PART 5

THE FRAMEWORK SPECIES METHOD OF FOREST RESTORATION

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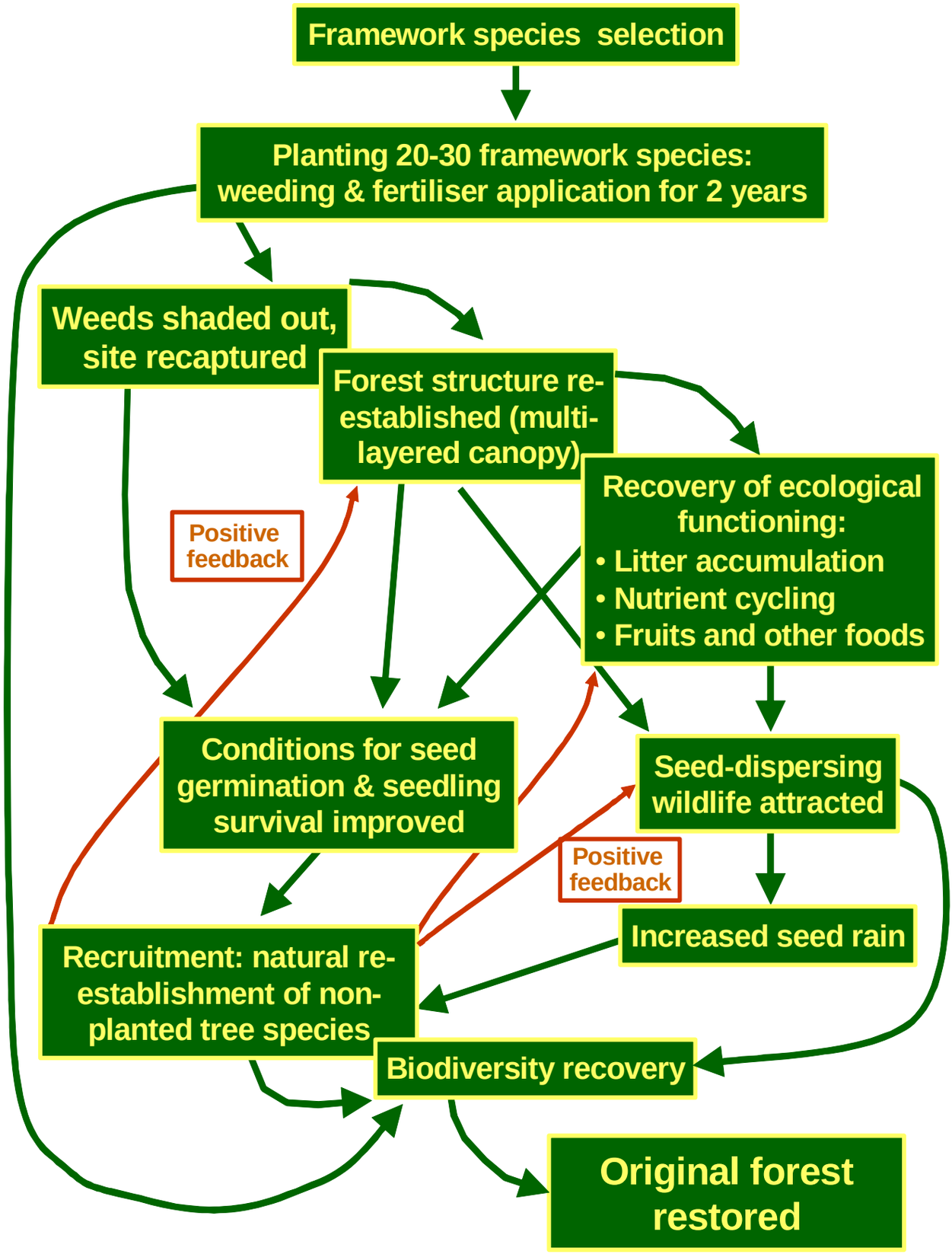
DEFINING THE CONCEPT
SELECTING FRAMEWORK SPECIES
TESTING FRAMEWORK SPECIES

"The "framework species" method, developed in northern Queensland (Goosem and Tucker, 1995) uses suites of local tree species that promote more rapid natural succession. It has greatest potential where substantial forest tracts and remnants still exist"

- four of the world's leading forest restorationists: David Lamb, John Parrotta, Rod Keenan & Nigel Tucker, 1997

How the Framework Species Method Works



THE FRAMEWORK SPECIES METHOD OF FOREST RESTORATION

"The destruction of rainforest has sparked an unprecedented response in many people to both save what remains and if possible rebuild what we can."
- Steve Goosem and Nigel I. J. Tucker, "Repairing the Rainforest", 1995.

