Chapter 8

Setting up a forest restoration research unit (FORRU)

Forest restoration and research go hand-in-hand. Throughout this book, we have emphasised the need to learn from restoration projects, both successful and unsuccessful, and have provided standard research protocols that will enable you to do so. In this chapter, we provide advice on setting up a dedicated Forest Restoration Research Unit (FORRU) in which to carry out the research, to organise and integrate the information derived from it and to implement education and training activities. The aim should be to place the results of the research into the hands of all those involved in forest restoration, from school children to community groups and government officials.

8.1 Organisation

Who should organise a Forest Restoration Research Unit?

The success of a Forest Restoration Research Unit (FORRU) depends on strong support from a respected institution. Without a long-term, consistent host, it is difficult to attract funding and ensure local participation in forest restoration programmes. A FORRU is best organised by a recognised institution that has established administrative procedures. This could be the national government forestry department, a university faculty or department, a botanical garden, a seed bank, a government-run research centre or a recognised NGO.

Strong institutional support is essential for establishing and maintaining good relations between the diverse organisations involved, i.e. stakeholders such as community groups, government departments, NGOs, funding agencies, international organisations, technical advisers and educational establishments. Clear and mutually acceptable arrangements governing the management of a FORRU that are laid down by the institution can both ensure its smooth running and help to prevent disputes among stakeholders.

Staffing a FORRU

An inspirational leader, a committed conservationist with experience in tropical forestry, is required to run a FORRU. In addition to having a scientific education and relevant experience, he or she should be skilled at project administration, personnel management and public relations. If a FORRU is hosted by a university, the unit leader could be a senior scientist from the faculty staff. In a government forestry research centre, a senior forestry officer could take on this role. Initially, part-time secretarial assistance might be adequate to support the leader, but as the unit grows, full-time administrative help will become necessary.

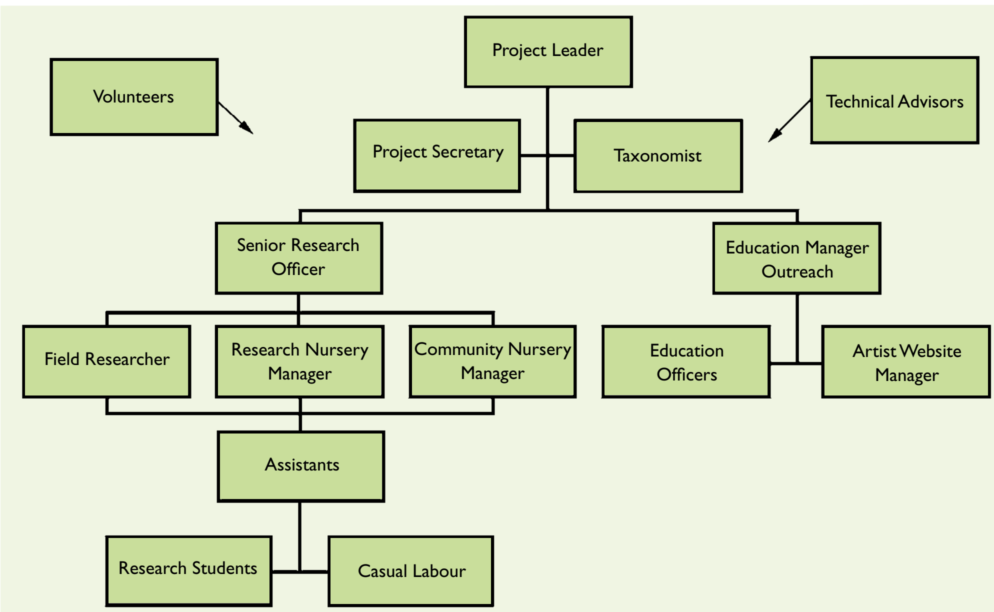
Access to a professional plant taxonomist and herbarium facilities is essential to ensure that tree species are identified accurately. Although the host organisation might not have a taxonomist on the payroll, it is essential to build a good relationship with a taxonomist who can be called upon to identify plant specimens as needed, perhaps on a part-time basis.

When starting a FORRU, two key research posts must be filled:

- a nursery manager will be needed to implement nursery research, manage data, supervise nursery staff and ultimately produce good-quality trees for field trials;
- a field officer must be employed to maintain and monitor field trials, as well as to process field data. Initially, this post might be part-time, but it will become permanent as the field-trial plot system is expanded.

Forest restoration research is not 'rocket science' and, with a little training, anyone can carry out the research protocols described in this book. So apart from the key posts described above, the rest of the unit staff can be recruited from among the local community, regardless of educational qualifications. Local people are more likely to collaborate with a FORRU if some of them are directly employed by it and if they are the first to benefit from the new knowledge and skills generated by it. Local people might be employed full time as nursery or field research assistants or on a part-time or seasonal basis, when extra work is required, such as when preparing for planting events and maintaining planted trees. Including local people in monitoring, so that they share in the project's success, is most important.

As the project proceeds, the dissemination of research results directly to those responsible for implementing forest restoration becomes increasingly important. An education and outreach programme must be designed and implemented. Educational materials must be produced, workshops and seminars organised, and someone must be available to deal with the inevitable stream of interested visitors to the unit. To begin with, the research team might be able to handle some education work, but eventually, an education manager should be recruited; otherwise, research outputs will decline as the unit's research staff are distracted from their main work.



A suggested organisational structure for a FORRU. Volunteers and technical advisors can have inputs at all levels.

In addition to routine research on tree propagation and planting (carried out by the full-time staff), a FORRU provides excellent opportunities for research students to carry out thesis projects on more specialised aspects of restoration. For example, students might investigate the influence of mycorrhizas on tree growth, the best ways to control pests in the nursery, which tree species attract seed-dispersing birds or foster establishment of tree seedlings, or carbon accumulation in restored areas … to name just a few possible studies. It is important that the FORRU is freely open to students and researchers from other institutions. In this way, the unit quickly generates an impressive list of publications that can be used to encourage further funding and institutional support.

Students measuring carbon accumulation in an established forest restoration plot. A FORRU's nursery and plot system provide endless possibilities for research students.

Training requirements

It is unlikely that anyone applying to work at a FORRU will possess the full skill set necessary to develop efficient forest restoration techniques. Therefore, most new recruits will require training in at least some of the following skills:

- project management and administration, proposal writing, reporting and accounting;
- experimental design and statistics;
- tropical forest ecology;
- plant taxonomy;
- seed handling;
- nursery management and tree propagation techniques;
- managing field trials and silviculture;
- biodiversity survey techniques;
- environmental education;
- working with local communities.

