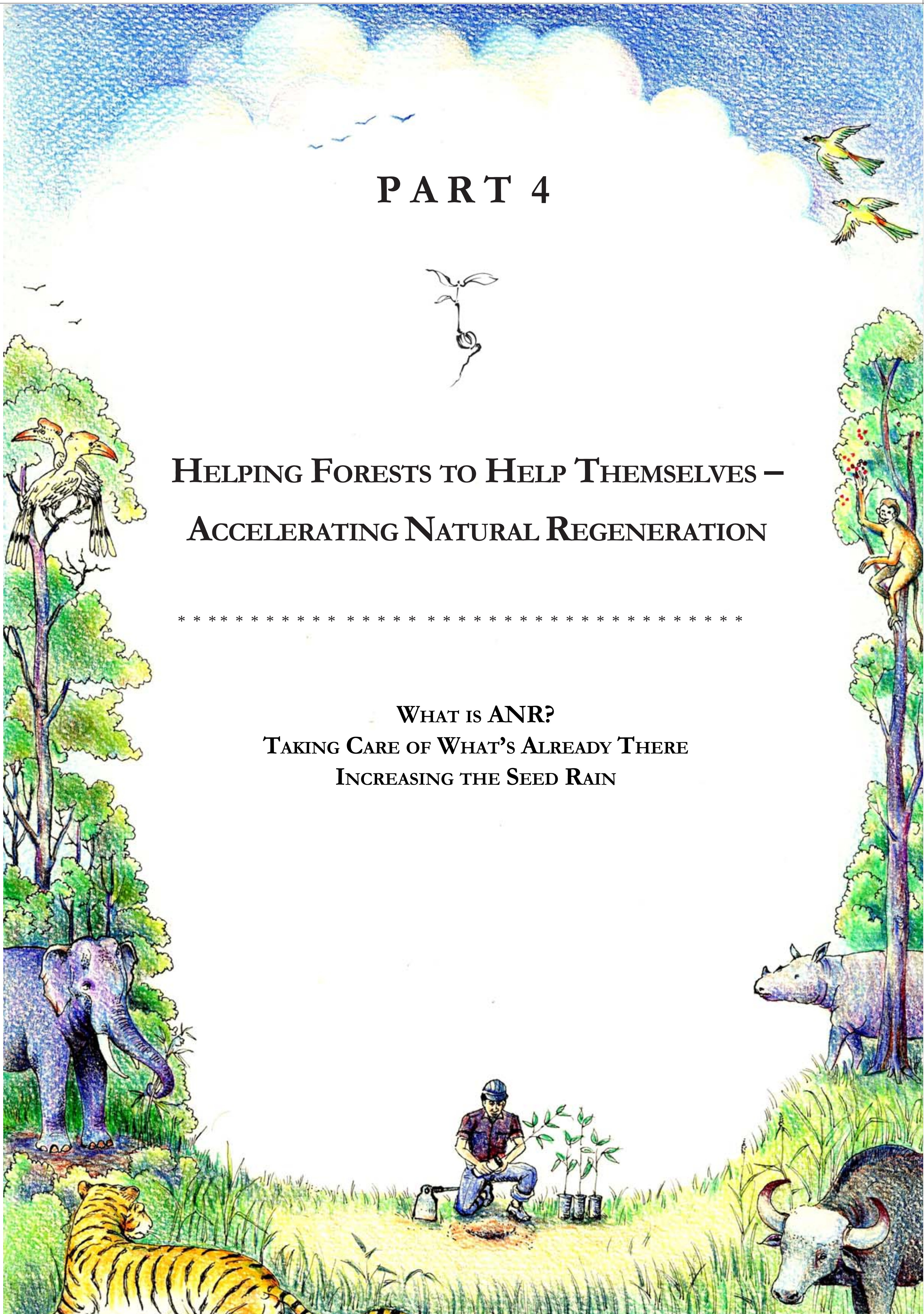

# PART 4

## HELPING FORESTS TO HELP THEMSELVES – ACCELERATING NATURAL REGENERATION

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**WHAT IS ANR?**
**TAKING CARE OF WHAT'S ALREADY THERE**
**INCREASING THE SEED RAIN**

# No Tree Planting Necessary?

*This gap is surrounded by mature seed-bearing rainforest trees that provide a dense seed rain.*

*Nearby forest provides habitat for seed-dispersing animals.*

*Sprouting tree stumps provide a source of rapid regeneration.*

*Naturally established tree seedlings and saplings are plentiful.*

*This area has only recently been deforested and was not subsequently cultivated. Therefore, viable seeds from the original forest remain in the soil seed bank.*