SECTION 1 – DEFINING THE CONCEPT

What is framework forestry?

Even though forest restoration is a young science, several different approaches have begun to emerge. They vary in intensity, from ANR with no tree planting (Part 4) to the planting of all the tree species that formerly comprised the original climax forest (*e.g.* the maximum diversity method of Goosem and Tucker (1995) or the Miyawaki method from Japan (Miyawaki, 1993)). The framework species method is a compromise between these two approaches. It is more effective at restoring biodiversity than the former, whilst requiring fewer inputs than the latter.

It combines the planting of a moderate number of key tree species, selected for their potential to accelerate biodiversity recovery, combined with various ANR techniques (Part 4) to enhance natural regeneration, creating a self-sustaining forest ecosystem from a single planting event. Originally conceived in northern Queensland to repair damaged tropical rain forest (Goosem and Tucker, 1995), the framework species method has been successfuly modified to restore seasonally dry tropical forests to deforested sites in northern Thailand's conservation areas.

What are framework tree species?

Framework trees are **indigenous**, non-domesticated, forest tree species, which, when planted on deforested land, help to re-establish the natural mechanisms of forest regeneration and accelerate biodiversity recovery.

How does it work?

The framework species method involves planting 20-30 carefully selected tree species and caring for them for two or more years (*e.g.* weeding, applying fertilizer *etc.*) The planted trees "re-capture" the site, by shading out herbaceous weeds. They also re-establish forest structure, by developing a multilayered canopy. Furthermore, they restore ecosystem processes, such as nutrient cycles, and improve conditions for seed germination and seedling establishment of additional (non-planted) tree species (termed "recruits"), by creating a cooler, more humid microclimate on the forest floor. Moist, nutrient-rich leaf litter, free of weed competition, creates the perfect conditions for germination of incoming tree seeds and survival of tree seedlings.

Biodiversity recovery relies on birds, bats and other small mammals being attracted to the planted trees. The 20-30 tree species planted represent only a fraction of the total number of tree species that grow in tropical forest ecosystems. To restore the forest's original tree species composition, wildlife must be employed as seed-dispersers. Once planted trees have created conditions conducive to tree seedling recruitment, they must produce resources (*e.g.* nectar-rich flowers, fruits or bird nest sites *etc.*), which attract seed-dispersing animals. These animals transport seeds of many additional tree species from nearby surviving forest into the planted sites. It is this next generation of naturally established trees, germinating from the seeds brought in by animals, which ultimately restores the forest to its original condition.

What are the characteristics of framework tree species?

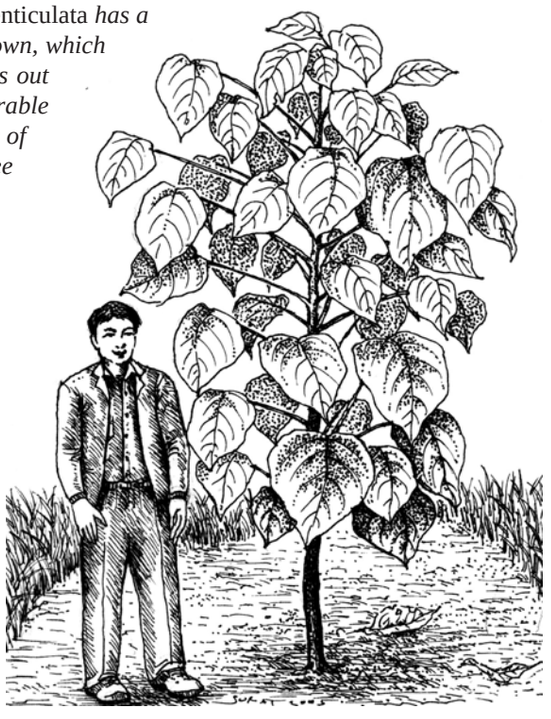
The essential ecological characteristics of framework tree species are therefore:-

- high survival when planted out in deforested sites;
- rapid growth;
- dense, spreading crowns that shade out herbaceous weeds and
- flowering and fruiting, or provision of other resources, at a young age, to attract seed-dispersing wildlife.

