Chapter 5

Assisted Natural Regeneration

5.1 Introduction

5.1.1 What is Assisted Natural Regeneration?

Suggest if:
- **Pioneer trees and patches of shrub and forest are mixed with *Imperata*.**

Not recommended for:
- **Sheet *Imperata*, large grasslands**

Assisted natural regeneration (ANR) is a flexible approach to reforestation that:

1. Uses natural regeneration of forest trees ("wildlings" or natural seedlings, and sprouts).
2. "Assists" natural regeneration by preventing fire pressing *Imperata*, and helping trees grow faster in other ways. ANR is sometimes called "accelerated natural regeneration."
3. Plants additional trees when needed or wanted (enrichment planting).

Natural regeneration. "Pioneer" trees are the natural regeneration already growing in grasslands. These pioneers are already well established and adapted for the site. ANR also stimulates new natural regeneration from seed from nearby natural forest. In both cases, by using naturally occurring trees, ANR avoids the problem of matching species to the site. The encouragement of these species can help restore a diverse, native forest.

***Imperata* grasslands.** Preventing fire assists natural regeneration in *Imperata* grasslands, other grasslands (*Miscanthus florida*, *Themeda triandra*, *Saccharum spontaneum*, *Capillipedium parviflorum*), and secondary forest. Pressing (Section 3.3.1) is effective in *Imperata* and *Saccharum*.

Community approach. Assisted natural regeneration has been successfully implemented in village projects on communal or public lands. Full community participation is necessary to prevent fire. In the Philippines, ANR has been used in programs giving villagers legal tenure on national lands, in return for the assistance of the villagers in converting grasslands and mixed brushlands into forest. ANR techniques can also be used on individual farms, especially for fallows and agroforests.

5.1.2 Why Practice ANR?

Where the ANR approach has been implemented successfully, *Imperata* grasslands develop into secondary forest. Compared to conventional reforestation with a single tree species, the ANR approach may have social, environmental, and cost advantages. Depending upon the site, it has the potential to:

- Involve local people in developing a forest that meets their needs, to motivate them to conserve it.
- Reduce total reforestation costs, because there is less site preparation, nursery establishment, and enrichment planting.
- Fit well with farmers' cropping schedules, because ANR concentrates on maintenance instead of planting.
- Provide local employment, if there is outside funding. Most expenses are for local labor.
- Include species chosen by villagers, through enrichment planting.

Village ANR in Pakhasukjai, Chiangmai, Thailand

Akha people who migrated to this village in the mid-1970s were forced to settle in an area dominated by *Imperata*, with small scattered patches of forest and bamboo. The villagers wanted a community forest for production and for spiritual needs, so they set aside several hundred hectares of *Imperata* fallow for forest regeneration. In the forest regeneration area, they:

- Constructed a fuelbreak once a year.
- Formed fire-fighting teams.
- Cut *Imperata* for thatch.
- Did not allow farming.
- Allowed trees to be cut only with the permission of village leaders.
- Planted some areas with trees.

After eighteen years, the village forest had more than a hundred species. About half the species are typical of primary forest. The population has increased and now there is not enough land for villagers to fallow their agricultural fields. Even so, the villagers are continuing to maintain their forest. To handle the increased land pressure, they:

- Look for methods to intensify production on their remaining farmland.
- Migrate in search of work.
- Stop farming their steepest fields and assist natural forest regeneration on them.

The desire to obtain land rights and citizenship is helping to motivate these villagers to manage the forest in their village, which is within an important watershed.

- Develop a forest with many species, especially native species. This benefits wildlife habitat and reduces the risk of severe damage from pests and diseases.
- Reclaim land for long-term timber production, since it assists natural woody species that can be used as nurse trees for enrichment plantings of high-value timber tree species.
- Avoid soil erosion. ANR includes little or no cultivation. Pressed *Imperata* continues to cover and protect the soil.
- Quickly restore forest cover to watersheds. The secondary forest is likely to be multistory, including shrubs and herbaceous plants. Multistory forests control soil erosion and increase the amount of rainfall going into the ground. Restoration may take 2-7 years.

5.1.3 Constraints of ANR

Here are some problems that can prevent ANR from succeeding, together with possible solutions.

Lack of community participation.

Plan the project with local people, not for them (see Chapter 1).

Conflicting laws and regulations; insecure land and tree tenure. If communities are not legally allowed to own, enter, or manage their surrounding forests, then the community will not cooperate with fire prevention and maintenance for ANR.

Negotiate tree or land tenure as part of the project, to give people long-term interest in planting or caring for trees.

Poverty. Local people must provide for their short-term needs. Their time and possibly the ANR area is needed for food production.

Consider food and farming needs first. Negotiate pay for local people's labor if the project serves regional goals and can be subsidized.

Labor scarcity. ANR activities are labor intensive. Labor often becomes a limiting factor, since ANR is usually applied in remote grassland areas with low population densities.

Be realistic in estimating labor availability.

Inadequate extension. Because ANR activities are spread throughout the year, project staff cannot supervise all activities, and must put more responsibility in the hands of villagers.

Train local people in ANR techniques; plan adequate resources for that training.

Lack of staff support. Foresters or other project staff might not support or accept the ANR approach because it is new to them and may seem more complicated than conventional reforestation.

Experience with successful ANR implementation can help build staff confidence and support.

Planning uncertainties. Total nursery costs, maintenance activities, and production are difficult to predict because of uncertainties in the number of seedlings or wildlings needed for enrichment plantings, the time period for the natural woody species to close canopy, and the composition and volume of the secondary forest vegetation that will eventually emerge.

Conduct inventories of species present on the site (Section 5.2.2 and Appendix F). Acknowledge uncertainties in targets and budgets; plan flexibly. Monitor results and learn from experience.

Fire.

See Chapter 3 regarding fire protection.

5.2 Implementing Assisted Natural Regeneration

These steps of ANR implementation in *Imperata* grasslands are based on experience but can be adjusted depending upon the sites, resources available, and project and community objectives.

		Timing…
5.2.1	Clarify goals and objectives.	--->
5.2.2	Select appropriate sites.	--->
5.2.3	Protect the area from fire and grazing.	---------->
5.2.4	Identify and mark woody plants.	---------->
5.2.5	Suppress the grass layer.	---------->
5.2.6	Stimulate new natural regeneration.	---------->
5.2.7	Help existing woody plants grow faster.	---------->
5.2.8	Continue to suppress grass.	---------->
5.2.9	Enrich by planting sun-loving species.	---->
5.2.10	Enrich by planting shade-tolerant species.	---------->
5.2.11	Thin and prune.	---->

5.2.1 Clarify goals and objectives

Be sure that the goals and objectives of any ANR project are clear before it begins. ANR is a technology that may be used by farmers and communities on their own, but ANR may also be promoted and subsidized by a regional or

Community planning land use with a map

national program addressing watershed or timber goals. Broad goals must be negotiated and agreed upon between the community and those providing assistance from outside (see Section 1.3). Not all goals are compatible, and misunderstanding must be avoided. Here are some examples.

	Community	***Outside program***
Compatible long term goals	Get access to land for non-timber forest products, fuelwood and poles.	Produce high-value hardwoods for timber concessions.
	Get legal tenure to nearby or ancestral forest lands.	Improve watershed conditions by stopping fires and reforesting.
	Practice shifting cultivation.	Guide shifting cultivators to use *Imperata* grasslands and secondary forest land instead of primary forest land.
Conflicting long term goals	Use the land later for shifting agriculture.	Be sure that the area will be managed as forest in the future.
Compatible short term goals	Get help with road access and marketing for farm and forest products.	Provide roads to facilitate reforestation activities.
Conflicting short term goals	Earn cash income for labor on the project.	Keep project costs low by expecting villagers to invest labor in ANR in expectation of later products.

Specific objectives for ANR and land management must also be decided upon ahead of time (watershed, timber, fallow improvement). Implementation and resources needed will depend upon the objectives.