*Tree planting is not always essential for forest restoration. This deforested gap, amidst rainforest in southern Thailand, is small. Seeds are easily dispered into its centre. If sufficient numbers of tree species are regenerating from seeds, seedlings, saplings or tree stumps, there is no need to plant trees. However, if tree species richness is low, then enrichment planting with framework species is recommended (Part 5).*

# Helping Forests to Help Themselves – Accelerated Natural Regeneration

*"Knowing trees, I understand the meaning of patience. Knowing grass, I can appreciate persistence."* - Anon

Part 3 identified the factors that hinder natural forest recovery in large deforested areas. The next logical step is to design practical techniques to overcome those limitations. In any particular location, several techniques are usually combined, to counteract each of the limiting factors that may be operating. Collectively, such techniques are termed "accelerated (or assisted) natural regeneration" or ANR for short.

## Section 1 – What is ANR?

ANR covers any set of activities that enhance the natural processes of forest regeneration. These include promoting the natural establishment and subsequent growth of indigenous forest trees, whilst preventing any factors that might harm them *e.g.* competition from weeds, browsing by cattle, fire *etc.*

Because ANR relies on existing natural processes, it requires less labour input than tree planting and is therefore a very cheap way to restore forest ecosystems. However, ANR and tree planting should not be regarded as two exclusive alternatives to forest restoration. More often than not, forest restoration depends on the clever combination of tree planting with ANR techniques. Under certain circumstances, ANR may be sufficient alone to restore forest ecosystems, but tree planting should always be implemented in combination with whatever ANR techniques may be appropriate.

### Where is ANR appropriate?

ANR is appropriate wherever the natural processes of forest regeneration are, to some extent, already happening. For example, at least a few seed trees should exist nearby and seed-dispersing animals should remain common in the vicinity. Sites, which already support a high density of tree saplings or sprouting tree stumps, are particularly suited to ANR.

A detailed site assessment is necessary to decide if ANR might be sufficient, on its own, to restore forest and (if it is) to select the most appropriate techniques.

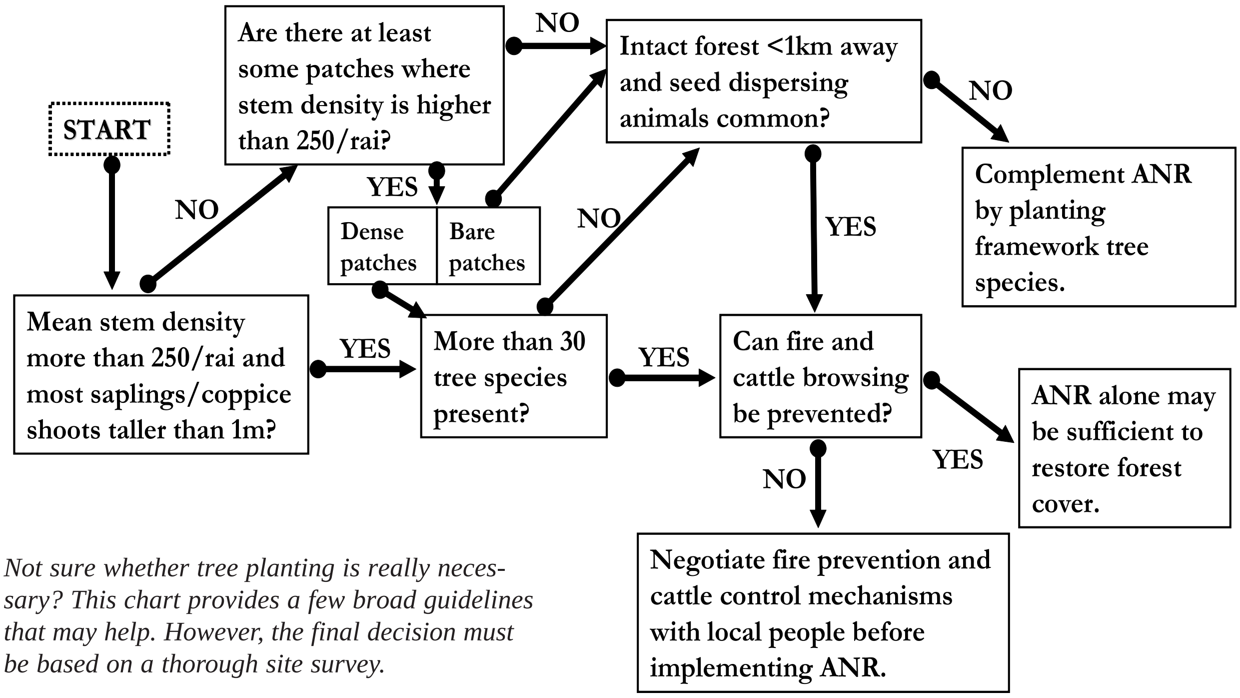
The site assessment should:-

i) determine the existing potential for natural forest regeneration and

ii) identify which factors might be limiting natural forest regeneration.