Initially, the project leaders themselves must provide adequate training for all newly recruited FORRU staff, but as the levels of skill among the staff rise, nursery or field managers can begin to train assistants and casual staff. In addition to this book, the six-volume series: "Tropical Trees: Propagation and Planting Manuals" published by the Commonwealth Science Council, London, might be a helpful resource for training programmes. Outside organisations can also provide important advice or run training courses for FORRU staff. An advantage of involving overseas advisors is the opportunity to forge collaborative links, which can result in joint projects supported by international funding agencies. Opportunities may also arise for FORRU staff to attend training courses at other institutions, both locally and abroad.

Staff from the Royal Botanic Gardens, Kew train FORRU-Cambodia staff in seed-handling techniques.

Facilities

A FORRU comprises a range of facilities that are needed to the conduct the research activities described in **Sections 6.6**, **7.5** and **7.6**. These include:

- access to an area of the target forest type (see **Section 4.2**);
- a phenology trail through the target forest type (see **Section 6.6**);
- access to an herbarium;
- a research tree nursery in which tree propagation is studied and trees produced for field trials (see **Section 6.6**);
- a community tree nursery in which the feasibility of tree propagation techniques are tested by local stakeholders;
- office facilities for project administration, data handling, library and specimen storage etc.;
- a field trial plot system (see **Section 7.5**);
- an education and outreach sub-unit (see **Section 8.6**).

8.2 Working at all levels

Establishing a FORRU requires working with people from all sectors of society from high-ranking government officials to local villagers.

Contribution of FORRUs to national forest policy

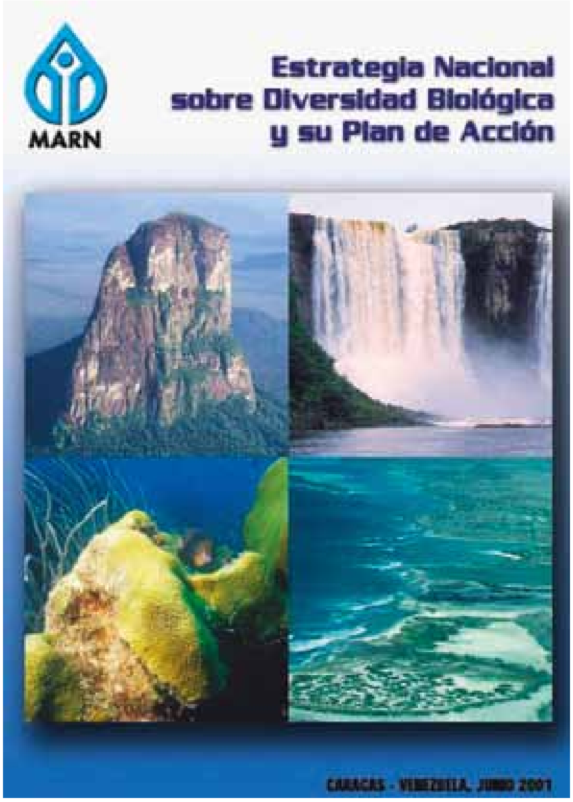
To satisfy funding agencies, as well as the administrators of FORRU host institutions, it may be necessary to justify the establishment of a FORRU in terms of its contributions to:

- implementing national policies on forestry or biodiversity conservation;
- meeting the obligations of governments under international agreements.

If a government is a party to the Convention on Biological Diversity (CBD) (www.cbd.int), it is obliged to implement policies and programmes to meet the provisions of the convention; for example, it might have made commitments to:

- "rehabilitate and restore degraded ecosystems and promote the recovery of threatened species…" (Article 8 (f));
- "support local populations to develop and implement remedial action in degraded areas, where biological diversity has been reduced…" (Article 10 (d));
- "promote and encourage research which contributes to the conservation and sustainable use of biological diversity…" (Article 12 (b)).

Furthermore, under the terms of the convention, each member country must prepare a National Biodiversity Strategy and Action Plan (NBSAP). These plans usually include provisions for the restoration of forest ecosystems for biodiversity conservation, which can be used to justify the establishment of a FORRU. The full text of the CBD can be downloaded from www.biodiv.org/convention/articles.asp and NBSAPs for most countries can be found at www.cbd.int/nbsap/search/.



FORRUs can contribute towards achieving the goals of national biodiversity strategies and action plans, as required under the Convention on Biological Diversity.

If the country in which you are working is a member of the International Tropical Timber Organization (ITTO), you should consult "ITTO guidelines for the restoration, management and rehabilitation of degraded and secondary tropical forests" (www.itto.int/policypapers_guidelines). Although this document does not have the legal weight of an international convention, it does represent an international consensus of opinion that national organisations tend to respect. It includes 160 recommended actions, many of which could be supported by information generated from a FORRU.

Most countries have published national forest policies that stipulate forestry programmes and projects over periods of 5–10 years. Many of these policy statements include recommendations about the rehabilitation of degraded areas, which can be quoted to justify the establishment of a FORRU.

Finally, the UN's REDD+[1] and various other carbon-trading schemes (both voluntary and obligatory under the UN's Kyoto Protocol, e.g. the Clean Development Mechanism) aim to limit the accumulation of carbon dioxide in the atmosphere by channelling funds from carbon emitters into projects that absorb carbon or reduce emissions (see **Section 1.4**). Forestry-related carbon sequestration projects are now required to conserve biodiversity and there is therefore a growing requirement for the kind of research outputs generated by a FORRU.

[1] www.scribd.com/doc/23533826/Decoding-REDD-RESTORATION-IN-REDD-Forest-Restoration-for-Enhancing-Carbon-Stocks

Working with protected area staff

As biodiversity recovery is one of the principal aims of forest restoration, nature reserves and national parks are ideal locations for FORRU nurseries and field trials. Support from the person in charge of a protected area (PA) and his/her staff should be easier to obtain after national and local government officials have been persuaded of the value of a FORRU. A close working relationship must then be cultivated between the PA authority and FORRU staff.

The PA authority might be able to grant permission for the construction of a nursery and the establishment of field trials on PA land, provided such activities are in accordance with the area's management plan. This authority might also be able to provide staff or casual labour to assist with the activities of the unit, as well as other logistical support. When drafting funding applications, consider including the salary of one or more members of the PA staff to be seconded to the FORRU. If field trials contribute to increased forest cover, extent or quality within a PA, then the PA staff will probably want to be involved in tree planting events and in the maintenance of the planted trees. Vehicles owned by the PA might be available for transporting trees, nursery supplies and planting materials around the area. Sometimes, the full cost of providing such help can be charged to the FORRU budget, but some PAs might choose to absorb the costs into their central budget. In such cases, include a contribution to the PA overheads in funding applications.