5.2.2 Select appropriate sites

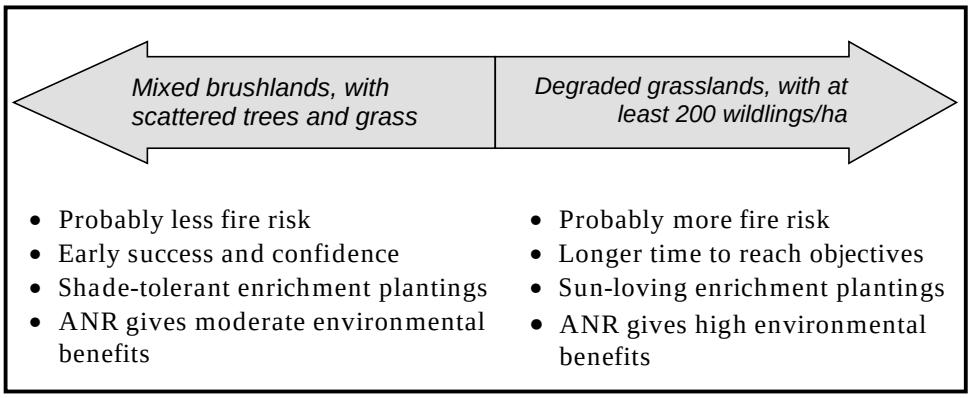
Work in communities that are interested in ANR. Work first with villages or communities that have objectives that can be achieved with ANR, and are willing to organize themselves to prevent fire. Work on lands that the village identifies (see Section 1.3.3).

Choose sites that match the objectives. Also choose objectives that match the sites!

Site	Objectives
Areas accessible to villages, where villagers have tenure or harvest rights	Produce forest and tree products for local use and sale.
Areas bordering villages or where shifting cultivation is practiced	Improve fallows. Use land for agroforestry in the future.
Steep slopes	Reduce fire threats. Reduce flow of water from area during the rainy season.
Areas subject to erosion because of regular burning of *Imperata* cover	Reduce soil erosion and siltation. Reduce flow of water from area during the rainy season.
Land under timber concession	Establish nurse trees for timber species at a low cost.
Areas in or near national parks, game refuges and nature reserves	Restore native forest species. Improve wildlife habitat.

Begin ANR work only in areas that can be protected from fire. Consider labor available to monitor and control fire, and plant and maintain firebreaks.

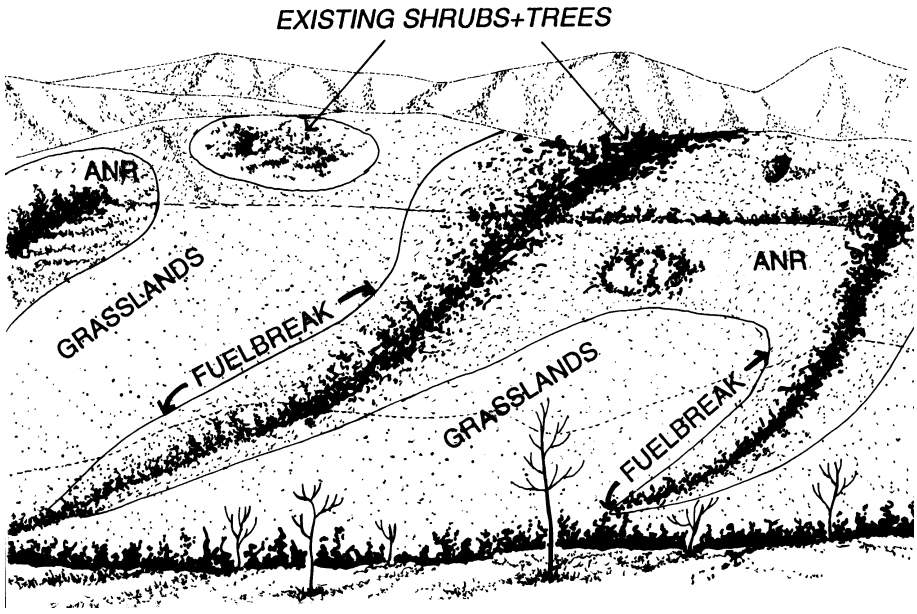
Consider the stage of plant succession of the site. If little or no natural regeneration has occurred, conventional reforestation would be as effective as ANR. If natural regeneration is advanced and most of the area has a closed canopy and trees that are over 2 m tall, use timber stand improvement techniques (including thinning, Section 5.2.11) instead of ANR. In the middle range, decide what areas to prioritize as follows.



Choose sites with enough natural regeneration already present to meet objectives. Estimate the number of existing woody plants/ha, including seedlings and saplings 15-200 cm tall. Count clumps of seedlings within one square meter as one plant. The guidelines given below are for natural regeneration relatively well spread out regardless of slope. If regeneration is uneven, use an estimate for large areas with less regeneration. To make a more careful estimate, use a tally sheet for sample plots (Appendix F).

Woody plants / ha	Timber, watershed objectives	Nature reserves, areas near forest edges, wet sites not prone to fire
Less than 200 / ha (wider than 7 x 7 m)	Use conventional reforestation or agroforestry techniques.	Use conventional reforestation or agroforestry.
200-600 / ha (7 x 7 m to 4 x 4 m)	Use conventional reforestation or agroforestry.	Use ANR with enrichment planting.
600-700 / ha (4.1 x 4.1 m to 3.8 x 3.8 m)	Use ANR with enrichment planting so that canopy closure will take place within 3-5 years.	Use ANR with enrichment planting so that canopy closure will take place within 3-5 years.
Over 700 / ha (narrower than 3.8 x 3.8 m)	Use ANR. For timber production: enrich by planting to achieve desired stocking.	Use ANR.

Choose sites close to forest patches. Gallery forests, forest edges and patches of forest have seed-bearing plants and seed-dispersing animals. This increases the number of new wildlings that can come into the ANR area. Soil conditions may also be more favorable near forest patches. Grasslands that are far from any remaining forests, and grasslands that have been burned and grazed for a long time, do not have enough natural regeneration to make ANR successful.

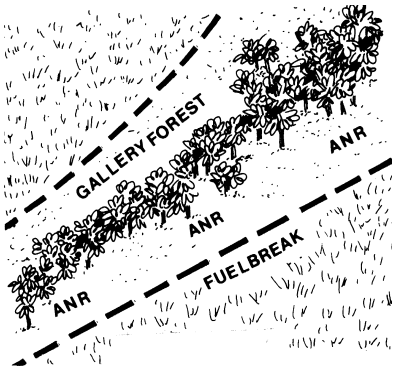


Initial areas for assisted natural regeneration

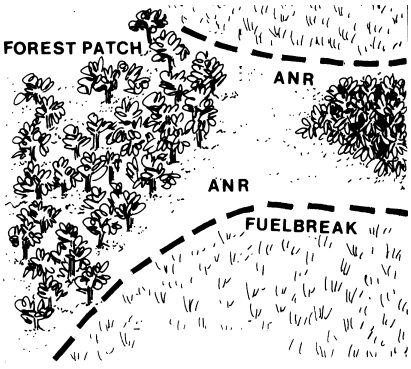
After choosing the site, get to know it well. Understand the local people, the history of the area, local species, and local soils and rainfall (Chapters 1 and 2).

5.2.3 Protect the area from fire and grazing

The most critical step in ANR is protection of woody plants from fire. Review Chapter 3 carefully. Since ANR is often implemented by communities rather than individual farmers, groups can be organized for fire control. At least a month before the dry season begins, make plans and organize firefighting crews. Review plans and roles when dry season begins. During the dry season, patrol the ANR area to locate fires.



