species, the 15th year sees another round of thinning. (This thinning may occur anywhere from the 10th until the 15th year depending on growth and the needs of the PO.)

- Years 16th through 19th are typically ones of low maintenance.
- By the 20th year, possibly the 25th, the plantation is ready for harvest and replantation (if the mother tree planting method is used, the plantation will be allowed to naturally regenerate).

Maintenance activities in the early years—In general, maintaining a young plantation involves:

- Regular visits (daily or every other day)
- Removal of debris
- Installation or fence repair
- Removal of barnacles and other pests
- Uprooting and replacement of sick or dead plants

The purpose of regular visits is to make certain that things are all right and to perform the daily chores listed above. For example, if a large amount of green algae floats into the area, those who regularly visit will be able to remove it before it can do much damage. Other debris that might adversely affect the seedlings include pieces of driftwood, fishing nets and other heavy materials that can knock over the seedlings or damage them by tearing their bark.

Visit the plantation at least every other day, although daily visits are preferable. Develop a routine so that the entire plantation is inspected. It is best conducted at low tide since it will be easier to walk around the plantation. Because it is impossible to look at each and every seedling, the inspectors should make it a point to look closely at a few plants in each block. Inspectors should check for:

- Encrusting organisms like barnacles
- Insects and moth larvae eating leaves
- Dead or dying plants
- Plants entangled in green algae or other debris

Where extensive problems are observed, and it is clear that more than a few hours are necessary to fix the damage, it will be necessary to involve more members of the PO (perhaps all of them).

- *Removing encrusting barnacles*—The shells must be removed by hand (preferably using gloves) before the propagules are totally covered. Figure 3.6 shows an example of encrusting barnacles. Do not scrape the propagules with a bolo since that will result in plant damage and eventual death. Once the organism is carefully scraped off, simply throw it in the water because it cannot be able to attach again.

- *Removing grazing organisms*—These organisms are much easier to remove than barnacles. Simply pluck them from the leaves, trunks and branches of the seedlings, place them in a bag and remove from shore for disposal; simply throwing them in the water may allow them to reach another tree.

- *Removing dead and dying trees*—Dead or dying trees should be quickly removed from the area. If they are dying in large numbers, it may be necessary to replace them with seedlings from the nursery or other stocks. If seedlings are dying in large numbers, it is important to determine why. Bring some sample seedlings to the Community Environment and Natural Resources Office (CENRO) or ask a forester from the CENRO to visit the area to evaluate the plantation.

Without caring for the area daily, a host of problems can develop. The more problems a plantation has the less it benefits the coastal ecosystem and the less valuable it is to the CBFMA holders.

Do We Need a Fence Around Our Plantation?

This is an important question. If a fence is necessary, then quite a bit of work will go into building and maintaining it. In general, a fence is only necessary if you believe that livestock may graze on your plantation. However, if you want to build a fence to keep out people or screen out debris, one is probably not necessary. Regular patrols of the plantation are much more effective.