Direct observations of site conditions should be combined with interviews with local people to address the following questions:-

- What is the density of tree seedlings, saplings and tree stumps in the site? Are they evenly distributed or confined to a few parts of the site?
- How recently was the site deforested? Ask local people about the history of land use practices on the site.
- Does the site show signs of fire *e.g.* blackened tree stumps *etc.*? Ask local people how frequently fires occur in the area.
- Are there any signs that cattle use the site? Ask local people about cattle rearing practices in the area.
- How far away are the nearest sources of forest tree seeds?
- What is the status of seed-dispersing birds and mammals in surrounding areas?




*Not sure whether tree planting is really necessary? This chart provides a few broad guidelines that may help. However, the final decision must be based on a thorough site survey.*

The density of naturally occurring tree saplings and stumps (number of stems per hectare) provides a good prediction of whether ANR, on its own, may be sufficient to restore forest on any particular site. However, it is also important to consider the sizes of the saplings and stumps. Tall saplings are more likely to survive than small ones. The chances of a sapling growing into a mature tree increases greatly once it overtops surrounding weeds. So, it is also useful to record whether saplings are taller or shorter than the weed canopy.

Randomly place circular sample plots across the site. Use a pole to mark the centre of each plot and a 5-m-long piece of string as the radius. Count, identify and measure all stumps and saplings taller than 1 m, closer than 5 m to the pole. Calculate density by dividing the total number of saplings/stumps counted by the total area surveyed.

As a rough guide; if the density of saplings + live stumps exceeds 250 stems per rai (1,562 per hectare), ANR alone may be sufficient to restore basic forest structure within 5 years, provided fire, cattle and other limiting factors are controlled. Where density of saplings + live stumps is lower, ANR alone is unlikely to be successful, unless the site is very close to intact forest and seed-dispersing animals are common. If these conditions are not met, ANR should be combined with tree planting.

The intensity of tree planting required may vary within sites, since the distribution of natural saplings and tree stumps is often patchy or clumped. For those parts of the site undergoing vigorous regeneration, such as forest edges or around remnant, fruiting trees, tree planting would be a waste of resources. In the centers of large deforested areas, where tree seedling recruitment may be limited by distances from seed sources, the need to augment ANR with tree planting will be greater.

## What are the limitations of ANR?

ANR acts mostly on trees that are already established in deforested areas. Unfortunately, most of the tree species that are capable of colonizing such areas are light-demanding pioneers (see Part 3, Sections 1 & 8), with seeds dispersed by the wind or small birds. They represent only a small fraction of the tree species richness of climax forest. Therefore, whilst ANR, might be sufficient to restore tree cover and to some extent forest structure, full recovery of biodiversity may require additional measures. Where large seed-dispersing animal species have become extirpated, planting large-seeded climax forest tree species may be the only way to convert secondary forest, created by ANR, back into primary forest.

# Section 2 – Taking Care of What's Already There

The most thoroughly tested and widely practiced ANR techniques are those, which increase survival and growth of the woody plants that are already established on a site. Various methods are used to manipulate the environmental conditions around the seedlings and saplings of woody plants, as well as sprouting tree stumps, to accelerate their growth and to protect them from harm.

## Can tree stumps be encouraged to sprout?

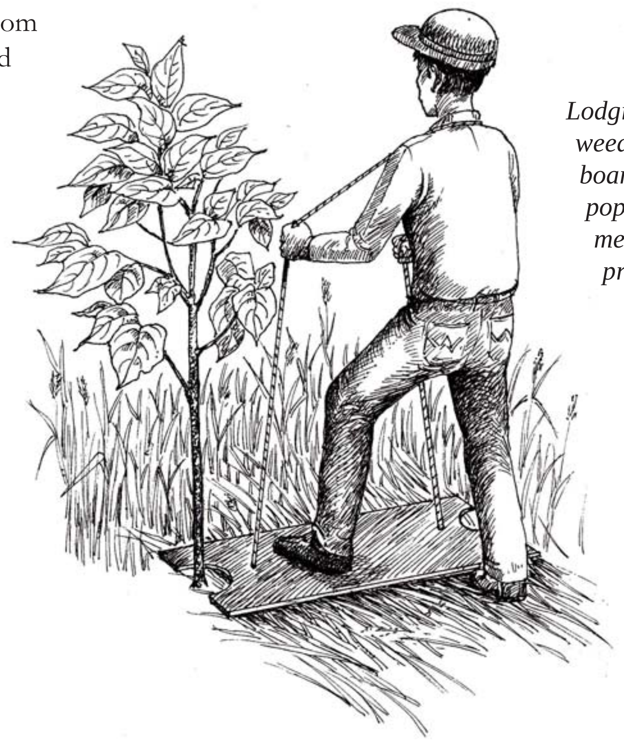
Sprouting tree stumps provide the most rapid means of re-establishing forest cover in seasonal tropical forests. Consequently, where they exist, they should be the focus of initial ANR efforts. Coppicing shoots can grow much faster than tree seedlings, since they can draw on large food reserves through the stumps' existing root systems. They are less susceptible to drought than seedlings, and they are thus less affected by weed competition. Held above the weed canopy, coppicing shoots are less likely to burn during a fire, but even if they do, they can recover rapidly.