Follow the edge



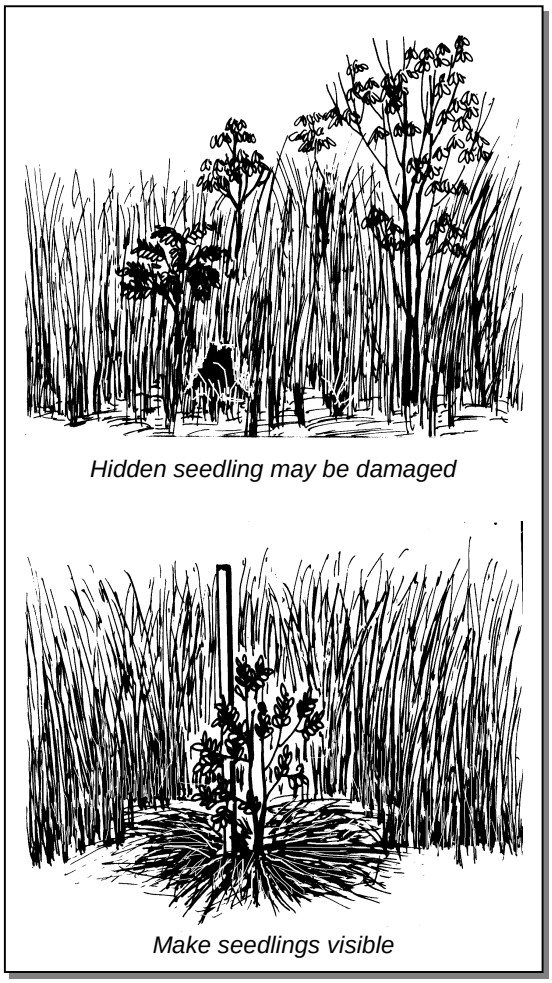
Close the gap

One strategy is to "follow the edges and close the gaps." This means to implement ANR along the edges of forests, agroforests, and other fuelbreaks. Implement ANR in the gaps between areas of forest and agroforest. These adjacent areas will serve as fuelbreaks and sources of seed.

The question of grazing in ANR areas must be addressed by the community. Animals may eat or trample woody seedlings and saplings. However, they may also help spread seeds; for example, cattle eat *Albizia saman* pods and deposit the seeds in their manure, where they germinate and grow well. Establish a one-year test comparing areas where grazing animals are kept out by a fence to areas where grazing animals are allowed to enter and spread seeds. Compare the results and adopt the better method.

5.2.4 Identify and mark woody plants

All existing woody wildlings hidden in the grass should be located and clearly marked in order to protect them during grass pressing and clearing. This can be done by two workers: the first marks the wildlings with a stake, and the second ringweeds or presses the grasses and weeds with his/her foot.



Hidden seedling may be damaged

Make seedlings visible

Mark wildlings. Use stakes only if they are available on the site. The stakes should be visible above the grass, about 1.5-3 cm in diameter and 1.5 m in height. Stakes can often be cut on the site. Do not cut any trees needed to reforest the site. Instead, make stakes from branches pruned from large trees, stems thinned from stumps of fire-hardy species, stems thinned from dense thickets, or thinnings from forests near the ANR area. When cutting stakes from clusters of stems on stumps and in thickets, cut the smaller stems, and leave the largest stems to grow. If stakes are not available, ringweeding will help make the wildlings more visible.

Ring weed. The most efficient procedure is to:

- Press grass away from the base of the wildling, using feet or a pressing board (see Section 3.3.1).
- Pull climbing vines from the trees.
- Slash or uproot ferns, climbing vines, and other weeds within ½ m of the stem. Be careful not to damage wildling stems and roots.

- Hand cultivate around the tree, removing grass rhizomes, up to a ½ m diameter if labor is available. Slashing may be done instead if it will be repeated often.

After ringweeding, the ANR site will look like this.

Be careful that ringweeding does not take away shade from wildlings that need shade, such as seedlings of climax forest tree species, especially in the dry season.

Identify and count wildlings in sample plots if this was not already done during site selection. Do this at the same time as marking and clearing. Local people may be very helpful in identifying plants, though with local names. Extensionists may also record sizes and tag seedlings for future measurement, to monitor growth and survival.

5.2.5 Suppress the grass layer throughout the site

After fire prevention and control, the most important activity in ANR is suppressing *Imperata* and other weeds. *Imperata* must be suppressed efficiently, with minimum use of cash and labor. Usually a combination of methods is used, with cheap and easy methods in open areas and more intensive methods around trees and near forest edges.

Native legumes should be protected and even released from weed competition. They make the soil more fertile and may help suppress *Imperata*. However, climbing legumes must be kept off of trees and seedlings.

Grass pressing. This is a major ANR technique; review Section 3.3.1 carefully. Its purposes in ANR are to:

- Reduce fuel hazard for fire. Press at the beginning of the dry season and whenever the grass is tall and dry.
- Control *Imperata* growth and reduce competition with trees. Press during the rainy season when leguminous cover crops and woody species emerge most rapidly.
- Make it easier and faster to move around and work in the ANR area. Press at any time of the year.
- Prepare enrichment planting areas. Press before the planting season.

Herbicides. With ANR, herbicides can be considered if labor is very limited. See the companion manual *Imperata Management for Smallholders* for practical techniques. However:

- Herbicides are expensive.
- Experience and training is required for safe handling and use.

- A shield must be used to kill only grasses and weeds and not damage woody plants.
- Dead *Imperata* is still a fuel hazard.

Not recommended:
- **Cultivation (plowing)**
- **Controlled burning**
- **Brushing (slashing)**

Widespread cultivation or plowing is generally not recommended for ANR because it exposes the land to erosion on steep slopes and destroys existing woody plants. Controlled burning is not recommended for ANR because *Imperata* regrowth is rapid, woody species are killed or damaged, and the soil is exposed to erosion. For grass suppression throughout the site, brushing is not recommended because it takes more work than pressing and stimulates more regrowth of *Imperata*.

5.2.6 Stimulate new natural regeneration

Brush grass near forests. Near forest edges and tree patches, temperature, moisture, and soil are more favorable for wildlings than in open grasslands. For the purpose of stimulating seed germination, slash or spray herbicide on all grasses and weeds within 5-20 m of the forest edge. Nearby trees and forest wildlife will provide seeds. If trees along the edge of the forest are covered with vines, pull down or slash the vines to release the trees and encourage them to seed.

Protect wildlife. Develop mechanisms within the community and educate children not to kill forest birds and bats. Birds, bats, and pigs can carry seeds into the grasslands.

Consider encouraging weeds that farmers may prefer to *Imperata*. Spraying glyphosate herbicide can cause increased germination of natural vegetation such as *Chromolaena odoratum* and *Melastoma* spp., probably because the dead grass mulches the soil.

5.2.7 Help existing woody plants grow faster

Mark new wildlings as they come in to the area, especially along forest edges.

Ring weed old and new wildlings (see Section 5.2.4).

Fertilize. The decision whether to fertilize depends upon:

- Species. Some species might not grow much faster in response to fertilizer. Before spending much money on fertilizer, test its effects on different species and different age classes in sample plots. Measure size before and after fertilization for both fertilized and unfertilized trees.
- Size of seedling. Newly planted enrichment seedlings or young wildlings will benefit more from a little fertilizer than older trees.
- Soil. Even in *Imperata* grasslands, some soils are fertile. The use of fertilizers on such soils may not improve tree survival and growth.
- Fire risk. Fertilizer might help trees close canopy sooner.
- Plantation value. Trees providing timber, or other high-value products, might be worth fertilizing.

To apply fertilizer:

- Apply fertilizer after ringweeding. Make sure it is placed in a hole and covered with soil.
- For seedlings: apply fertilizer in a spot, semi-circle, or circle about 15-20 cm from the tree.
- For nitrogen-fixing seedlings, apply about 10 g P per tree. For other seedlings, apply about 20 g N and 10 g P per tree, or about one tablespoon NPK. These are general recommendations; if recommendations from local soil tests are available, follow them instead.
- For larger trees: apply directly below the edge of the tree canopy, in a circle, semicircle, or three spots.