In addition, framework species must be easy to propagate in nurseries, using simple techniques. Trees cannot be planted if they cannot be grown. Therefore, desirable nursery characteristics of framework tree species include reliable seed availability; rapid and synchronous seed germination and, most importantly, production of vigorous seedlings of a plantable size in less than 1 year.

In the seasonally dry tropics, where wild fires in the dry season are an annual hazard, an additional essential characteristic of framework species is resilience after burning. When fire prevention measures fail, the success of forest restoration plantings can depend on the ability of the planted trees to re-sprout from their rootstock after fire has burnt their aboveground parts (*i.e.* coppicing).

Macaranga denticulata *has a dense tree crown, which rapidly shades out weeds; a desirable characteristic of framework tree species.*



Are there any other tree characteristics important for biodiversity conservation?

Rare or endangered tree species require special consideration. Including such species in forest restoration plantings, can help prevent their extinction, even if they may lack some framework characteristics. A database of the world's endangered tree species is maintained by the World Conservation Monitoring Centre at: - www.unep-wcmc.org/cgi-bin/SaCGI.cgi/trees.exe?FNC=database_Aindex_html.

In addition, where large seed-dispersing animals (*e.g.* elephants, wild cattle, rhinos *etc.*) have disappeared, planting tree species with **large, animal-dispersed seeds** (often climax forest species) has obvious benefits.

Are framework trees pioneer or climax species?

Mixtures of framework tree species planted should include both pioneer and climax species (see Part 3). Goosem and Tucker (1995) recommend that at least 30% of trees planted should be pioneers. By planting both pioneer and climax trees in a single step, forest succession can be short-circuited. Many climax forest tree species perform well in the open, sunny conditions of deforested areas, but they fail to colonize such areas due to lack of seed dispersal. Many climax tree species have large, animal-dispersed seeds. The decline of large mammals, over wide areas now prevents dispersal of large-seeded, climax trees into deforested sites. By including some climax forest tree species amongst those planted, it is possible to overcome this limitation and accelerate recovery of climax forest.

Fast-growing, pioneer trees rapidly close canopy and shade out weeds, whilst slower growing climax species form an understorey beneath the pioneer tree crowns, adding structural diversity to the forest and increasing the variety of wildlife resources available. Pioneer trees begin dying 15-20 years after planting. However, by this time, a rising understorey of climax forest trees is ready to replace them, along with a dense layer of naturally established trees, derived from seeds brought in by wildlife.

What kind of animal species must planted framework trees attract?

Any trees can provide perches that birds may use for short visits, but trees that provide food or nesting sites can attract seed-dispersing animals for longer periods, during which the animals may deposit seeds that begin the process of restoring the forest's original tree species composition. Therefore, planted framework trees act as "bait" for seed-dispersing animals.

As already explained in Part 3, dispersal of seeds between intact forest and planted plots is carried out by relatively few, common, fruit-eating, animal species that are equally at home in forest and in deforested areas. These include small to medium sized, birds, particularly bulbuls, fruit bats (*e.g. Cynopterus* spp) and a few other medium-sized mammals, including civets, Common Wild Pig, Common Barking Deer, Hog Badger *etc.*

Tree species that are most likely to attract such animals produce small to medium-sized fruits within 3 years after planting (*e.g.* in northern Thailand: *Callicarpa arborea, Castanopsis tribuloides, Eugenia grata, Ficus abellii, F. hispida, F. semicordata, F. subincisa, Glochidion kerrii, Heynea trijuga, Macaranga denticulata, Machilus kurzii, Prunus cerasoides* and *Rhus rhetsoides*) or flowers producing copious quantities of nectar (*e.g. Erythrina subumbrans*).

Tree species used by birds as nesting sites, within 5 years after planting include *Alseodaphne andersonii, Balakata baccata, Bischofia javanica, Cinnamomum iners, Duabanga grandiflora, Erythrina subumbrans, Eugenia albiflora, Ficus glaberima, F. semicordata, F. subincisa, Helicia nilagirica, Hovenia dulcis, Phoebe lanceolata, Prunus cerasoides, Pterospermum grandiflorum, Quercus semiserrata, Rhus rhetsoides* and *Spondias axillaris.*

Increases in insects in planted plots might also attract seed-dispersing birds and mammals with mixed diets, but little is known of how planted trees affect insect populations. More research to discover which insects are associated with each framework tree species would be beneficial.