Support from PA staff can be maintained by inviting them to attend joint workshops and training programmes at the FORRU nursery and field plots. Make sure that the Head of the PA and his/her staff are also invited to seminars and conferences at which results from the FORRU are presented and that the PA is acknowledged in all published outputs. Finally, provide the Head of the PA with regular progress reports, even if they are not requested. This will help to ensure continuity when staff changes occur at the PA headquarters.

National park officers join with local community members and FORRU-CMU staff to plant an area within Doi Suthep-Pui National Park.

The importance of working with communities

The majority of PAs are inhabited. Developing working relationships with communities is therefore essential to prevent misunderstandings about the aims of the work, and to diffuse any potential conflicts over the positioning of forest restoration plots. A good relationship with local people provides a FORRU with three important resources:

- indigenous knowledge;
- a source of labour;
- an opportunity to test the practicability of research results.

Indigenous knowledge helps with the selection of candidate framework species. Local people often know which tree species colonise abandoned cultivated areas, which attract wildlife and where suitable seed trees are located (see **Section 5.3**).

The establishment of field plots, maintenance and monitoring of planted trees, and fire prevention are labour-intensive activities. Local people should be the first to be offered such work and to benefit from payments for it. This helps to build a sense of 'stewardship' of the forest restoration plots, which increases support for the work at the community level. Thus, planted trees are more likely to be cared for and protected.

The species choices and propagation methods developed by a FORRU must be acceptable to local people. Establishing a community tree nursery, where local people can test the techniques developed by research, is therefore highly advantageous

Even the youngest members of a community can participate in restoring forests. With a long future ahead of them, children have most to gain from environmental recovery.

and provides another opportunity for local people to gain income from the project. In addition, community nurseries can produce trees close to planting sites, thereby reducing transportation costs.

Developing a close working relationship with people who live within a PA is not always easy, especially if they feel disenfranchised by the establishment of the PA. Local communities are, however, often the first to benefit from the restoration of their local environment, particularly from the re-establishment of supplies of forest products and the improvement of water supplies. A FORRU can encourage local people and PA staff to work together to establish field plots and nurseries, which can help to build closer ties between them. This benefits both local people and PA management. Stressing such benefits can help to persuade local people to participate in the activities of a FORRU.

Hold frequent meetings with the village committee to ensure that the local community is involved in all stages of a FORRU programme, particularly in the positioning of field experiments, so as not to conflict with existing land uses. Appoint someone from the local community to be the main contact person who relays information between FORRU staff and villagers. In funding applications, make provisions for the employment of local people, both in running a community tree nursery and as casual labour for the planting, maintenance and monitoring of tree planting plots and for fire prevention and suppression. Invite local people to meet visitors to the project, so that they are aware of growing interest in their work and involve them in media coverage of the project, so that they benefit from a positive public image.

Working with foreign institutes and advisors

Expertise and advice from foreign organisations can greatly accelerate the establishment of a FORRU and prevent the duplication of work that has already been done elsewhere. Foreign institutions might also be able to contribute to FORRU workshops on nursery production techniques, seed handling or other topics. Some institutions might be able to accept FORRU staff for short periods of training. Advisors could also be engaged as required to provide expertise in specialist disciplines, such as plant taxonomy.

It is unlikely that a FORRU will have the funds necessary to pay international consultancy fees to foreign experts. Consequently, it is important to build collaborative partnerships so that the costs of involving foreign advisors can be covered by their own institutions, by international funding agencies, or from collaborative project grants.

A further benefit of involving foreign institutions and their staff is that they have access to national sources of funding that are only available to projects working in partnership with the donor country. It is important to work with foreign advisors who understand the ethos of the FORRU and who do not try to change the direction of the work to suit preconceived ideas that do not accord with the ecological or socioeconomic conditions of the country where the FORRU is operating.

Box 8.1. Politics and public relations: alternative motives for participation in forest restoration.

Ban Mae Sa Mai is the largest Hmong village in northern Thailand with 190 households and a total population of more than 1,800. The Hmong is one of several ethnic minorities in northern Thailand that are collectively known as 'hill tribes'. Ban Mae Sa Mai village was originally founded at 1,300 m elevation, but was moved down the valley to its present location in 1967, after deforestation caused the village water supply to dry up. The relocation left the villagers with a strong sense of the link between deforestation and loss of water sources.

In 1981, the village and surrounding farmland were included within the boundaries of the newly declared Doi Suthep-Pui National Park. This meant that the villagers faced a legal threat of eviction as they had no formal land-ownership rights.

To avoid possible enforcement of this law, a few of the villagers formed the 'The Ban Mae Sa Mai Natural Resources Conservation Group' and built a community-wide consensus to gradually reduce the cultivation of the upper watershed and to re-plant the area with forest trees. The village committee designated a remnant of degraded primary forest above the village as 'community forest', thereby protecting three springs that supply both the village and the agricultural land below it with water.

The villagers also decided to contribute to a national project to celebrate His Majesty King Bhumibol Adulyadej's Golden Jubilee, which aimed to restore forest to more than 8,000 km^2 of deforested land nationwide. They agreed with the Park Authority that they would phase out cultivation of a 50-ha area in the upper watershed and replant it with forest trees; in return, they would be allowed to intensify agriculture in the lower valley. The Royal Forest Department provided eucalypt and pine trees for planting in the upper watershed, but the villagers were disappointed with the limited species choice and the results. So, when FORRU-CMU approached the village committee in 1996 with a proposal to test the framework species method in trial plots near the village, the committee enthusiastically agreed (**Case study 6**). Villagers collaborated with all aspects of the project, from planning to seed collection, growing trees in a community tree nursery, tree planting, maintenance, fire prevention and monitoring.

Village children show off the trees they have potted in the community tree nursery. Eight months later, they helped to plant them in the watershed above the village.

In 2006, questionnaires were used to evaluate the villagers' perceptions of the project and to explore their motivation for participation. Although villagers expressed general satisfaction with the project's tangible outputs, they valued the project's impact on improving relationships most highly: both relationships within the village and external relationships with the authorities and the general public.