- Fertilizer will stimulate the growth of *Imperata* and weeds. Be sure to ring weed and hand cultivate regularly for at least 12 months after fertilization.

Thin. Where two seedlings or saplings are close enough to each other to compete for light, water, and nutrients, remove the one that is smaller, less healthy, or of a less desirable species. When a tree stump has several sprouts, remove all but the 1-3 largest.

Transplant. Make use of planting materials from thinning operations. If thinning takes place during the rainy season, transplant healthy thinned wildlings and cuttings to nearby areas with similar conditions (soil, light, moisture) where there is not enough natural regeneration. If it is near the end of the rainy season, transplant small wildlings of valuable species to a nursery. See Sections 5.2.9 and 5.2.10 for more information on enrichment planting and transplanting wildlings.

5.2.8 Continue to suppress grass

Repeat pressing and ringweeding when *Imperata* begins to compete with wildlings and trees for light and nutrients. During the rainy season, pressing and ringweeding usually need to be repeated at least once every 1½ months.

During the dry season, pressing should be done if the grass begins to grow tall, usually every 2-3 months. Be careful not to take away shade from species of wildlings that need shade.

During all activities, watch for new natural regeneration to be marked and ringweeded.

5.2.9 Enrich by planting sun-loving species

Enrichment planting can include cover crops (Section 4.3), orchard trees (Section 4.6), and plantation trees (Section 4.7), including nurse trees (Section 4.8).

Possible objectives are to:

- Fill gaps to shade out *Imperata* and convert the whole area to forest.
- Increase density so that the canopy will close sooner.
- Add trees of species valued for timber, fruit, nuts, or other products.
- Add nitrogen-fixing species as an improved fallow.

Choosing sites and strategies

Plant only as much area as can be maintained in addition to the natural regeneration that is already being ringweeded and cared for.

Strategy: follow the edges and close the gaps. Concentrate efforts where they are most likely to be successful: along the edges of existing forests and plantations, and in gaps between patches of large trees. These areas have more fire protection than open grasslands, more shade, and possibly better soil conditions. Each planting season, follow the edges of recently planted areas, and close gaps between them.

Strategy: plant nurse trees first. To plant high-value species that need shade while young, plant nurse trees first. This is similar to multistory agroforestry (Section 4.8) and tree plantations (Section 4.7).

Species choice

ANR in *Imperata* grasslands often uses the same species as in simple tree plantations in *Imperata*: species that can survive harsh conditions, grow quickly and cast heavy shade to suppress *Imperata* (Section 4.7). But the ANR approach is different from simple tree plantations because it:

- Uses a wider variety of local native species and agroforestry species.
- Has a variety of “microsites” where shrubs and trees provide shade, affect soil moisture, and form windbreaks.

Therefore, instead of choosing a single species, try to use several enrichment species matched to different spots within the ANR area.

Natural regeneration considerations. Include a few local tree species known to provide fruit or food for birds and bats that spread seed. Include local species that are common roosts (sleeping and nesting areas) for birds and bats.

In *Imperata, Acacia mangium* is a good hardy nurse tree for natural regeneration of native forest species. This is probably because *A. mangium* fixes nitrogen and provides shade. The shade is important in ANR because it suppresses *Imperata* and is favorable for shade-tolerant tree species.

Production considerations. For fertile and accessible sites, consider tree crops, multistory agroforestry species, and improved fallow species (Chapter 4). For timber and multipurpose species, choose some that will be harvested within 5-10 years (short rotation) and some high-value species that will be harvested later (medium and long rotation). Having more than one wood or timber species will absorb the loss from a low market price for one species.

Site matching. Information about common reforestation species and agroforestry species is available from foresters and agriculturalists. Information may not be available in books about local native species, but local species should be considered for local cultural, medicinal, wildlife, or other values. To figure out how to match these local species to planting spots:

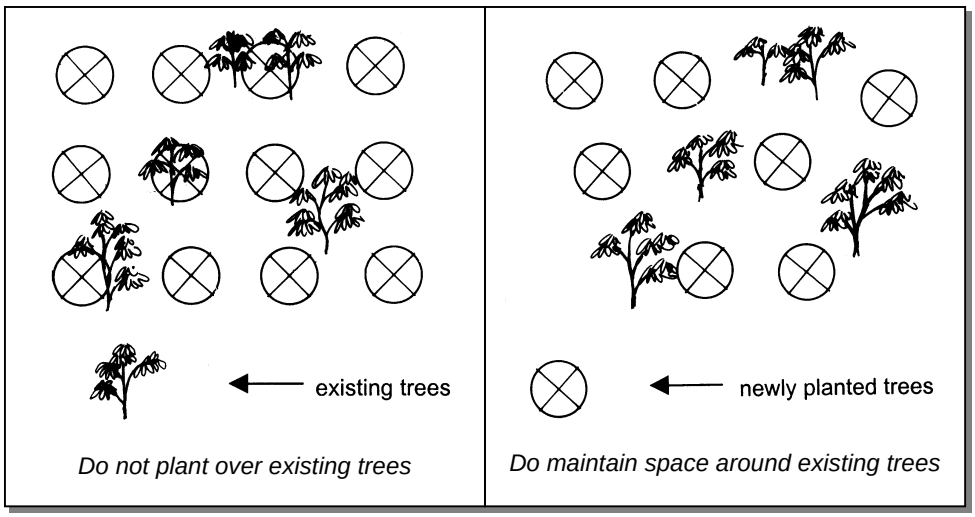
- Observe surrounding areas and notice where similar species grow well. Notice soil texture and color, soil drainage (wet, dry, variable), topographic position (slope, aspect, hilltops and ridges, streamsides, flood plains), rainfall, elevation, and shade. Consider having a soil test done for fertility.
- Talk with local people to identify potential species, their uses, and habitat requirements.

Plant a few target species in different sites as a test. Observe how they grow or adapt to different conditions. Select the tree species that grow the best for each site.

Implementation

Many planting techniques are the same as those for simple tree plantations (Section 4.7).

Spacing. As a rule of thumb, use a 2m x 3m spacing to close canopy within 3-5 years. For nurse trees, use 3m x 3m, or use a closer spacing and thin later. Other spacings can be used depending upon the species and objectives for the site. Maintain spacing between new trees and existing natural regeneration.



Nursery production. To estimate the amount of planting material needed, subtract the average woody plants/ha already present from the target stocking. For example, a 2m x 3m spacing is about 1670 trees/ha. If there are already 600 wildlings/ha, 1070 seedlings/ha will be needed, plus an allowance for mortality in the nursery, under transport, and in the field.

Site preparation. Cultivate planting areas 1 m in diameter.

5.2.10 Enrich by planting shade-tolerant species

Begin enrichment planting of shade-tolerant trees:

- As soon as nurse trees and existing woody species cast appropriate shade for the shade-tolerant species. Continue to weed and control *Imperata*.
- Or, wait until nurse trees and existing woody species cast heavy shade and have outcompeted *Imperata*. Thin or prune nurse trees to allow the right amount of light and shade for the shade-tolerant species. Control *Imperata* if it begins to grow again.

At the start of the rainy season, plant the high-value tree species between the nurse trees at 3 x 3 m or 4 x 4 m spacing, or at the recommended spacing requirements of each species.

Produce seedlings in the nursery, and transplant wildlings from nearby forests. When gathering wildlings, dip the roots in thick mud or a slurry of clay soil and water, and wrap them in leaves to keep them moist while being moved. Mix soil from where they were taken into the mud, slurry or nursery soil, to inoculate them with mycorrhizae and rhizobia to improve their growth. Transplant small wildlings or heavily shaded wildlings to the nursery to grow them larger and gradually accustom them to the right amount of sun.