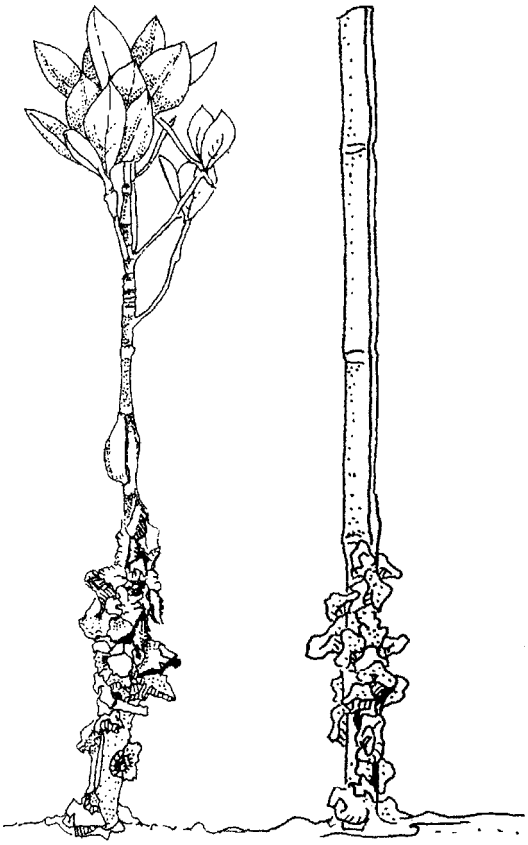

Figure 3.6. Barnacles encrusted on bakauan *trunk.*

Maintenance Activities in Subsequent Years

When the trees attain economic size, thinning of the stand should be done to allow better trunk growth. Thinning is the cutting of trees to reduce competition from sunlight, nutrients and soil moisture in order to improve the quality of the stand.

Thinning is performed only two or three times during the life of the tree. The timing and number of thinnings depend on the expected age at harvest for the trees. For example, *bakauan bato* plantations can be harvested between their 7th-10th and 15th-20th years. They can be thinned in their 5th and 8th or 9th years depending on when harvesting is expected. Table 3.4 provides estimates of the number of times and spacing of thinning for the major plantation species. This information may also be used for enhancement/ enrichment planting. Figure 3.7 shows how a *bakauan* forest would look at various points where it is thinned.

Thinning is best done in several stages. After each stage count how many have been cut. If the target (as calculated above) has been reached, thinning must stop. If not, go on to the next stage. First, cut only those trees that are obviously malformed, stunted or sickly. Next, cut those trees that appear to be significantly shorter than the surrounding trees. Finally, cut the trees that are not as tall as the average trees. Thinning, however, is not recommended for environmental protection.

Table 3.4. Common species and recommended thinning rates (C. Yao, pers. obs.).

Species	Initial density (no./ha)	First thinning (yr, % removed)	Second thinning (yr, % removed)	Third thinning (yr, % removed)	Harvest (yr)	Products
Bakauan bato	50,000	5, 50	10, 50	9, 50	15	Poles
Bakauan group	10,000	3, 50	8, 50	13, 50	25 - 30	Poles
Tangal and *langarai*	10,000	5, 50	10, 50	15, 50	15	Tanbark
Tabigi and *pagatpat* group	5,667	4, 50	10, 50	15, 50	25 - 30	Lumber

***Figure 3.7. Thinning operation in natural stand of* bakauan.**

Pruning is another maintenance activity that takes place after the initial year or two of intensive maintenance. It is defined as the cutting of unnecessary branches and stems. Pruning is done to:

- Enhance height and trunk diameter growth rate. The nutrients that otherwise would be absorbed by the branches will now be utilized by the upper part of the tree, thus increasing growth rate.
- Improve the tree form and wood quality. Cutting the lower branches will help to define the tree trunk and reduce knots in the lumber. (As the tree increases in diameter, the uncut branches become encased in the trunk, which results in knot formation in the lumber. Cutting the branches minimizes this encasing.)

Pruning should be conducted with some restraint to avoid adverse effect on trees. The following are some pruning rules:

- Do not cut more than 30% of the live crown over a 1-2 year period. Overpruning will adversely affect plant growth because of sudden reduction of leaves that are active in photosynthesis.
- Paint stub preferably with tar to prevent fungal attack.
- Cut smaller branches close to the trunk to increase merchantable height—clear length from base of the trunk to the first branch. The branch should be 3 meters from the ground limits its length of lumber if not pruned. As the branch enlarges, it creates knots that limit the tree to produce lumber more than 3 meters. This is one of the important justifications for pruning operations.
- For bigger branches, make an undercut 10 centimeters from the trunk. The upper cut should be close to the trunk to avoid bark splitting.
- Use a pruning saw (a saw attached to a long pole) to reach branches up to 5 meters in height.