Around 80% of respondents agreed that the project had reduced internal social conflicts over shortages in natural resources, particularly water. Interviewees stated that they had noticed an improvement in water quality and increased water quantity (particularly during the dry season), as well as a reduction in soil erosion and a better local climate.

Box 8.1. continued.

The majority of villagers appreciated that the project had resulted in an improved relationship between the village and the National Park Authority, with which the villagers had previously been in conflict, and consequently they felt more secure living within the park. Villagers also highly appreciated that the project had improved their public image by attracting positive media coverage. This enabled the village to receive other forms of support, such as that from the Sub-district Administration Organisation (90% of villagers recognised this benefit) and from local units of Royal Forest Department and the National Park Authority (60% of villagers listed this as a benefit). Estimates of the amount of support attracted from these other sources varied from US$ 360 to US$ 1,070 per year.

In general, benefits that affected income were less appreciated than those that affected relationships. Nevertheless, the villagers appreciated the salaries and daily labour payments for caring for the reforestation plots and support for community development, i.e., improvements to road access, water supply, fire prevention work and religious ceremonies.

About 40% of interviewees agreed that the numbers of naturalists and/or ecotourists visiting the village had increased markedly in the previous few years, mostly because of the forest restoration programme, and that such ecotourism was generating an income of approximately US$ 350–1,250 per year, mostly through the provision of accommodation.

With regard to non-timber forest products, the villagers recognised that forest restoration had contributed to the increased production of products such as bamboo shoots and stems, banana leaves and flowers, edible leafy vegetables (mostly young leaf shoots from trees), other flowers and fruits (mostly from trees) and some mushrooms.

Tangible benefits (US$)	**US$/year/household**
Direct employment by the project	25.50
Attracted funds from local government	3.83
Ecotourism income	4.46
Forest products	208.93
Mean increased income per household	**242.72**

Intangible benefits	**% of interviews attributing a high value**
Improved relationships with:	
Forestry Department	74
NGOs	85
Others in the community	93
Improved community image	86
Improved water quality	83
Improved ability to attract funding from local government	90

Box 8.1. continued.

The marginal, steep cabbage fields above the village have largely been restored back to forest. Intensification of agriculture in the lower valley has improved the villagers' livelihoods, and was made possible by improved water quality supply from the restored watershed.

A restoration plot, established on an abandoned cabbage field, photographed 16 months after planting 30 framework tree species.

The village nursery and plots have now become vital facilities for education, attracting frequent visitors and workshops. Representatives from other communities visit the village to find out how they too, can establish successful forest restoration projects. Thus, the villagers of Ban Mae Sa Mai have converted their cabbage fields into a classroom for forest restoration, while simultaneously securing their water supply and improving both their public image and their livelihoods. Overall, this collaboration between FORRU-CMU and the Ban Mae Sa Mai community has demonstrated how scientific research and the needs of a community can be combined to create a model system for environmental education.

The village received an award from the Thai government recognising their efforts in restoring the forest around their village. An improved relationship with the authorities was a major motivational factor in this project.

8.3 Funding

Obtaining funding

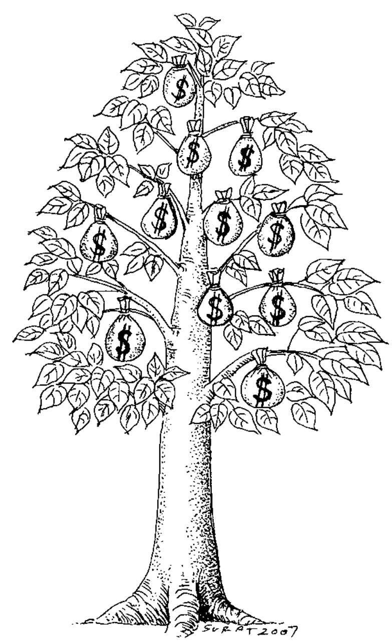
If a FORRU is established within an existing, centrally funded, institution, it may be possible to make use of existing staff and facilities to initiate a research programme. As the research programme expands, however, independent funding must be found.

Funding sources for forest restoration projects have already been discussed in **Section 4.6** and all are suitable for funding a FORRU. As FORRUs are essentially academic research facilities, however, they may also draw on research grants, particularly if they are based in a university. For financial stability, it is best to maintain a varied 'portfolio' of different sources of research funding by dividing the work of the unit into clearly defined research areas (e.g. forest ecology, tree propagation and biodiversity recovery), each one supported by a different funding mechanism with different start and finish dates. In this way, the end of a single grant period does not result in staff redundancies and the collapse of the unit.

Research funding can be obtained from a wide range of different organisations. Multinational or international aid agencies (e.g. the European Union (EU) or the International Tropical Timber Organization (ITTO)) can provide large grants for large projects, but they usually impose complicated and time-consuming application and reporting procedures in order to maintain accountability and transparency to their donor governments. Therefore, only organisations with highly trained administrative staff who are capable of coping with the cumbersome bureaucratic procedures can expect to be successful in securing international funds.

Grants provided by individual foreign governments can also be very generous (e.g. under the UK's Darwin Initiative or Germany's Gesellschaft für Internationale Zusammenarbeit (GTZ)). They are usually administered through institutions in the donor country, which may also receive some support from the grant. The involvement of foreign advisors from the donor country is often a condition of the grant. This option is suitable when a good working relationship with an institution in the donor country has already been developed and the need for the involvement of foreign experts has been clearly identified. Grants from national mechanisms that support research in the project's own nation might be easier to obtain and require less bureaucracy than foreign funding, although the amounts granted are generally less.

The "CPF Sourcebook on Funding for Sustainable Forest Management", mentioned in **Section 4.6**, also covers many agencies that support forestry research (www.cpfweb.org/73034/en/).



Unfortunately, money doesn't grow on trees, so fundraising, accounting and reporting are vital activities when running a FORRU. Luckily, interest in funding forest restoration, particularly to mitigate global climate change, is growing. Major funders should be interested in supporting research and in ensuring that large-scale projects are implemented using the most cost-effective methods.

8.4 Information management

Computer databases

Once established, a FORRU generates large amounts of data from diverse sources. One of the unit's most important roles must be to organise and integrate these data to generate reliable advice for practitioners. Computer databases provide the most appropriate way to i) store large diverse data sets and ii) analyse them to answer a wide range of different questions. For example, if a site at 1,300 m elevation becomes available for forest restoration, the questions asked of a database might include:

- What tree species grow at similar sites and at similar elevations?
- Of those species, which ones have fleshy fruits that attract seed-dispersing animals?
- Of those species, which ones will be fruiting in the next month so that seed collection might commence?
- Of those species, which ones have previously germinated well in the nursery?