However, almost no practical techniques have been tested to enhance the role of tree stumps in ANR, besides general recommendations that they should be protected from chopping, burning or browsing. Would application of plant hormones encourage sprouting? Could chemicals be used to prevent fungi or termites attacking tree stumps? Would laying mulch or applying fertilizer around tree stumps have the same beneficial effect as they do on tree seedlings? If many coppice shoots are growing from a single tree stump, would trimming back the weaker, smaller shoots enhance growth of the taller, stronger ones? These questions would make interesting topics for future research. Practitioners of ANR are encouraged to experiment.

## How can competition with weeds be reduced?

Weeding, to reduce competition with herbs and grasses, is just as beneficial for naturally established trees as it is for planted ones. The smaller the tree seedlings or saplings, the more they benefit from weeding, especially during the rainy season. In the dry season, a weed canopy may help to protect small tree seedlings from desiccation (Hardwick, 2000), but this potentially beneficial effect must be weighed against the fire risk posed by the dried vegetation. Weeding around tree stumps is unlikely to be very beneficial, since tree stumps already have deep root systems that extend well below those of herbaceous weeds.

Before weeding, tree seedlings or saplings should be clearly marked with brightly coloured tape or poles, to make them more visible. This prevents accidentally trampling or cutting them during weeding. Weeding should first be concentrated around the marked trees, before clearing weeds from the rest of the site. Around small seedlings, it is better to hand-pull weeds than to use tools, since digging can damage the seedlings' delicate root systems. Suitable weeding techniques are described in detail in Part 7, Section 4.



*Lodging, or flattening weeds with wooden boards has become a popular weed control method amongst ANR practitioners.*

One weeding method that seems particularly suited to ANR is "lodging", *i.e.* flattening weeds with a board, rather than cutting them or digging them out. This does not kill the weeds immediately but each time the weeds grow back, they use up food reserves stored in their root systems. If the weeds are flattened often enough, food reserves are eventually exhausted and the plants die. Lodging weeds does not disturb the soil surface and, by shading the soil, the flattened weeds suppress germination of light-dependent weed seeds. This technique is particularly effective against grasses and bracken fern.

Use a wide plank of hard but lightweight wood (about 5 x 25 x 130 cm). Carve out semicircles at both ends of the plank so that it can be used to flatten weeds growing close to tree saplings. Attach a piece of sturdy rope and a shoulder pad to both ends of the plank, making a loop, long enough to pass over your shoulders. Lift the plank onto the weed canopy and step on it with full body weight. Repeat this action, moving forward in short steps (for more information please log on to http://www.fs.fed.us/psw/publications/documents/other/3.pdf). The method has been used to great effect in the Philippines to clear *Imperata* grass and accelerate forest regeneration on abandoned slash and burn sites there (Sajise, 1972).

## Can mycorrhizae increase tree growth?

The dependence of tropical trees on symbiotic relationships with mycorrhizal fungi has already been explained in Part 3, Section 6. The prevalence of such relationships raises the question: could inoculating naturally establishing trees with mycorrhizal fungi improve their performance?

Recently, commercial preparations of mycorrhizal spores have become available. Usually such products contain a mixture of spores of several ubiquitous fungus species, adsorbed onto an inert substrate. However, as far as we are aware, the use of such products to improve performance of naturally establishing tree seedlings in ANR sites has never been tested. This is clearly another topic worthy of further research.

## Should cattle be removed?

Ultimately, the decision to reduce the number of cattle or to remove them altogether depends on careful consideration of their economic value to the community, balanced against their effects on the regenerating trees.