Agroforestry species, rattans, orchids, and other non-timber forest species can also be planted (Section 4.8).

5.2.11 Thin and prune

Prune branches of nurse trees. Prune nurse trees to gradually increase light for dipterocarps and other species that need shade when young and sun when large.

Thin trees as the forest develops. As the canopy begins to close and trees compete with each other, in some cases it is worth the labor to thin trees.

If an unhealthy, branchy, crooked, or worthless tree is interfering with the growth of a healthy, straight, or valuable tree,

Cut the unhealthy, branchy, crooked, or worthless tree.

If trees are crowded, and the thinned trees can be used for firewood or other products,

Cut trees that are shorter, smaller in diameter, or less straight. The remaining trees will grow faster and produce superior seed.

When dipterocarps reach pole diameter,

Thin enough nurse trees to increase sunlight.

Do not:
- **Remove needed shade**
- **Let *Imperata* back in**
- **Damage other trees**

Be careful not to cut trees that are still needed for shade of shade-tolerant plants or seedlings. Don't cut so many trees that *Imperata* returns and becomes a fuel hazard for fire. Finally, cut trees carefully so that they don't damage other trees as they fall.

5.3 Labor and cost estimates for ANR

Appendix G shows tasks and estimated labor for a hectare of assisted natural regeneration, assuming that the site begins with 1000 woody plants/ha and no enrichment planting takes place. Labor for firebreaks establishment, pressing and ringweeding in Year One requires 49 person-days. Years Two and Three each require 31 person-days. Total labor for the three years is 111 person-days.

Cost savings of ANR in comparison to conventional reforestation can be roughly estimated by considering that a percentage of costs will be saved because of the stocking already on the site. For example, if 60% of the area already has adequate stocking and 40% of the area is planted, the costs for seedling production and outplanting will be reduced by 60%. Fire control, ringweeding and grass suppression costs would be about the same. In this example, ANR costs about 78% as much as conventional reforestation. However, that does not consider the differences in site

preparation. ANR usually uses pressing and spot cultivation for enrichment planting. Conventional reforestation might use removal of existing brush vegetation followed by complete cultivation.

ANR demonstration (general expectations)

Carefully monitor the pressing and ringweeding of the first few hectares of an ANR project, to train participants and put a demonstration area in place that will attract attention. To press and ringweed 1 ha requires 15 person-days / ha. Three hired laborers and one extensionist experienced with ANR will form a good team to demonstrate ANR on 4 ha. Allowing time for weekends, holidays, and training for interested local farmers, implementation of ANR on this demonstration area will take about one month.

5.4 Summary

Assisted natural regeneration techniques can be applied to many land uses.

Fire protection is a requirement for agroforestry, reforestation or ANR in *Imperata* grasslands. Communities motivated by land tenure or other factors can implement ANR with fire protection alone if there is sufficient natural regeneration (see the Kalahan case study, Section 3.5). ANR can therefore be a very low-input approach to reforestation within the abilities of local communities.

Pressing *Imperata* grass (Section 3.3.1) is a technique that can be used in agroforestry and tree plantations as well as ANR, to help control *Imperata* between rows and beside fuelbreaks.

Natural regeneration can be incorporated into agroforestry and conventional reforestation. Wildlings and larger shrubs and trees already present may be retained because they have timber or other values, because they provide organic material in fallows, or because they can help form fuelbreaks as they compete with *Imperata*.

Enrichment planting combined with ANR can develop a multi-species forest plantation, or can lead to a multistory agroforestry system (Section 4.8) as shade-tolerant crop species are established underneath pioneer species that are used as nurse trees.

Imperata grasslands, agricultural and agroforest crops, plantations, and native forest species each have their place in the landscape. Flexibility and open communications will help as local communities interact with the governments of larger watersheds and nations to make wise decisions about how to use land, labor, cash and other resources to achieve the greatest good for all.

Appendix A. Recommended practical references

The following references provide useful information on tree species, agroforestry systems, reforestation, community participation, and fire protection.

del Castillo, R., R. Dalmacio, R. Lasco, and N. Lawas, eds. 1994. ***Agroforestry Production and Post Production Systems: a Training Manual.*** University of the Philippines Agroforestry Program (UAP), Laguna, Philippines, and KAPWA Upliftment Foundation Inc., Davao City, Philippines. [Available from UPLB Bookstore]

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PROSEA. 1992-1997. ***Plant Resources of Southeast Asia, Vol 1-11*****.** Prosea Network Office. Bogor, Indonesia.

USDA FS. [No date] ***Manual for Forest Fire Fighters.*** United States Department of Agriculture, Forest Service, Northeastern Area. Pennsylvania, USA. [Available from IPIF]

Addresses of sources:

CIFOR: Librarian, Center for International Forestry Research, Jl. CIFOR, Situ Gede, Sindangbarang, Bogor Barat 16680 Indonesia. Fax: (0251) 622-1100.

FAO/Rome: Director, Publications Division, Food and Agriculture Organization of the United Nations, Viale delle Terme di Caracalla, 00100 Rome, Italy.

FAO/Thailand: Food and Agriculture Organization of the United Nations, Regional Office for Asia and the Pacific, Maliwan Mansion, Phra Atit Road, Bangkok 10200, Thailand. Fax 66-2-2800445. Email fao-rapa@cgnet.com

ICRAF: International Centre for Research in Agroforestry, P.O. Box 161, Bogor 16001, Indonesia. Fax (62-251) 625-416. Email icraf-indonesia@cgnet.com

IIRR: International Institute of Rural Reconstruction, Y. C. James Yen Center, Biga, Silang 4118, Cavite, Philippines. Fax (63-46) 414-2420. Email iirr@cav.pworld.net.ph

IPIF: Institute of Pacific Islands Forestry, USDA FS, 1151 Punchbowl St. Rm. 323, Honolulu, Hawaii 96813 USA. Fax (1) 808-522-8236. Email ipif@gte.net

KAPWA: KAPWA Upliftment Foundation, Inc. 427 Durian St., Juna Subdivision, Matina, P.O. Box No. 81508, Davao City 8000 Philippines.

PCCARD: Philippines Council for Agriculture, Forestry and Natural Resources Research and Development, College, Los Baños, Laguna, 4030 Philippines. Fax (63) 094-50016.

PROSEA: Distribution Officer, Prosea Network Office, Herbarium Bogoriense 4th Floor, Bogor 16122 Indonesia.

UAP: University of the Philippines Agroforestry Program, 2nd Floor, UPLB-CF Administration Building, College, Los Baños, Laguna 4031 Philippines. Fax (63) 094-3206.

UPLB Bookstore: University Bookstore, SU Building, University of the Philippines at Los Baños, College, Los Baños, Laguna 4031 Philippines

Appendix B. Characteristics of contour hedgerow and rotational alleycropping species.