To generate lists of species that match specified criteria, it is necessary to construct a relational database that integrates all of the data produced by a FORRU together with published data and indigenous local knowledge. Spreadsheets do not allow the sophisticated search, sort and integration facilities of dedicated database programmes, and the larger spreadsheets become, the more difficult they are to work with. Therefore, most critical data must be extracted from spreadsheets (such as those described in **Sections 6.6, 7.5** and **7.6**) and re-entered into a relational database system.

Who should set up the database

Setting up a relational database system involves intensive collaboration between the FORRU research staff, who have first-hand knowledge of the data being generated and know how they would like to analyse it, and a colleague or consultant with specific experience of working with the chosen database programme.

Database structure

Databases are like sophisticated card index systems. A 'database file' is the equivalent of one box, containing many cards. A 'record' is the equivalent of one card and a 'field' represents one of the headings on the card and the information associated with it. It is not practical to store all of the information available about a species in a single record: for some types of information, there will be a single entry (e.g. the name and characteristics of a tree species, which do not change), whereas for other types of information there may be many entries (e.g. germination trial results for each batch of seed). Therefore, the database consists of several database files, each one storing a particular category of information.

In addition, records referring to a particular species in each database file should be linkable with records referring to the same species in all other database files. Links are achieved by assigning link codes to each record; these enable records referring to the same species to be joined, regardless of which database file they are in. The most convenient link codes are the species number (S. no.) and seed-batch number (b. no.)

(see **Section 6.6**), so it is of the utmost importance that the system of species and batch numbers is maintained throughout the research process, from seed collection to planting. These identification numbers are crucial to data integration, so they should appear on all datasheets and plant labels, both in the nursery and in the field. The database system must be able to recognise these codes and group together all records that share the same codes from all database files. Thus, the database should be able to generate species reports, listing all of the recorded information on each species. It is not a good idea to use the species names (or abbreviations of them) as link codes because it may take time to identify some species correctly, and even then, taxonomists are constantly changing the scientific names of plants.

On the following pages, we suggest some record structures that contain the most basic information generated by a FORRU. This basic database structure can be expanded with new fields and database files as required. Consider adding files to hold summary data on seed storage experiments, the attractiveness of each species to wildlife, or indigenous knowledge about the uses of each tree species. But be aware that data entry is time consuming, so before embellishing the database with extra fields or files, first consider whether the data entered will actually be used to support decision-making — whether the outputs really justify the data input time.

Foresters in the Philippines learn about data management before setting up their own research tree nurseries and restoration demonstration plots at universities across the country.

Database software

Database programmes vary in terms of their sophistication and ease of use. Unfortunately, the more sophisticated the programme is, the less user-friendly it is. Microsoft Access is probably the most widely used database system, but it is expensive and several open-source database programmes are available for free (e.g. Open Office).

Whichever package you select, make sure that it supports the essential features listed below:

- the ability to link records in different database files that refer to the same species;
- searches within fields for text occurring in any position in the field (e.g. find September (i.e. "sp") occurring anywhere within a list of fruiting months…. "jl ag sp oc nv");

- the ability to generate information in one field from calculations using numbers stored in other fields, e.g. median length of dormancy could be calculated by subtracting the date of seed collection from the median date on which the seed germinated.

Also consider whether the database package supports the script of your language and/or the insertion of images (if needed). Database technology has other applications for a FORRU besides storing experimental data. Consider constructing a database that stores the names and contact details of everyone who has contact with the unit, so that you can easily organise invitations to workshops and other educational events, as well as a circulation list for the unit's newsletter. Another database could be used to catalogue books that are kept in the unit's library or photographs taken by the unit's staff.

Files, records and fields

Database file "SPECIES.DBF"

One record for each tree species. This file stores basic information about each species, which can be linked to records in other database files through the "SPECIES NUMBER:" field. Most of this information can be retrieved from a flora. Modify the list of flowering and fruiting months, as data from the phenology survey become available (see **Section 6.6**).

SPECIES NUMBER: *e.g. S71*

SCIENTIFIC NAME: *e.g. Cerasus cerasoides* **FAMILY:** *Rosaceae*

LOCAL NAME: *Nang Praya Seua Krong*

EVERGREEN/DECIDUOUS: *D*

ABUNDANCE: *e.g. 0 = Probably extirpated; 1 = Down to a few individuals, in danger of extirpation; 2 = Rare; 3 = Medium abundance; 4 = Common, but not dominant; 5 = Abundant.*

HABITAT: *develop your own codes for forest types e.g. egf = evergreen forest; species may occur in more than one forest type, list them all in any order.*

LOWER ALTITUDE: **UPPER ALTITUDE:** *from direct observations*

FLOWERING MONTHS: *ja fb mr ap my jn jl ag sp oc nv dc*

FRUITING MONTHS: *ja fb mr ap my jn jl ag sp oc nv dc*

LEAFING MONTHS: *ja fb mr ap my jn jl ag sp oc nv dc*

FRUIT TYPE: *e.g. dry/fleshy drupe/nut/samara etc.*

DISPERSAL MECHANISM: *e.g. wind/animal/water etc.*

NOTES:

ENTRY INTO DATABASE CHECKED BY: **DATE:**

Database file "SEED COLLECTION.DBF"

This database contains one record for each batch of seeds collected. Records for the different seed batches for each species are linked to a single record in "SPECIES.DBF" by the "SPECIES NUMBER:" field. Transcribe information from seed-collection data sheets (see **Section 6.6**).

SPECIES NUMBER: *e.g. S71* **BATCH NUMBER:** *e.g. S71b1*

COLLECTION DATE: **TREE LABEL NUMBER:** **TREE GIRTH:**

COLLECTED FROM: *e.g. ground/tree*

LOCATION: *e.g. Rusii Cave* **GPS CO-ORDINATES:**

ELEVATION:

FOREST TYPE: *develop your own codes for forest types e.g. egf = evergreen forest.*

NO. SEEDS COLLECTED: **STORAGE/TRANSPORT DETAILS:**

SOWING DATE:

VOUCHER SPECIMEN COLLECTED: *e.g. Yes/no*

NOTES FOR HERBARIUM VOUCHER LABEL:

ENTRY INTO DATABASE CHECKED BY: **DATE:**

Database file "GERMINATION.DBF"

This database contains one record for each treatment applied to each sub-batch of seeds. Multiple records for each species or each batch, respectively, are linked to a single record in "SPECIES.DBF" by the "SPECIES NUMBER:" field and to a single record in "SEED COLLECTION.DBF" by the "BATCH NUMBER:" field. Extract data from germination data sheets (see **Section 6.6**) Use mean values from all replicates.