In Nepal, villagers do not allow cattle to roam freely in their community forests. To protect the trees, villagers keep their cattle at home. They cut forage from the forests and bring it to their villages to feed their cattle. Not only does this feed the cattle without damaging the trees, but it also encourages effective weeding of forest plots. On the other hand, in Central America, cattle are used as an important tool in the early stages of forest restoration. They are regarded as "living lawn mowers", releasing young trees from competition with grasses and providing a vital seed dispersal service for some of the dominant forest tree species. Using cattle to control herbaceous vegetation also reduces fire risk.

## How can fire be prevented?

As already explained in Part 3, Section 7, fire is the most serious hindrance to forest regeneration in the seasonally dry tropics. Where the fire risk is considered to be significant, fire prevention is a vital activity for ANR. Firebreaks around ANR sites must be cut at the beginning of the hot, dry season and a fire warning and suppression system must be maintained until the rainy season begins. These techniques are described in detail in Part 7.

## What other techniques can be used to encourage tree growth?

The same methods of mulching and fertilizer application, described in Part 7 for planted trees can be used to enhance growth and survival of naturally established trees. Small seedlings or saplings are more likely to respond positively to such treatments than large trees. It is probably a waste of effort and expense to apply such treatments to older saplings and tree stumps, since they would already have developed deep root systems.

## SECTION 3 – INCREASING THE SEED RAIN

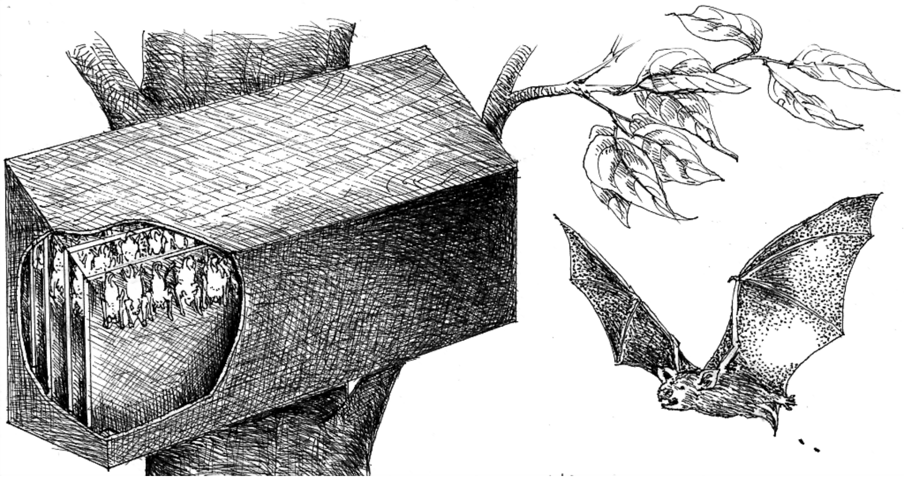
After severe and prolonged disturbance, remnant tree stumps, seedlings and the soil seed bank will be sparse or absent, so the potential for natural regeneration will depend critically on the seed rain.

### Can seed-dispersers be attracted to ANR sites?

Yes. The seed rain can be dramatically increased by adding very simple structures to ANR sites that attract the most common seed-dispersing animals *i.e.* birds (particularly bulbuls) and fruit bats.

Research in FORRU's experimental plots has shown that simple artificial bird perches, made from bamboo, placed randomly across sites, can significantly increase the seed rain (see Box 4.1). Moving such perches around, from time to time, could help to distribute seeds over wider areas. Adding bait to the perches may increase their attractiveness (but is labour intensive) and clearing weeds beneath them increases survival of germinating tree seedlings. Bird nesting boxes may have a similar effect.

*Roosting boxes may attract small fruit bats into ANR plots. Such bats drop seeds in flight, creating a widespread seed rain around the boxes, but the potential of bat boxes to accelerate forest regeneration has never been tested.*



Provision of roosting boxes might attract seed-dispersing fruit bats into ANR sites. The boxes can be hung from remnant trees or mounted on tall poles. Bats have very particular requirements so it is important that boxes are made from rough timber and that the entrance to the box matches the body size of the target bat species. Detailed instructions for construction of bat boxes are provided at http://www.dnr.state.md.us/wildlife/batboxes.html. Unlike bird perches, the effects of bat boxes on forest regeneration in the tropics have never been tested.

Structurally diverse vegetation, especially fruiting shrubs or remnant trees, act as natural attractants to seed-dispersing animals. So, protecting such vegetation will greatly help to increase the seed rain.

In seasonally dry climates, water is a strong attraction to wildlife, so digging artificial ponds might also attract potential seed dispersers.