One of the best things about both thinning and pruning is that the felled trees and branches are of economic benefit to the people who have done the work. For example thinning of most trees at the 5-year point and beyond results in:

- Some poles for fish pen construction
- A large amount of forage for animals feeding
- A large amount of branches for firewood production

Pruning benefits people in a similar manner. Pruning will generate both forage and firewood. Since people are in the forest pursuing these activities anyway it is likely that there will be no shortage of PO volunteers to assist.

MANAGEMENT OF PLANTATION AND NATURAL FOREST

Plantation Types

Production forest—A plantation is established to produce wood for specific purposes. Typical mangrove forest products include: poles, posts, firewood and charcoal and lumber for furniture or construction. A production forest is characterized by long, straight rows of trees. They may range in size from 2,500 square meters to hundreds of hectares. The trees grown in these forests are always meant for eventual harvest. Figure 3.8 shows

one of the most successful and oldest production forests in the country.

Figure 3.8. One of the most successful and oldest production forests in the country located at Banacon, Getafe, Bohol.

Protection forest—A plantation is developed to provide additional refuge for coastal organisms, or for keeping an area safe from damaging from wave action and sediment transport. While protection forests may be planted in the same manner as production forests, it is sometimes better to randomly plant the areas with different species that are known to survive in the area. These forests are not meant to be harvested but to maintain the ecological balance. Figure 3.9 shows an excellent example of a protection plantation along a causeway.

Figure 3.9. Protection plantation established to protect causeway of Pangangan, Calape, Bohol.

Mangrovetum—a plantation consisting of several species planted in blocks by family/genus for easy differentiation of closely similar species and comparison of growth performance. Mangrovetum is an ecological attraction while conserving biodiversity.

In addition to the above there is *enhancement planting*, but this is not, strictly speaking, used to develop a plantation. It is done in areas where some forest exists but in a much lesser density than the original forest. These areas include the following:

- Abandoned fishponds
- Heavily cut mangrove forest areas
- Gaps in naturally reforested areas

In each case, there may be some logged-over area where the PO determines that enrichment (planting additional trees of either the same or different species) would benefit the environment and the community.

As you can see, there is a variety of objectives that a PO might have in developing a plantation or in performing additional planting within an already established forest. It is important for the PO to remember that it may have all activities going on in some part of its CBFMA area. For example, a 250-hectare CBFMA may include 50 hectares where a production forest is planned, 75 hectares of protection forests, 10 hectares of an abandoned fishpond where enrichment planting is planned, 15 hectares of forest identified for enhancement and 100 hectares of forest identified as an area for no intervention at all.

Harvesting and Regeneration Systems and Enhancement Planting

Since the intention of the CBFMA is to have a sustainable forestry system, it is important that the plantations are harvested and regenerated in that manner so that future generations can make use of the wood and the benefits to the coastal ecosystem. This section discusses appropriate harvesting and regeneration technologies for mangrove plantations and natural forests. Following these approaches will allow the PO to enjoy the benefits of their mangrove forests for generations.

Harvesting—This section discusses appropriate harvesting techniques for four major products:

- Firewood and charcoal
- Piles, poles, posts and lumber
- Fodder
- Tanbark

While harvesting these products is routine, it is often done in a manner that is not sustainable and leads to destruction of the forest. If a PO uses traditional techniques to harvest, it is very likely to cause significant damage to the forest. Thus, the use of sustainable harvesting techniques is critical. Luckily, practicing these techniques does not reduce the economic benefit of harvesting over the long term; in fact, benefits increase.

- *Firewood or charcoal* harvesting can begin at the time of the first thinning for plantations and all other planting strategies. As earlier, subsequent thinning and pruning can be used as a method of firewood harvesting. Later in the growth cycle, firewood will be generated from topping, thinning and harvesting trees. This is especially true when the main product of the plantation is poles or lumber. Figure 3.10 shows a firewood harvester returning with some freshly cut wood.