SPECIES NUMBER: *e.g. S71* **BATCH NUMBER:** *e.g. S71b1*

PRE-SOWING TREATMENT: *enter only one treatment (or control) e.g. scarification.*

MEDIAN SEED GERMINATION DATE: *date on which half the seeds germinated.*

MLD: = GERMINATION.DBF/MEDIAN SEED GERMINATION DATE: *minus* **SEED COLLECTION.DBF/SOWING DATE:**

MEAN FINAL PERCENT GERMINATION:

MEAN FINAL PERCENT GERMINATED BUT DIED: *as a percentage of the number of seeds that were sown.*

ENTRY INTO DATABASE CHECKED BY: **DATE:**

Database file "SEEDLING GROWTH.DBF"

This database contains one record for each treatment applied to each batch. Multiple records for each species are linked to a single record in "SPECIES.DBF" by the "SPECIES NUMBER:" field. The record for each batch of seeds collected is linked to a single record in "SEED COLLECTION.DBF" by the "BATCH NUMBER:" field. Extract data from seedling growth data sheets (see **Section 6.6**).

SPECIES NUMBER: *e.g. S71* **BATCH NUMBER:** *e.g. S71b1*

POTTING DATE:

TREATMENT: *enter only one treatment (or control) e.g. Osmocote once every 3 months.*

NO. OF SEEDLINGS: *total number of seedlings subjected to treatment (combined replicates).*

SURVIVAL: *as a percentage, between potting and just before planting out.*

TARGET DATE: *date on which mean seedling height reaches target value (e.g. 30 cm for fast-growing pioneers and 50 cm for slower growing climax tree species). Derived from interpolation between points on the seedling growth curve (p. 207).*

OPT. PLANTING DATE: *first optimum planting out date after the target date (usually 4–6 weeks after the first rains).*

TNT: *total nursery time* = **SEEDLING GROWTH.DBF/OPT.PLANTING OUT DATE:** *minus* **SEED COLLECTION.DBF/COLLECTION DATE:**

OST: *over storage time* = **SEEDLING GROWTH.DBF/OPT. PLANTING OUT DATE:** ***minus*** **SEEDLING GROWTH.DBF/TARGET DATE.** *This value is useful for identifying species for seed storage experiments.*

RGR HEIGHT: *relative growth rate, based on height measurements from just after potting to just before planting out.*

RGR RCD: *relative growth rate based on root collar diameter measurements from just after potting to just before planting out.*

ROOT/SHOOT RATIO: *from sacrificed plants just before planting out.*

NOTES ON HEALTH PROBLEMS: *descriptions of pests and diseases etc.*

ENTRY INTO DATABASE CHECKED BY: **DATE:**

Database file "FIELD PERFORMANCE.DBF"

This database contains one record for each silvicultural treatment applied to each batch. Multiple records for each species or each batch can be linked to a single record in "SPECIES.DBF" by the "SPECIES NUMBER:" field, and to records in the other database files by the "BATCH NUMBER:" field. Extract data from the field data analysis spreadsheets (see **Section 7.5**). Insert mean values for combined replicates for a single silvicultural treatment.

SPECIES NUMBER: *e.g. S71* **BATCH NUMBER:** *e.g. S71b1*
PLANTING DATE:
FTPS LOCATION: **PLOT NUMBER(S):**
TREATMENT: *enter only one treatment (or control) e.g. cardboard mulch.*
NO. OF TREES PLANTED: *total number of trees planted and subjected to treatment (combined replicates).*

MONITORING DATE 1: *just after planting.*
SURVIVAL 1: *as a percentage.*
MEAN HEIGHT 1: **MEAN RCD 1:** **MEAN CANOPY:**
WIDTH 1:

MONITORING DATE 2: *after first rainy season.*
SURVIVAL 2: *as a percentage.*
MEAN HEIGHT 2: **MEAN RCD 2:** **MEAN CANOPY:**
WIDTH 2:
MEAN RGR HEIGHT 2: **MEAN RGR RCD 2:**

MONITORING DATE 3: *after second rainy season.*
SURVIVAL 3: *as a percentage.*
MEAN HEIGHT 3: **MEAN RCD 3:** **MEAN CANOPY:**
WIDTH 3:
MEAN RGR HEIGHT 3: **MEAN RGR RCD 3:**
MONITORING DATE 4: *add additional fields as needed for each subsequent monitoring event.*
ETC......

NOTES: *descriptions of pests and diseases etc. observed.*

ENTRY INTO DATABASE CHECKED BY: **DATE:**

8.5 Selecting suitable tree species

A relational database has many functions, but one of the most useful is to select the most suitable tree species to restore forest to any particular site. For degradation stages 3 to 5 (see **Section 3.1**), trees species should be selected according to the criteria that define framework species and/or nurse crop species (**Table 5.1** and see **Section 5.5**), combined with any other situation-specific considerations. This selection can be very subjective or involve complex analyses of the database. Therefore, we suggest two simple semi-quantitative methods to facilitate the process of species selection: the 'minimum standards' approach and a 'suitability index', which is based on a ranked scoring system. They may be used independently or in tandem, using minimum standards to create a short-list of species that is subsequently ranked by suitability index. These two methods make best use of the data available, while retaining the flexibility required to meet the various objectives of different projects.

Applying minimum acceptable standards of field performance

The most important field-performance criterion is survival rate after planting out. No matter how well a species performs in other respects (e.g. it might have rapid growth and/or be attractive to seed-dispersers), there is not much point in continuing to plant it if its survival rate after 2 years falls below 50% or so. Additional minimum acceptable standards can be applied to growth rates, canopy width, suppression of weed cover and so on, but all are subordinate to survival. The values of the minimum acceptable standards are largely subjective, although sensible values can usually be decided upon by scanning the data sets and looking for the divisions that set species apart, particularly values that contribute towards canopy closure within the desired timeframe.

Extract field data collected after 18–24 months (at the end of the second rainy season in seasonal forests) from the database into a spreadsheet with species names in the left-hand column, with data on the selected performance criteria arranged in columns to the right. Use mean values from planted control plots (see **Section 7.5**) or mean values from whichever silvicultural treatment produced the best results.