*Seedlings growing from seeds dropped by bats*

## Can large, seed-dispersing animals be brought back?

As already explained in Part 3 Section 3, large seed-dispersing animals (*e.g.* elephants, rhinos and wild cattle) have been extirpated over much of their former ranges or reduced to populations too small to play a significant role in seed dispersal. So might it be possible to bring them back? After all, human beings must be paid to plant trees, whereas elephants not only plant tree seeds, but provide them with a generous dose of fertilizer, for free!

Unfortunately, re-introduction of large seed-dispersing mammals is a difficult and expensive process. It is only worthwhile where the problem, which caused the species to become extirpated in the first place, has been solved. This usually means persuading local people not to hunt re-introduced animals.

Re-introducing captive animals back into their natural habitats is particularly difficult because captive animals often lose the skills needed to survive in the wild. A lengthy rehabilitation process is usually necessary. However, even translocating wild animals, from conservation areas where they are common, to those where they have become extirpated, is not easy. The risk of death or injury during capture is high and the source population may be seriously disturbed or depleted. Veterinary care, maintaining genetic diversity within small populations, monitoring animals after release and, most crucial, preventing hunting, are all vital components of any animal re-introduction programme.

In addition to the technical issues, local people may object to the return of large animals, which might damage crops, compete with domestic animals or threaten human life.

However, such obstacles are not insurmountable. For example in northern Thailand, domestic elephants have been successfully returned to the wild. So, despite the difficulties, re-introduction programmes are worth careful consideration. For further information, please refer to the guidelines issued by the Species Survival Commission of the International Union for the Conservation of Nature (http://iucn.org/themes/ssc/pubs/policy/reinte.html).

## Can people be seed dispersers?

Yes. One method of forest restoration is to collect seeds from nearby forest trees and sow them in deforested sites. This is called "direct seeding". The technique can rapidly increase tree density as well as tree species richness, but it has several drawbacks. The hot, dry conditions, of most deforested sites can rapidly desiccate seeds on the soil surface. In addition, seed predators, such as rodents and ants, (see Part 3, Section 4) are particularly common in deforested sites and can cause complete loss of some tree seed species, within a few days after sowing.

### Direct seeding

*First, clear weeds from seeding spots.*


*Next, make small holes and half fill them with forest soil.*

Burying seeds can substantially reduce both desiccation and predation, but it also increases the labour input required. Selecting tree species with seed characteristics that make them resistant to predation (*e.g.* small size, tough seed coat, *etc.* see Part 3, Section 4) can increase the success of direct seeding. Treating seeds with chemical repellents is also worth exploring, but further research is needed to identify compounds that deter seed predators without harming the seeds. Since prolonged dormancy increases the chances that seed predators will find seeds, treating seeds to break dormancy (*e.g.* soaking, scarification *etc.*), before direct seeding, might shorten that vulnerable period, during which predation could occur. However, sometimes such treatments can increase the risk of desiccation or make seeds more attractive to ants by exposing the cotyledons.

As with nearly all ANR techniques, experiments must be carried out to determine the most successful techniques to use in any particular site. Naturally, any animals, which prey on rodents (*e.g.* birds of prey, wild cats *etc.*), should be regarded as valuable assets on ANR sites. Preventing the hunting of such animals can help control rodent populations and reduce seed predation.

If it is decided to include direct seeding in an ANR programme, try the procedures in the diagrams below. At the beginning of the rainy season, collect seeds from fruiting forest trees, near to the ANR site. Dig out weeds in "seeding spots", approximately 30 cm across, spaced about 1.5-2 m apart (the spacing can be wider where saplings or tree stumps are common).

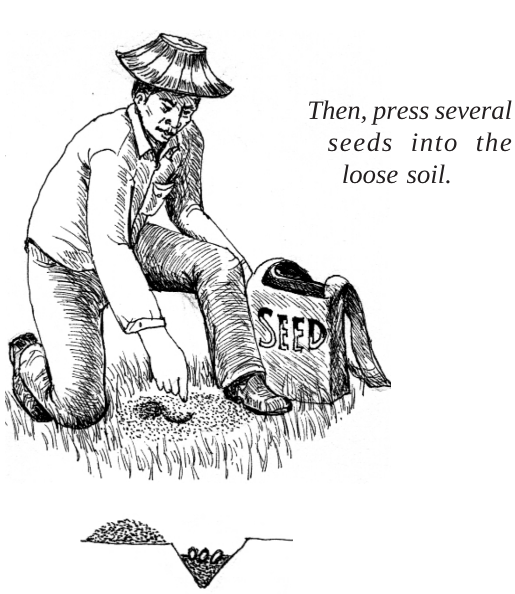
Dig a small hole in the soil and loosely fill it with forest soil (dug up from where the seeds were collected). This ensures that beneficial symbiotic micro-organisms (*e.g.* mycorrhizal fungi *etc.*) are present when the seed germinates. Finally, press several seeds into each hole, to a depth of about twice the diameter of the seed and cover with more forest soil.