The ability of planted trees to attract wildlife is one of the least known aspects of the framework species method. More research on the ecology and diet of seed-dispersers would enable better selection of framework tree species that are most likely to attract them.

What are the essential design features of a framework forest?

Between 20 and 30 framework tree species are planted on any particular site. The trees are randomly positioned across the site, averaging about 1.8 m between adjacent trees (about 494 trees per rai or 3,086 per hectare). This planting density can be reduced, if some naturally established tree seedlings are already present. Protecting and nurturing naturally established woody plants, during site preparation and tree planting activities, is an essential feature of the framework species approach.

What management is required?

For at least 2 years after planting, frequent weeding is essential, to prevent herbaceous weeds competing with the planted trees. Fertilizer application accelerates tree growth, resulting in rapid canopy closure, which shades out the weeds. In seasonally dry climates, an effective fire prevention program is also essential. Naturally established trees are nurtured and protected from fire in the same way as the planted trees. Preventing hunting is also necessary to conserve populations of seed-dispersing wildlife. Plantation design and management are discussed in detail in Part 7.

Does the framework species method have limitations?

For recovery of tree species richness, the framework species method depends on remnant natural forest existing nearby to provide a diverse seed source and habitat for populations of seed-dispersing animals. FORRU's work has shown that in degraded upland evergreen forest sites in northern Thailand, civets and other animals may disperse seeds of some forest tree species up to 10 km. So the technique can potentially work well within 10 km of forest patches. Scattered trees can also provide a seed source for recovery of tree species richness. If seed sources or seed dispersers are absent from the landscape, recovery of tree species richness may be slow. If planting framework tree species fails to stimulate biodiversity recovery within 4-5 years, subsequent enrichment planting with more tree species may be necessary.

SECTION 2 – SELECTING FRAMEWORK TREE SPECIES

Are there published lists of framework tree species?

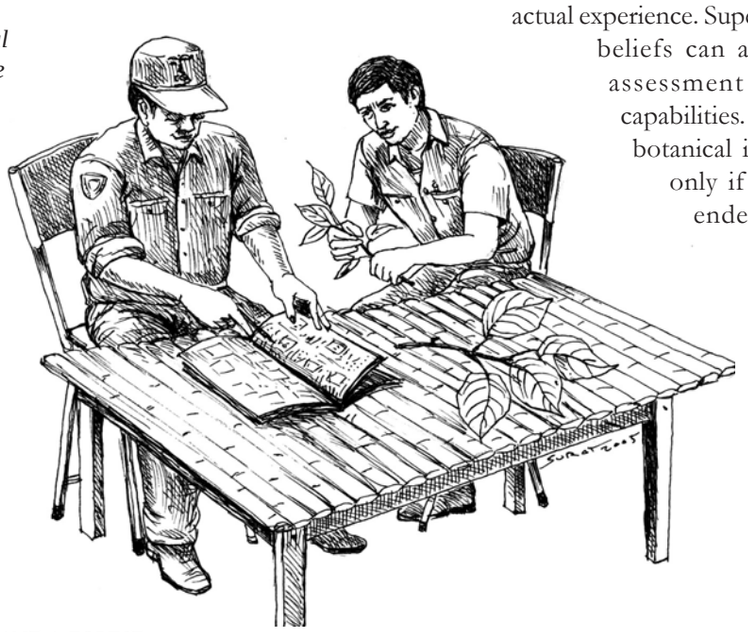
No lists of framework species have been published, except for Queensland's tropical rainforests in Australia (Goosem and Tucker, 1995) and the seasonally dry forests of northern Thailand (Part 9 of this manual). Elsewhere, framework tree species must be identified by assessing likely tree species for framework characteristics. The literature and indigenous knowledge can be used to identify candidate framework species, but their ability to perform as such must be confirmed by field trials.

How are candidate framework species selected?

Candidate framework species should be non-domestic and indigenous to the area being planted. Only tree species suited to the original forest type and elevation of the planting site should be selected for testing. This information can be found in botanical texts (*e.g.* for northern Thailand, Maxwell and Elliott (2001) and Gardner *et al.* (2000)). Although the literature usually describes flower or fruit characteristics likely to attract wildlife, it is important to complement such information by observing trees in the forest. Labelled trees should be observed monthly for fruits and seeds and the animals that disperse them. Such phenological studies generate information on when seeds may be collected and the attractiveness of each tree species to seed-dispersing animals. They also provide an opportunity to observe tree crown structure and consequently to judge how effectively tree species might shade out weeds

Published data on growth performance of the vast majority of tropical tree species are very scarce, but for Southeast Asian trees, some information is presented in the excellent handbooks on timber trees (Soerianegara and Lemmens, 1994; Lemmens *et al.*, 1995 and Sosef *et al.*, 1998, www.prosea.nl/prosea5.html#5(1)), published by PROSEA (Plant Resources of Southeast Asia). However, monitoring seedling growth in a nursery probably provides a better indication of potential performance. In most cases, species that perform well in nurseries are worth testing in the field.