  If a *bakauan* plantation has been established solely for firewood the tip of seedling can be split to encourage branching. Initial spacing for such plantations should be at least 1 x 1 meter (10,000 seedlings). This is done to encourage crown development and maximize the yield of branches for firewood. The plantation should be mature enough, with usual thinning and pruning, to support sustained harvesting between the 7th and 12th years after planting. At that time, firewood can be harvested exclusively from the top branches of individual trees allowing the lower branches to regenerate.

- In plantations developed for producing *piles, poles, posts and lumber* it is possible and indeed desirable to harvest firewood. By aggressively pruning side branches after the first thinning (while leaving the crown alone), energy will be directed into producing more trunk wood and therefore bigger and taller poles more quickly. As the thinning and pruning are used to produce firewood it also is possible to shift to selective cutting and remove poles on an as needed basis. This would help to move the plantation towards a seed tree form of forestry where the largest seed or mother trees are kept for seedling production and the middle story is harvested for poles or posts. (This is discussed in more detail later.)

Figure 3.10. A firewood harvester with freshly cut wood.

- Traditionally, *fodder* harvesting has been done for cattle and goats. Fodder (the leaves and shoots from the cut branches) is taken from pruning and thinning activities and given to these animals. Since it is well known that cattle and goats like to eat these leaves it makes sense to extend it into a livelihood activity. Fodder can be obtained as part of firewood gathering and sold to local farmers or the PO, or its members can raise sheep or cattle on the fodder as a liveli-

hood activity making use of this product. *Avicennia* species are common for fodder purposes.

It is important to make certain that there is enough fodder to support the number of animals you want to grow. In several countries including India and Bangladesh, overgrazing by animals has caused significant loss to mangrove forests.

- *Tanbark* is another mangrove product the PO can produce from several species (the one from *tangal* commands the highest price for the *bahalina* industry in Samar and Leyte). Harvesting is done by cutting the trees and placing them under water for several days until the bark becomes more supple for debarking by stripping it from the trunk of the tree. Based on observations of bark in markets, the typical diameter of these trees is 20 centimeters suggesting that the trees in natural stands are harvested at about 40 to 50 years of age. Table 3.4 shows the average age at which the major mangrove species can be harvested given proper care and maintenance of the plantation.

Regeneration systems—This refers to cutting methodologies used to make certain that a forest remains as cutting continues. When properly pursued, regeneration systems allow for a virtually continuous harvest.

- Selective cutting is a common method of harvesting in areas where there is no constant market. Trees are cut to order based on requests from customers. (Poles are cut for fishpens or posts for housing, for example.) The more the trees are cut in selective harvesting, the faster the remaining trees grow since much more sunlight reaches the ground. The new openings created by the harvest also hasten regeneration. This method can lead to a more or less naturally occurring regeneration method called the seed tree and plant method.

- Strip cutting is typically done in larger plantations (greater than 10 hectares) (see Figure 3.11). A strip 10-20 meters wide by 50-100 meters long is cut at a 45 degree angle from the sea to lessen the impact of waves and to enhance regeneration by recruitment of wildlings or new planting. Alternating strips of forest are harvested. The harvested areas are allowed to reseed naturally or are replanted. The seed tree and plant method also can be used in strip cutting. Assuming that the area to be harvested is 10,000 square meters, a total of 40 mature trees can be left in place to act as seed trees. Over time, the forest naturally regenerates.

Seed Tree and Plant Method

Under this method, harvesting in natural stand is allowed provided that at least 40 healthy trees per hectare, spaced regularly over the area and representation of the species in the area, shall be retained to provide seeds/ propagules for regeneration purposes. In case there are not enough surviving wildlings, the gaps will be planted with the desired species (DENR 1990).

These major regeneration techniques can be easily incorporated in mangrove forestry, as they do not require extensive technical ability. A PO that follows this approach will enjoy a plantation and forest that can take care of itself, in a way, and thereby minimize maintenance work and maximize both profitability for the PO and benefits to the coastal resources.