## What if ANR doesn't work?

ANR is a very young science, as is apparent from the many "topics requiring further research" identified in this part. Provided ANR techniques are applied to a suitable site, they are unlikely to be a complete failure, but they might not yield desired results quickly enough, especially biodiversity recovery.

Another approach is to use a "nurse crop" of trees to re-establish canopy cover, whilst also implementing ANR techniques. This approach is called "foster ecosystem" or "plantations as catalysts". Almost any tree crop will encourage the processes that accelerate forest regeneration, by ameliorating the micro-climate and attracting seed-dispersing birds. Even an exotic tree species can be used, especially where economic benefits are required. The nurse crop is gradually thinned, to yield an economic return, as the plantation becomes colonized by forest trees (Parrotta *et al.* 1997).

However, planting a single tree species needlessly delays biodiversity recovery. Hence the "framework species method" is explained and recommended in the next part.

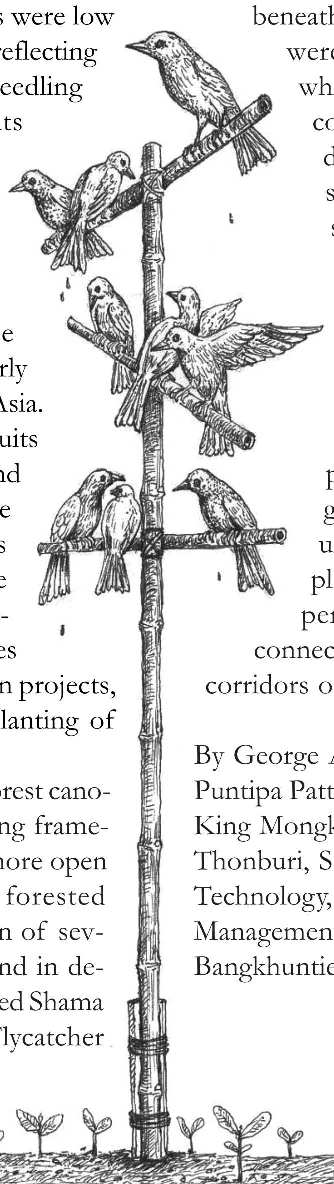



## Box 4.1 - The Role of Birds in Forest Regeneration

**Dr. George Gale and his team from King Mongkut's University of Technology Thonburi, placed artificial bird perches, made of bamboo, in deforested areas in the highlands of northern Thailand. Some plots were being planted with framework tree species, whilst others were undergoing natural regeneration. They observed which bird species used the perches; counted seeds dropped by the birds beneath the perches and monitored seedlings that subsequently established (see Scott et al, 2000).**

"Artificial perches in deforested areas attracted many seed-dispersing birds. Although direct observations of birds on the perches were infrequent, birds clearly used the perches often enough to significantly increase seed input. Below the perches, both the seed rain and seed germination significantly increased, compared with adjacent control plots with no perches. Seedling survival below the perches was also higher than in the control plots, although seedling numbers were low in both perch plots and controls, reflecting the naturally low rate of tree seedling survival in the wild. Two plants commonly found in disturbed areas, the treelet *Melastoma malabathricum* and the tree, *Trema orientalis*, accounted for more than 50% of new seedlings found growing beneath the perches. These are important early successional species throughout Asia. In particular, *M. malabathricum* fruits are frequently eaten by birds and other wildlife. However, if the surrounding vegetation grows above the perches, they become less attractive to birds; an important consideration, if bird perches are to be used in forest restoration projects, especially those involving the planting of fast-growing trees.

In forest restoration plots, forest canopy closure, 2-3 years after planting framework tree species, resulted in a more open understorey, more typical of forested areas. This encouraged the return of several bird species not usually found in degraded areas, such as White-rumped Shama (*Lonchura striata*) and Hill Blue Flycatcher (*Cyornis banyumas*).



Bird perches are very inexpensive, compared with producing trees in nurseries and planting them. In addition, minimal labour is required to erect and maintain the perches, compared with the very high labour inputs needed for tree planting. However, tree planting does appear to be more effective at restoring biodiversity-rich forest in highly disturbed sites compared with using perches alone.

Furthermore, natural tree recruitment beneath perches was higher at sites, which were only moderately disturbed and which had at least some nearby tree cover. Success with perches seems to depend on the proximity of early successional tree species. Few late succession tree species recruited beneath perches.