Studies of the botanical knowledge of local people (ethnobotany) can provide insight into the potential of trees to act as framework species. When carrying out such studies, it is important to work with communities that have a long history of living close to forest and deforested areas, especially those that practice swidden (slash and burn) agriculture. Farmers from such communities usually know which tree species colonize fallow fields and grow fast. However, the results of such studies must be critically scrutinized. Local people sometimes provide information, which they think will please the researcher, rather than that based on actual experience. Superstition and traditional beliefs can also distort objective assessment of a tree species' capabilities. Consequently, ethnobotanical information is reliable only if it is provided independently, by members of several different communities, with different cultural backgrounds. To design effective ethnobotany surveys, please refer to Martin (1995).



Information from local people can contribute much to the selection of candidate framework tree species.

Table 5.1 Summary of information sources for initial selection of candidate framework tree species for assessment.

Framework Characteristics	Literature	Nursery Research	Field Observations	Ethnobotany
Indigenous, non-domesticated, suited to habitat/elevation	Often indicated in plant descriptions in botanical literature.		Survey tree species in nearest patch of intact forest.	Unreliable: villagers often fail to distinguish between native and exotic species.
High survival and growth	Published data sparse, but try PROSEA handbooks.	Assess seedling survival and growth in nurseries.	Assess survival and growth of trees establishing naturally in fallow fields.	Ask local people which tree species survive well and grow rapidly in fallow fields.
Dense broad crown, which shades out weeds	Few texts cover tree crown structure for individual tree species.		Observe crown structure of trees in the forest and fallow fields and weed cover beneath.	
Attractive to wildlife	Fleshy fruits or nectar-rich flowers described in taxonomic descriptions.		Observe fruit type and animals eating fruits or flowers in forest.	Villagers often know which tree species attract birds.
Resilient after fire			Survey tree survival in areas accidentally burnt.	Villagers often know which tree species recover after burning.
Easy to propagate		Germination experiments & seedling monitoring.		
Climax/large seeds	Often indicated in plant descriptions in botanical literature.		Observe fruits & seeds of trees in climax forest.	

SECTION 3 – TESTING FRAMEWORK TREE SPECIES

How are candidate framework species tested?

Once candidate tree species have been selected, field trials can be set up to determine to what extent their field performance conforms to "framework" criteria outlined in Section 1. Preparation for field trials may take a year or more, as sufficient numbers of seedlings (>50 per species) must be raised in a nursery, from seed collected from many parent trees (Part 6). Experimental plots should be planted with 20-30 candidate framework tree species (Part 7). Plots of at least one rai (40x40 m), replicated at least 3 times, are the minimum required, to show significant differences in survival and growth among the species tested (Part 7, Section 5). Identical silvicultural treatments must be applied to all replicate plots.

How soon can performance be assessed?

At the end of the second rainy season (*i.e.* approximately 1 years) after planting, the monitoring methods described in Part 7, Section 5 can be used, to assess growth and survival of candidate framework tree species.

The greatest cause of mortality is drought stress during the first dry season after planting. By the end of the second rainy season, most trees have either established well or died. Therefore, survival and growth at that time provide a good indication of ultimate performance. In contrast, provision of wildlife resources by the planted trees and biodiversity recovery occur more slowly. Consequently, monitoring these framework characteristics must continue for at least 5 more years.

Table 5.2 Proposed minimum field performance standards for framework species at the end of the second rainy season after planting on evergreen forest sites in northern Thailand (Elliott *et al.*, 2003)

Measurement[1]	Excellent	Acceptable	Marginal	Reject
Survival (%)	>70	50-69	45-49	<45
Height (m)	>2.0	1.5-1.99	1.25-1.49	<1.25
Crown width (m)	>1.8	1.5-1.79	1.00-1.50	<1.0
Reduction in weed cover score	>1	0.5-1.00	0.40-0.49	<0.4
Survival after fire[2] (%)	>70	50-69	45-49	<45

[1]For measurement techniques and definitions see Part 7 Section 5
[2]Measured when fire prevention fails and trees burn accidentally. **Do not deliberately burn plots.**

Saplings of some of the top-performing framework tree species, which FORRU has identified, using the screening process described here.