Bear in mind that whether or not a species exceeds minimum standards can depend on i) the silvicultural treatments applied, ii) climatic variability (some species may exceed the standard in one year but not the next) and iii) site conditions. So a species need not necessarily be rejected if it marginally fails to achieve the minimum standard in a single trial. Intensified site preparation or silvicultural treatments could convert a rejected species into an acceptable one.

The application of minimum standards results in three categories of species:

- category 1 species: those that fall short of most or all minimum acceptable standards (i.e. rejected species);
- category 2 species: those that exceed some minimum standards but fall short of others, or those that fall short of several standards by only a small amount (i.e. marginal species);
- category 3 species: those that greatly exceed most or all minimum standards (i.e. excellent or acceptable species).

Category 1 species are dropped from future plantings. Category 2 species could either be rejected or subjected to further experimentation to improve their performance (e.g. to improve the quality of the planting stock or to develop more intensive silvicultural treatments), while category 3 species are approved for use in future restoration work.

Example:

Three minimum standards are applied to field-performance data collected at the end of the second rainy season after planting:

- survival >50%;
- height >1 m (as seedlings should be planted when 30–50 cm tall, this represents a more than doubled height);
- crown width >90 cm (i.e. the crown has obtained more than half the width required to close canopy at a tree spacing of 1.8 m (equivalent to 3,100 trees per hectare)).

In the table below, data that fail to meet minimum standards are indicated in red.

Species	% Survival	Mean height (cm)	Mean crown width (cm)	Category	Action
S001	89	450	420	3	Accept
S009	20	62	65	1	Reject
S015	45	198	255	2	Research to increase survival
S043	38	102	20	1	Reject
S067	78	234	287	3	Accept
S072	90	506	405	3	Accept
S079	65	78	63	2	Research to increase growth
S105	48	82	77	2	Research to increase growth and survival

What if too few species exceed minimum acceptable standards?

There are several options:

- improve overall planting stock quality — review the nursery data to see whether there is anything that can be done to increase the size, health and vigour of the planting stock;
- experiment with intensified silvicultural treatments (e.g. carry out weeding or apply fertiliser more frequently), particularly if you think that site conditions could be limiting;
- try different species — review all sources of tree species information (**Table 5.2**) and start collecting seeds of species that have not already been tested.

Developing a suitability index

A semi-quantitative scoring system can be used to rank species according to a suitability index that combines a wide range of criteria. It can be applied either to refine the short-list of acceptable (or marginal) species that emerge from application of minimum standards or to all species for which data are available. Bear in mind that species with low field survival rates should always be screened out first, before calculating a suitability index.

A suitability index can take into account both easily quantifiable performance data and more subjective criteria, such as the attractiveness of each tree species to seed-dispersing animals. The simplest approach is to note whether species produce fleshy fruit or not. In older plots, this could be further refined by using the number of years to first flowering and fruiting, or the number of animal species that are attracted to a tree species.

Extract relevant data from the database and add additional information to a spreadsheet as required.

Example

Before biodiversity data are available, ability to produce fleshy fruits can be used as an indicator of 'attractiveness' to seed dispersers

TNT = 'total nursery time' required to produce planting stock is used here to indicate ease of propagation. % germination or seedling growth rates in the nursery could also be used

Species	% Survival	Mean height (cm)	Crown width (cm)	Fleshy fruits	TNT (years)
S001	89	450	420	Yes	<1
S015	45	198	255	Yes	<1
S067	78	234	287	Yes	1 to 2
S072	90	506	405	No	<1
S079	65	78	63	Yes	1 to 2
S105	48	82	77	Yes	>2

In this example, the species that were rejected as a result of applying minimum standards have been removed, while marginal values for some criteria remain indicated in red.

Find the species with the highest mean height. Assign a value of 100% to that maximum mean height and convert the mean heights of all other species to percentages of that maximum value to provide a height 'score' for each species. In this example, S072 has the highest mean height (506 cm) so the heights of all other species are multiplied by 100/506. Carry out the same calculation to provide scores for other chosen quantifiable criteria, including nursery performance criteria (e.g. % germination, seedling survival and so on).

Add extra weight to the criteria you feel are most important by multiplying their scores by a weighting factor (e.g. the survival has been doubled in the example below). Sum the scores and, as before, convert them into a percentage of the maximum score (adjusted score). Then rank the species in order of declining overall score.

Example

Mean % survival ×2

100 = fleshy fruits present; 0 = not present

TNT <1yr = 100; 1–2yr = 75; >2yr = 50

Per cent of maximum score

Species	Survival score	Height score	Crown width score	Fleshy fruits score	Ease of propagation score	Total scores	Adjusted score
Max Score	200	100	100	100	100	600	–
S001	178	88.9	100.0	100	100	566.9	100.0
S015	90	39.1	60.7	100	100	389.8	70.0
S067	156	46.2	68.3	100	75	445.6	80.0
S072	180	100.0	96.4	0	100	476.4	85.6
S079	130	15.4	15.0	100	75	335.4	60.2
S105	96	16.2	18.3	100	50	280.5	50.4

Based on the suitability scores above, S001, S015, S067 and S072, are the best species for planting, even though S015 would require some additional effort to increase survival. Lack of fleshy fruits in S072 is compensated for by excellent scores for other performance criteria. Rejection of both S079 and S105, which marginally failed to meet minimum standards, is confirmed as their adjusted suitability scores are only about half that of the most suitable species.

The interpretation of such a scoring system is ultimately subjective as the user must decide on which performance criteria are included, how they are quantified and how low or high the adjusted score must be to indicate the rejection or acceptance of a species.

Deciding on the species mix

One of the disadvantages of applying standards or a scoring system too rigorously is that it could result in the selection of only fast-growing pioneer species. This would create a rather uniform forest canopy (see **Section 5.3**). Planting pioneer and climax forest tree species together creates more structural diversity, even if some of the climax tree species fail to meet minimum standards or are ranked low in a scoring system.

So, when compiling the final mixture of species to be planted each year, use standards or scores to provide guidelines rather than absolute rules. Be flexible and always keep in mind the need for diversity. For example, a few slower-growing tree species could be acceptable for planting if they score highly on other criteria (e.g. early fruiting) and where most of the other species being planted are fast-growing. Similarly, a few species with narrow crowns may be desirable to add to the structural diversity of the forest canopy, provided they are planted alongside other species that score highly for canopy width. Ultimately, the species mix is selected by a subjective judgement that is modified and improved each year as a result of adaptive management.

What is adaptive management?