Thus, we recommend that artificial perches are used in conjunction with restoration tree planting, particularly during the first two to three years after planting, before the planted trees grow tall. Perches may be particularly effective along the edges of planted sites. Furthermore, rows of perches could be erected to interconnect planted areas with "bird-created" corridors of early successional vegetation."

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# Attracting Animals that Help to Restore Forest Biodiversity

Cynopterus sphinx - *a medium-sized bat. Flying long distances during nights spent feeding on fruit, this bat disperses seeds over long distances and often drops them into deforested areas. Is it possible to attract bats like this into ANR plots?*

*Where they remain extant, wild cattle (such as the Gaur pictured above) and other large seed-dispersing animals can be attracted into ANR plots by making artificial water holes or salt licks.*

P. Round

*At home in both forest and deforested sites, five species of Bulbul are among the most important dispersers of seeds into ANR plots in northern Thailand (Part 3, Section 3); including the Black-crested Bulbul (above), Red-whiskered, Sooty-headed, Black-headed and Flavescent.*

A. J. Pierce

*Feeding on both insects and fruits in forest and open habitats, the White-browed Scimitar Babbler is attracted to perches in ANR sites.*

A. J. Pierce

A. J. Pierce

*Once canopy closure is achieved, the Hill Blue Flycatcher (far left) and White-rumped Sharma (left) are among the first climax forest bird species, to colonize newly restored forest plots.*

*Increase the animal-dispersed seed rain by erecting bird perches or bat boxes or by making artificial ponds or salt licks to attract seed-dispersing animals into ANR sites. Strict precautions, to completely prevent hunting of such animals, are essential for successful ANR.*

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The photos above were taken as part of a properly supervised scientific study, by trained researchers. Birds were subsequently released.

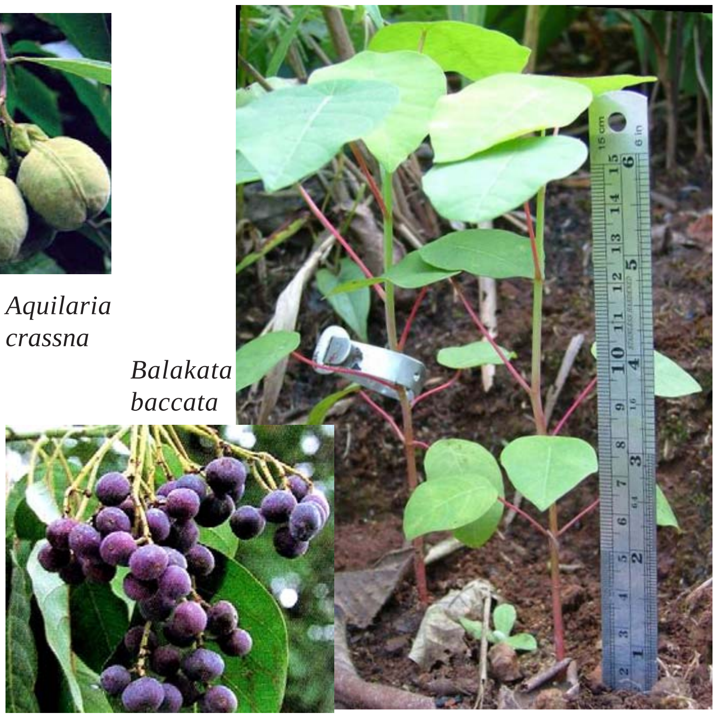
## Box 4.2 - Testing the Effectiveness of Direct Seeding

Tunjai (2005) investigated which tree species may be suitable for direct seeding in both deciduous and evergreen forest types in northern Thailand. She collected seeds from fruiting trees and sowed half of them in a nursery under standard conditions and the rest directly into deforested sites at the start of the rainy season, using the methods previously described in Section 3. For several species, germination percent and early seedling survival and growth were higher in the field than in the nursery. After one year, nursery-raised saplings were planted next to direct seeded saplings in the field. Subsequent monitoring confirmed continued high relative performance of direct seeded saplings of several species. Direct seeding is cheaper than planting nursery-grown trees. So, future forest restoration systems may well incorporate both direct seeding, for those tree species that respond well to the techique, and conventional tree planting, for those that do not. Based on Tunjai's experiments, direct seeding is recommended for *Afzelia xylocarpa, Schleichera oleosa* and *Trewia nudiflora* in deciduous forest types, and for *Aquilaria crassna, Balakata baccata, Eugenia fruticosa, Gmelina arborea, Melia toosendan, Prunus cerasoides, Sarcosperma arboreum* and *Spondias axillaris* in evergreen forest sites.

*Afzelia xylocarpa*

*Trewia nudiflora*

*Aquilaria crassna*



*Balakata baccata*