Melia toosendan Sieb. & Zucc.

Prunus cerasoides D. Don

Spondias axillaris Roxb.

Can performance standards be used to select framework tree species?

Flexibility is needed if performance standards are used to judge whether planted tree species qualify as framework species. Tree performance can be highly variable. Variability in climate from year to year can result in a species meeting the standards one year and failing to do so the next.

If growing trees from seed, suitable nursery standards by which to judge "ease of propagation" are: i) seed germination rates higher than 40%; ii) survival rates higher than 70% and especially iii) production of plantable saplings within a year after seed collection.

The field performance standards presented in Table 5.2 have been developed by FORRU to enable initial evaluation of potential framework tree species for restoring evergreen forest sites by about 18 months after planting.

Production of flowers or fruits or observations of birds' nests in the trees, within 4 years after planting, is a useful standard, by which to assess provision of wildlife resources.

Selecting framework species, requires a combination of quantitative measurements and subjective assessment. Very few tree species tested will exceed all the standards, but among any mixture of 20-30 species planted on any particular site, all framework characteristics should be collectively well represented.

For example, although fast growth is desirable, a few slow-growing species might be tolerated to diversify canopy structure and create understorey niches for wildlife. Likewise, a few species with narrow crowns might be acceptable in the planting mixture, provided they perform well in other respects.

Ficus subincisa *is excellent for attracting seed-dispersing birds, since it bears figs within a year after planting.*

Sapindus rarak *is a framework tree species with economic value. Its fruits are used to make soaps and shampoos.*

What if too few of the candidate framework species tested meet the standards?

If none or too few of the tree species tested meet the suggested standards, there are two options. Firstly, other, more promising candidate species may be selected for additional trials from amongst the local tree flora by re-evaluating the selection process.

Alternatively, the performance of those species that failed to meet standards in initial trials can be increased by various means. If species fail to meet nursery standards, propagation techniques can be modified to produce more vigorous planting stock (*e.g.* better media, fertilizer treatments *etc.*). In the field, silvicultural treatments can be intensified (*e.g.* more frequent weeding, mulching *etc.*) to improve growth and survival and accelerate canopy closure.

A ranking system can be used to select species with the highest relative performance from amongst those that fail initial field trails. Those species can then be prioritized for nursery and field experiments to develop techniques to improve performance. An example is provided in Table 5.3. Species ranked in the top 50% for all measurements (*i.e.* species A, B & C (rank scores all 4-6)) or those with the highest total rank scores could be recommended for further experiments.

A variation of this technique is to apply different weights (or multipliers) to each framework characteristic, according to its relative importance. For example, survival is more important than seedling height, so the rank scores for survival could be multiplied by 1.5 or 2, before addition to the total rank score. Factors which affect the magnitude of the multiplier applied might include; harshness of planting site; proximity to intact forest; seed availability or quality of nursery operation *etc.*

What about the economic value of framework tree species?

Framework tree species are most suitable for promoting biodiversity conservation in protected areas, where forest exploitation is minimal. Therefore, their commercial value is secondary to their ecological value. However, even within conservation areas, use of the forest by local people is often an important consideration. In such circumstances, framework species, which also yield non-timber products, should be selected. Remember, **there is no such thing as a *non*-economic tree species.** Most framework tree species yield several useful products such as traditional medicines, edible fruits or foliage, fuel-wood, fodder for domestic animals *etc.* In addition, the value of environmental services provided by framework forestry should not be underestimated, particularly watershed protection. Selected uses of individual framework tree species are described in Part 9.

Table 5.3 Selecting the best of the "failures" - example of a ranking system applied to field performance data to select species for experiments to improve silvicultural treatments.

	Survival		Height		Crown Width		
Tree Species	Mean (%)	Rank	Mean (m)	Rank	Mean (m)	Rank	Total Rank
A	60	6	1.3	5	1.52	5	16
B	42	4	1.4	6	1.61	6	16
C	55	5	1.2	4	1.48	4	13
D	40	3	0.9	1	1.20	2.5	6.5
E	35	1	1.1	3	1.20	2.5	6.5
F	39	2	1.0	2	0.89	1	5