Name	Soil fertility enhancement	Products	Elevation (m)	Drought tolerance	pH tolerance	form
Acacia villosa (*A. glauca*)	Green manure N-fixer	Fuelwood	0-1000+	good	Acid tolerant	shrub
Ananas comosus (pineapple)	Little or none	Food	0-1500	good	acid tolerant	<1 m
Calliandra calothyrsus (*C. tetragona*)	Green manure N-fixer	Fuelwood, fodder, honey	0-2000	moderate	acid tolerant	shrub
Delonix regia (fire tree)	green manure	Fuelwood	0-2000	very good		tree
Desmodium rensonii	green manure N-fixer	Fodder	0-1000	moderate	wide range of pH values	shrub
Erythrina poeppigiana (coral tree)	green manure N-fixer	Poles, fodder	0-1900	good	Acid tolerant	tree
Flemingia macrophylla	green manure N-fixer	fodder	0-2000	moderate	wide range of pH values	shrub
Gliricidia sepium (madre de cacao)	green manure N-fixer	Posts, fuelwood, fodder, honey	0-1500	good	wide range of pH values	small tree

Name	Soil fertility enhancement	Products	Elevation (m)	Drought tolerance	pH tolerance	form
Hibiscus rosasinensis	green manure	fodder	0-1500	moderate	wide range of pH values	shrub
Leucaena diversifolia	green manure N-fixer	Light poles, fuelwood	0-2000	moderate	acid tolerant	small tree
L. leucocephala, giant varieties (ipil-ipil)	green manure N-fixer	Poles, fuel-wood, fodder	0-2000	very good	not tolerant of acid soils	tree
Pannicum maximum (guinea grass)	little or none	fodder	0-2000	good	wide range of pH values	grass
Parkia roxburghii (kupang)	green manure N-fixer	fuelwood	0-2000	good	wide range of pH values	tree
Pennisetum purpureum (napier grass)	little or none	fodder	0-2000	moderate	wide range of pH values	grass
Piliostigma malabaricum (butterfly tree)	green manure	fodder, fuelwood	0-1500	good	wide range of pH values	small tree
Senna siamea (*Cassia siamea*, Thailand shower)	green manure	fuelwood, small timber, fodder, honey	0-1500	excellent	wide range of pH values	small tree
Senna spectabilis (Cassia spectabilis, golden shower)	green manure	fuelwood	0-1500	moderate	acid tolerant	tree

Name	Soil fertility enhancement	Products	Elevation (m)	Drought tolerance	pH tolerance	form
Setaria sp.	little or none	fodder	0-2000	good	wide range of pH values	grass
Vetivera zizanoides (vetiver)	little or none	little or none	0-2000	excellent	wide range of pH values	grass

Appendix C. Characteristics of leguminous cover crop species.

Species	Growth habit	Site preferences (Numbers in parentheses indicate conditions for less favorable sites)	Competition and use as cover crop
Calopogonium caeruleum (caeruleum calopo, thua saelulium)	• Perennial • Woody vines	• tolerates soil pH as low as 4 • tolerates wide variety of soils, but prefers well-drained soils • drought tolerant	• Slow-growing for 20 months • Vigorous growth from 20 months to 5 years of age • Shade tolerant • Can smother *Imperata* • Used as intercrop in with industrial tree crops
Calopogonium mucunoides (*Stenolobium branchycarpum*, robo de iguana, falso oro, calopo, kacang asu, thua karopo)	• Perennial • seeds profusely, may regenerate annually • creeping, twining	• elevation (0) 300-1000 (2000) m • Adaptable to various soils • Tolerates soil pH 4.5-5.0 • Dry season up to 4½ months • 1200+ mm rain/year preferred	• Achieves cover within 3-6 months • Medium-low shade tolerance • Especially useful for quick cover of cleared land • Dry season forage

Species	Growth habit	Site preferences (Numbers in parentheses indicate conditions for less favorable sites)	Competition and use as cover crop
Centrosema pubescens (Centro, butterfly pea)	• perennial • trailing, twining, climbing	• elevation 0-300 (1000) m • fair tolerance of low fertility soils • Dry season up to 4½ months; more drought-tolerant than *Calopogonium* or *Puereria* • annual rainfall (1200)1500+ mm • good tolerance of waterlogging	• establishes slowly, 4-8 months • vigorous once established • Medium-high shade tolerance • Used as relay crop • Good forage, mixes well with forage grasses
Crotolaria juncea (sunn hemp, orok-orok)	• annual • erect stem 1-3 m	• elevation 0-300 m preferred • pH (4.0) 5-7.5 • Light, well-drained soils • 760+ mm rain/year preferred • can produce crops with 50 mm rainfall in 6 weeks	• Can strongly suppress *Imperata* • may inhibit maize germination • can relay plant, fallow, or interplant with tall crops
Mucuna pruriens var. *utilis* (*Stizolobium atterinium, S. niveum,* kokoa, velvet bean, Bengal bean, cowhage, koro benguk)	• annual • vines up to 6 m long	• pH 5.0-6.5 • Less tolerant of degraded and waterlogged soils than *Imperata* • drought tolerant	• large seed, fast starter • vigorous growth for 4-6 months • Good for short fallows • Not used in intercropping

Species	Growth habit	Site preferences (Numbers in parentheses indicate conditions for less favorable sites)	Competition and use as cover crop
Pueraria phaseoloides (syn. *P. javanica*) (puero, tropical kudzu, kacang riji)	• perennial • twining, climbing	• tropical lowlands • tolerates acid soils • best suited to heavy soils • good tolerance of waterlogging • annual rainfall (1200) 1500+ mm • more tolerant of drought than *Calopogonium*	• establishes slowly, 6-9 months on average; vigorous once established • medium shade tolerance • good for smothering weeds • used in fallow or with trees
Stylosanthes guianensis (stylo, thua satailo)	• perennial • bushy	• adapted to many soil types including sandy soils • fair tolerance of waterlogging • annual rainfall 1525+ mm	• Used as fallow or relay crop • Good pasture legume

Appendix D. Site preferences of perennial fruit, nut, and resin agroforestry species

These species are suited to smallholder plantings on *Imperata* grasslands.
Numbers in parentheses indicate conditions for less favorable sites.

Species	Altitude (m above sea level)	Rainfall (mm/yr)	Rainfall distribution	Soil pH	Minimum soil depth	Soil type, texture, drainage
Aleurites moluccana (candlenut, lumbang)	0-800 (1200)	1000-2500	90-200 days rain / year			Podzolic, Latosols, sandy soils & limestone soils
Anacardium occidentale (cashew)	0-800 (1500)	500-3200	Can tolerate dry season over 6 months	5-8 (4.3-8.7)	Deep; tolerates shallow	Does well on sandy soil; prefers well-drained
Areca catechu (betel nut)	0-900	1250-3000				

Species	Altitude (m above sea level)	Rainfall (mm/yr)	Rainfall distribution	Soil pH	Minimum soil depth	Soil type, texture, drainage
Artocarpus heterophyllus, syn. *A. brasiliensis, A. integra, A. integrifolia* (jackfruit, nangka)	0-1000 (1200)	Above 1500	Evenly distributed; tolerates 2-4 month dry season	5-7 (4.3-8.0)	deep	Prefers well-drained sandy or clay loam
Canarium ovatum (pili)	0-400	moist humid	Tolerates dry season; prefers evenly distributed rainfall	Slightly acidic	deep	Adaptable; prefers well-drained soils
Ceiba pentandra, syn. *C. casearia, Bombax guineese, B. orientale* (kapok)	0-600	1500-3500				
Cinnamomum burmanii (cassiavera)	(0) 600-1500	1500-2500	150-240 days rain / year			

Species	Altitude (m above sea level)	Rainfall (mm/yr)	Rainfall distribution	Soil pH	Minimum soil depth	Soil type, texture, drainage
Citrus spp. (citrus)	0-1200 (1500)	(1000) 1500-2000		5.5-6.5 (4.3-8.3)	1 m	Well-drained sandy loam with high OM
Cocos nucifera (coconut)	0-600 (900)	1200-2000 (1000-2500)	evenly distributed through year	4.3-8.3	75 cm	Prefers adequately drained, high water-holding capacity (at least 30% clay)
Coffea spp. (coffee)	0-900 (1800)	1550-1800 (1200-2500)	evenly distributed through year or short dry periods	4.5-5.5 (4.3-8.0)	1.5 m	Requires friable, loamy soil with good water holding capacity and circulation of air & moisture
Eugenia aromatica (clove)	200-600	1500-3500	90-175 days rain / year			