Enhancement planting—Enhancement planting is the process of rehabilitation by increasing the number of seedlings of desirable species (Vande Vusse 1995). This is generally undertaken in denuded mangrove stands or stunted *nipa* groves to increase land productivity and conserve/increase biodiversity.

One of the common methods of enhancement is by planting *bakauan* and other desirable species with gaps of dense natural stands, or planting immediately under the canopy of less desirable species such as *api-api*

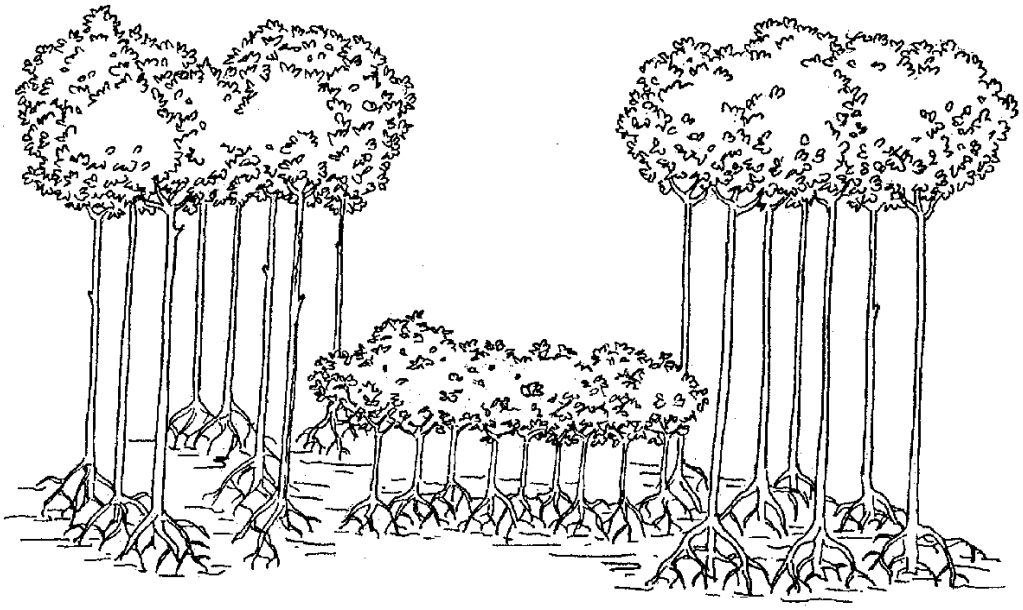

Figure 3.11. Strip cutting of trees.

(*Avicennia officinalis*) and *bungalon* (*Avicennia marina*) after pruning the lower horizontal branches to let in more sunlight. The cut branches may be used for posts and firewood.

Another strategy in enhancement planting is the introduction of fast growing trees in retarded/ unproductive *nipa* stands. These areas may be planted with desirable species that suit the area like *bakauan babae, bakauan lalaki* or *pagatpat* either by strip or spot clearing, depending on the growth/density of *nipa*. The newly planted seedlings should be properly cared for and maintained until they are tall enough to overtop the palm. Eventually the palm, which demands more light, will be illuminated.

As the introduced species becomes dominant, it is expected that the original species will decrease in number and value.

Enhancement planting is more likely to succeed than standard restoration/reforestation in open areas. In enhancement planting, the existing vegetation provides an effective cover and serves as nurse tree to the introduced species that are planted right under or behind big trees. Since most planting in the country is done along the shorelines exposed to strong waves, it is important to prioritize areas with existing stands, denuded or otherwise. Once the plantation is fully established, additional planting towards the sea should be done.

Another form of enhancement is the Assisted Natural Regeneration (ANR). This is done by modifying the forest floor or the forest stand to allow fallen seeds to optimally germinate and grow as wildlings to trees. The activities may include cleaning the ground surface, pruning or thinning of trees. This strategy is by far the economical way of rehabilitation.