Species	Altitude (m above sea level)	Rainfall (mm/yr)	Rainfall distribution	Soil pH	Minimum soil depth	Soil type, texture, drainage
Garcinia mangostana (mangosteen)	0-500		Tolerates dry season; prefers rainfall well distributed through the year	Slightly acid ideal (4.3-8.0)	deep	Loam or loose clay with good drainage
Hevea braziliensis (rubber)	0-600	1500-2000	Fairly evenly distributed through the year	Acidic 4.3-8.0	1 m	Requires well-drained clay loam or sandy loam
Mangifera indica (mango)	0-600	(300) 760-2700 mm/yr	at least 5 months' dry period	5.5-7.5 (4.3-8)	deep	prefers well-drained loam soils
Manilkara zapota, syn. *Achras zapota*, *Sapota achras* (chico, sapodilla, marmalade plum, bully-tree)	0-1500 (2500)	1250-2500	Can succeed in long dry season if watered when young	4.5-7 (8.6)	deep	Prefers well-drained sandy loam

Species	Altitude (m above sea level)	Rainfall (mm/yr)	Rainfall distribution	Soil pH	Minimum soil depth	Soil type, texture, drainage
Musa spp. (banana)	0-1500 (1800)	1400-2450	At least 100 mm/month	4.5-7.5 (4.3-8.3)	deep	Prefers friable loam soil with good drainage and aeration
Myristica fragrans (nutmeg)	0-700	1500-3500	80-180 days rain / year			
Piper nigrum (black pepper)	0-500 (1000)	1500-2000 (1000-3000)	100-200 days rain / year	4.3-7.4		Loam or loose clay with good drainage
Psidium guajava (guava)	0-800	700-3700	Less than 6 months' dry season	5.5-7.5 (4.3-8.3)	deep	Prefers rich, well-drained soils high in OM
Sandoricum koetjape (santol)	0-800		Tolerates dry season; prefers evenly distributed rainfall	Slightly acidic	deep	Well drained; prefers loose friable clay loam or sandy loam with high OM

Species	Altitude (m above sea level)	Rainfall (mm/yr)	Rainfall distribution	Soil pH	Minimum soil depth	Soil type, texture, drainage
Spondias purpurea (sineguelas)	0-600 (2000)	Succeeds in wet and dry sites	Better quality fruits where dry season is long	Slightly acidic		Adaptable; prefers moist, fairly heavy loam soil
Syzyqium cumini (duhat)	0-600	1000-1500	prefers distinct dry season	Slightly acid	Deep; tolerates rocky or shallow	Prefers well-drained clay loam or sandy loam
Tamarindus indica (tamarind)	0-1500	250-2700	best if well distributed through year	Moder-ately acidic or alkaline	Tolerates rocky or shallow	Prefers well-drained sandy or clay loam with high OM

Species	Altitude (m above sea level)	Rainfall (mm/yr)	Rainfall distribution	Soil pH	Minimum soil depth	Soil type, texture, drainage
Theobroma cacao (cacao)	0-500 (1000)	1000-3000 (5000)	no more than 3 months' dry period	5-6.5 (4.3-8.7)	60-70 cm	Must be well-drained, aerated, with good moisture retention; aggregated clay or loamy sand
Vanilla fragrans (*V. planifolia*, vanilla)	0-800	2000-2500 (1500-3000)	100-178 days rain / year		Deep	Friable well-drained soils

Appendix E. Plantation tree species suitable for *Imperata* suppression.

Table 1. Plantation species reported to successfully control *Imperata*.

Note: not all species always succeed; *Imperata* often continues to grow under *Eucalyptus* and *Pinus* species and *Paraserianthes falcateria*.

Indonesia

Acacia aulacocarpa
A. auriculiformis
A. crassicarpa
A. decurrens
A. mangium
Albizia procera
Aleurites moluccana
A. montana
Altingia excelsa
Anacardium occidentale
Cassia multijuga
Casuarina equisetifolia
Cecropia peltata
Endospermum malaccense
Erythrina sp.
Fagraea fragrans
Gmelina arborea
Hibiscus spp.
Hopea mengarawan
Intstia palembanica
Leucaena leucocephala
Morus macroura
Ochroma sp.
Ormosia sumatrana
Paraserianthes falcataria (syn. *Albizia moluccana*)
Peltophorum dasyrachis (syn. *P. grande*)
Pinus caribaea
P. merkusii
Psidium guajava
Quercus sp.
Schima wallichii
Sesbania sesban
Shorea leprosula
S. ovalis
S. platyclados
Sindora sp.
Styrax benzoin
Swietenia macrophylla
Syzygium spp.
Toona sinensis
Vernia arborea
Vitex parviflora
V. pubescens

The Philippines	Vietnam	Malaysia
Albizia procera	*Acacia auriculiformis*	*Dryobalanops aromatica*
Alnus maritima	*A. mangium*	*Hopea karangasensis*
Anacardium occidentale	*Anacardium occidentale*	*Pentaspodon motleyi*
Artocarpus heterophyllus	*Anthocephalus chinensis*	*Shorea leprosula*
Bauhinia malabarica	*Indigofera teysmanii*	*S. macrophylla*
Casuarina equisetifolia	*Lagerstroemia speciosa*	*S. ovata*
Eucalyptus camaldulensis	*Pinus kesiya*	*Vatica nitens*
E. grandis	*Pterocarpus* spp.	*Whiteodendron mpultonianum*
E. saligna	*Swietenia macrophylla*	
Gliricidia sepium		
Gmelina arborea		
Leucaena leucocephala		
Pinus insularis		
Psidium guajava		
Vitex parviflora		

Table 2. Site requirements of common plantation species in *Imperata* grasslands.

Numbers in parentheses indicate conditions for less favorable sites.

Species	Elevation (m)	Soil acidity	Soil texture, type	Rainfall (mm/year)	Length of dry season
Acacia auriculiformis	0-800	pH 3.0-9.5	Infertile OK deep-shallow	(1000) 1500-2500	0-6 months
A. mangium	0-720	pH over 4.5	Tolerates thin, rocky, or alluvial soils	1000-4500	2-4 months
Calliandra calothyrsus	150-1500 (0-2000)	moderately acidic	prefers light soils, not waterlogged	(1000) 2000-4000	3-6 months
Gliricidia sepium	0-500 (1600)	tolerates acid soils	tolerates limestone, saline, or degraded soils	1500-2300	0-6 months
Gmelina arborea	0-800 (1200)	adaptable to acid soils	does not tolerate waterlogged or leached soils, dry sand	750-4500	4-6 (7) months
Leucaena leucocephala	0-1000 (1500)	pH 6-7.7	not waterlogged	(250) 600-3000	4-6 (8) months
Vitex parviflora	0-700		adaptable; prefers limestones, tolerates dry, rocky sites		0-7 months

Table 3. Sun-demanding trees that can be planted into grasslands. All are native Philippine species recommended for areas with no pronounced dry season.

Scientific Name	Family	Economic Quality	Mature height (m)	Mature diameter (m)
Dracontomelon dao	Anacardiaceae	Superb; Furniture	40	1.0
Dracontomelon edule	Anacardiaceae	Good; construction	40	1.0
Koordersiodendron pinnatum	Anacardiaceae	Superb; All purpose	25	1.2
Radermachera pinnata	Bignoniaceae	Good; all purpose; pioneer	20	0.6
Garuga floribunda	Burseraceae	Superb; All purpose	35	1.0
Afzelia rhomboidea	Caesalpiniaceae	Superb; All purpose	25	0.5
Albizia lebbekoides	Caesalpiniaceae	Light construction; pioneer	25	2.5
Intsia bijuga	Caesalpiniaceae	Superb; Furniture	50	1.5
Casuarina equisetifolia	Casuarinaceae	Good; house posts	30	1.0
Casuarina nodiflora	Casuarinaceae	Good; house construction	20	0.8
Calophyllum blancoi	Clusiaceae	Good; all purpose	25	0.6
Calophyllum inophyllum	Clusiaceae	Good; furniture	20	1.5
Terminalia catappa	Combretaceae	Good; house construction, boats	25	0.8
Terminalia foetidissima	Combretaceae	Good; house construction, boats	25	0.8
Terminalia microcarpa	Combretaceae	Light construction, wine	35	1.0
Ormosia calavensis	Fabaceae	Light construction; good mycorrhiza	15	0.6

Scientific Name	Family	Economic Quality	Mature height (m)	Mature diameter (m)
Pterocarpus indicus	Fabaceae	Superb; Furniture	40	1.2
Petersianthus quadrialatus	Lecythidaceae	Superb; All purpose	40	1.5
Melia dubia	Meliaceae	Light construction; pioneer	15	0.5
Toona sureni	Meliaceae	Good; house construction	20	0.8
Albizia procera	Mimosaceae	Superb; Furniture	25	0.7
Artocarpus sericicarpus	Moraceae	Superb; All purpose, boats	35	1.0
Myrica javanica	Myricaceae	Good; construction	20	0.8
Eucalyptus deglupta	Myrtaceae	Good; construction, pulp	70	2.4
Tristania decoticata	Myrtaceae	Superb; Heavy construction	25	1.0
Pometia pinnata	Sapindaceae	Superb; All purpose	40	0.8
Trema orientalis	Ulmaceae	Light; good shade; pioneer	35	0.5
Tectona philippinensis	Verbenaceae	Superb; Heavy construction	15	0.5
Vitex parviflora	Verbenaceae	Superb; All purpose	20	1.0
Vitex turczanihowii	Verbenaceae	Good; construction; musical instruments	30	1.0

Table 4. Shade-demanding trees to be planted a year or more after nurse trees have been planted. All are native Philippine species recommended for areas with no pronounced dry season.

Desirable characteristics (not all found in all species shown in this table):

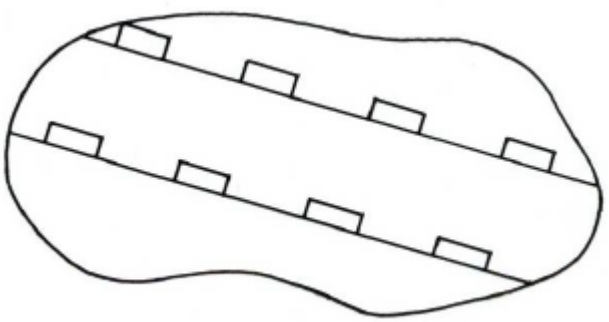
- Adjustable to a wide range of soil and light conditions
- Seeds and seedlings are easy to recognize, so germination and seedling management is easy
- Withstands transplanting to the field
- Resistant to strong winds
- Young shoots have the ability to grow through thickets or canopies of pioneer species

Scientific Name	Family	Economic Quality	Mature height (m)	Mature diameter (m)
Anisoptera thurifera	Dipterocarpaceae	Superb; All Purpose	45	2.0
Dipterocarpus warburgii	Dipterocarpaceae	Superb; All Purpose	50	1.8
Hopea acuminata	Dipterocarpaceae	Superb; Hard construction	35	0.9
Hopea foxworthyi	Dipterocarpaceae	Superb; All Purpose	35	0.6
Hopea philippinensis	Dipterocarpaceae	Good; construction	20	0.5
Hopea malibato	Dipterocarpaceae	Superb; Hard construction	35	0.5
Parashorea malaanonan	Dipterocarpaceae	Superb; All Purpose	60	2.0
Shorea almon	Dipterocarpaceae	Superb; All Purpose	70	1.6
Shorea contorta	Dipterocarpaceae	Superb; All Purpose	50	1.8
Shorea guiso	Dipterocarpaceae	Superb; All Purpose	40	1.8
Shorea malibato	Dipterocarpaceae	Superb; Hard construction	35	0.8

Scientific Name	Family	Economic Quality	Mature height (m)	Mature diameter (m)
Shorea negrosensis	Dipterocarpaceae	Superb; All Purpose	50	2.0
Shorea palosapis	Dipterocarpaceae	Superb; All Purpose	50	1.5
Shorea polysperma	Dipterocarpaceae	Superb; All Purpose	50	2.0
Diospyros philippinensis	Ebenaceae	Good; furniture	20	0.8
Castanopsis philippinensis	Fagaceae	Superb; Furniture	25	0.5
Lithocarpus pruinosa	Fagaceae	Good; construction	30	0.5
Heritiera sylvatica	Sterculiaceae	Superb; Construction, posts	20	0.8
Pterospermum obliquum	Sterculiaceae	Good; construction	25	0.7
Diplodiscus paniculatus	Tiliaceae	Good; light construction	20	0.8

Appendix F. Simple sampling for density and species of natural regeneration.

This simple method of sampling will help make decisions about whether a site has enough natural regeneration for ANR.



Layout of transects and plots

1. During the initial survey of the area, set the boundaries of the proposed ANR area.
2. Set two (2) straight parallel transect lines along the area, not too close to the boundaries or to each other.
3. Allocate four (4) 10m x 25m plots equally spaced along each line.
4. For each sample plot, record the number of seedlings of each species in the tally sheet on the next page.
5. Convert number of seedlings per plot to number of seedlings per hectare by multiplying by 40.
6. Average the results for each plot to get the average number per hectare for all plots.
7. If some adjacent plots do not pass the test for ANR but the average for the whole area passes the test (Section 5.2.2), consider whether the area should be subdivided and ANR used only where there is sufficient natural regeneration.

For good project monitoring and species and fertilizer trials, someone with a good knowledge of statistics should help plan a better sampling technique that takes into consideration (1) control plots, (2) stratification of areas with different characteristics, and (3) number of plots and plot size needed.

Tally sheet for inventory of natural regeneration.

Plot Location:

Province: _____ Municipality: _____ Name of Project/landowner: _____

Plot size: _____ m^2

Multiply number of stems by 10000/(plot size in m^2) to get total per hectare.
For a 10m x 25m plot, multiply by 10000/(10x25) = 40.

Name of Species	Tally Marks or check	Total	Total per ha.
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
TOTAL			

Appendix G. Assisted Natural Regeneration Work Plan.

Tasks, Schedule, and Average Manpower Requirements, One Hectare (Year One)

Activity	Schedule	Labor Requirements	
Year One		Derivation	Person days
1. Brushing/clearing of firebreaks 10 m wide, spaced 40 m apart within the planting block, plus firebreaks on all four sides of the perimeter. Complete grubbing out of grass; removal of cut and grubbed material from the firebreak.	Immediately prior to end of rainy season	2 internal firebreaks x 100 m long x 10 m = 2000 m2/ha Perimeter firebreaks average = 1,200 m2/ha 3,200 m2 / 200 m2/personday	16
2. Ringweeding of all naturally-growing woody-stemmed broadleaf plants (i.e. pioneers), 1 m circular. Grubbing out roots of grass in the circle. Pressing down the grass growing in areas outside the ringweeded area.	Start of rainy season	1,000 pioneers/ha / personday	10
3. Maintenance weeding/pressing down of grass in firebreaks	Once, just before end of rainy season	3,200 m2 /400 m2/personday	8
4. Maintenance ringweeding/pressing down of grass around pioneers	Every 2 months after end of rainy season (3 times)	3 times x 1,000 pioneers / 200 pioneers/personday	15
SUBTOTAL: Year One			**49**

Tasks, Schedule, and Average Manpower Requirements, One Hectare (Years Two & Three)

Activity	Schedule	Labor Requirements	
Year Two		Derivation	Person days
1. Maintenance weeding/pressing down of grass in firebreaks	Twice; one month after onset of rainy season and once just before end of rainy season	2 times x 3,200 m2 / 400 m2/personday	16
2. Maintenance ringweeding/pressing down of grass around pioneers	Every 2 months, starting 1 month after end of rainy season (3 times)	3 times x 1,000 pioneers / 200 pioneers/personday	15
SUBTOTALS: Year Two			**31**
Year Three – same as Year Two			**31**
TOTAL: 3 years			**111**

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