Ideally final species selection, as well as other management decisions, would not be made until all the data have been collected and analysed. It might, however, be many years before some of the field data are produced. Therefore, in the first few years of a FORRU, decisions are inevitably based on data that are produced early in the project, such as phenological observations or seed collection and nursery data. Tree performance data from field trials follow later, whereas data on biodiversity recovery and the establishment of recruit tree species become meaningful only after several years. Therefore, calculations of species suitability scores must be continually updated and modified as new data become available. Maintaining and updating the FORRU database is crucial to this process.

Continual re-assessment of species suitability is just one of several components of 'adaptive management', a concept central to the implementation of forest landscape restoration (see **Section 4.3**). Research results should feed into a social learning approach that is based on a process of experiential decision-making and monitoring. The database effectively acts as an archive of the outcomes of previous management trials and monitoring results, both good and bad, so that future decision-making can gradually be improved.

The process only works if all stakeholders have access to the database and can understand the outputs. Outputs must therefore be presented in user friendly formats and it is also necessary to run an education and outreach programme to ensure that all stakeholders can work with the database outputs and are thus well-equipped to participate meaningfully in management decisions. For more on adaptive management, see Chapter 4 in Rietbergen-McCracken *et al*. (2007).

8.6 Reaching out: education and extension services

Once an appreciable body of knowledge has been acquired, a FORRU should use it to provide comprehensive education and extension services that will improve the capacity of all of the stakeholders to contribute together to forest restoration initiatives. Such an outreach programme might include training courses, workshops and extension visits, supported by publications and other educational materials, each tailored to meet the different needs of each of the various stakeholder groups (e.g. government officials, NGOs, local communities, teachers, school children and so on).

Education team

To begin with, a FORRU's research staff might be called upon to provide training to interested groups as and when needed. As the project becomes more widely known, however, you should expect a rapid increase in demand for education and training services, which will begin to overwhelm the research staff, distracting them from vital research activities. It is better to recruit a team of education officers, with specialised experience of environmental education techniques, who are dedicated to providing stakeholders with the knowledge and technical support they need to implement restoration projects.

Newly recruited education staff will not be familiar with the knowledge-base acquired by the research staff. Therefore, the research team must first familiarise the education team with their research results and they must continue to provide frequent updates as the research delivers new information. The education team must then decide how to present the knowledge to stakeholders in user-friendly formats.

Education programme

Once the educators are familiar with the FORRU's knowledge-base, they must design curricula to meet the very different needs of the various stakeholders involved in forest restoration. A modular system is best, with subject material presented in different ways to match: i) the target audience and ii) the location where the module will be taught. For example, teaching forest officers about the framework species concept in a field plot requires a very different approach to teaching school children about the same concept in a classroom.

One of FORRU-CMU's nursery officers teaches workshop participants from the Elephant Conservation Network how to extract fig seeds. The participants subsequently set up their own FORRU in western Thailand, which is being used to restore elephant habitat (www.ecn-thailand.org/).

An education programme can include the following activities:

- workshops to introduce the general concepts of forest restoration and to present techniques and results; these are usually for government officers, NGOs and community groups who are considering forest restoration initiatives;
- more detailed training in forest restoration best practices for practitioners who are responsible for running nurseries and implementing planting programmes;
- extension visits to forest restoration projects that aim to provide on-site technical support directly to the people involved in implementing projects;
- hosting interested visitors to the unit such as scientists, donors, journalists and so on;
- helping with the supervision of college student thesis projects;
- presenting research results at conferences.

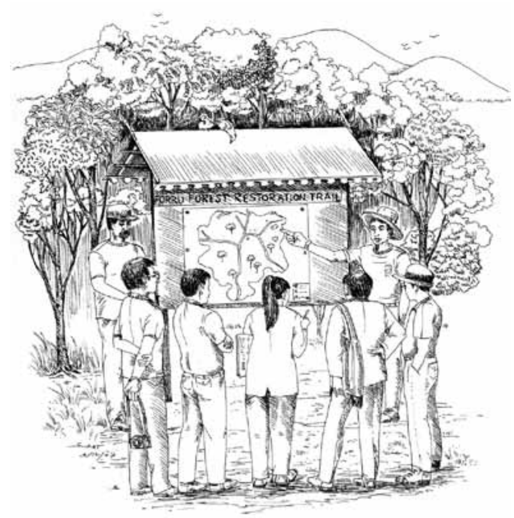
Special events for school children and a train-the-teachers programme (½ day to several days, for camps and teacher training) could also be undertaken as children have the most to gain from forest restoration.

Education materials

A FORRU education team should produce a wide range of educational materials to satisfy the needs of all stakeholders. Teaching aids will be needed for each module.

A video can provide a concise overview of the FORRU and its work for the opening sessions of workshops and training programmes, whereas a newsletter and a website can keep all stakeholders informed of a FORRU's outputs on a regular basis.

Publications are important educational outputs of a FORRU. Producing them can include a participatory component, involving consultations with and inputs from workshop participants. This ensures that the information provided by the FORRU is of maximum benefit for local people, and also that it makes best use of indigenous knowledge. Most of this material can easily be designed and laid out in-house with the aid of computers and desktop publishing software, particularly if someone with experience of graphic design is recruited to join the education team.



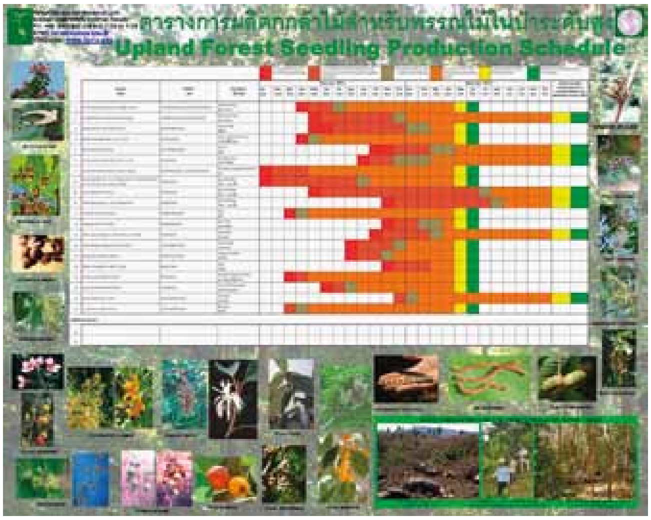
A trail through the field trials with informative sign boards turns a research facility into an educational resource of immense value.

Pamphlets and handouts

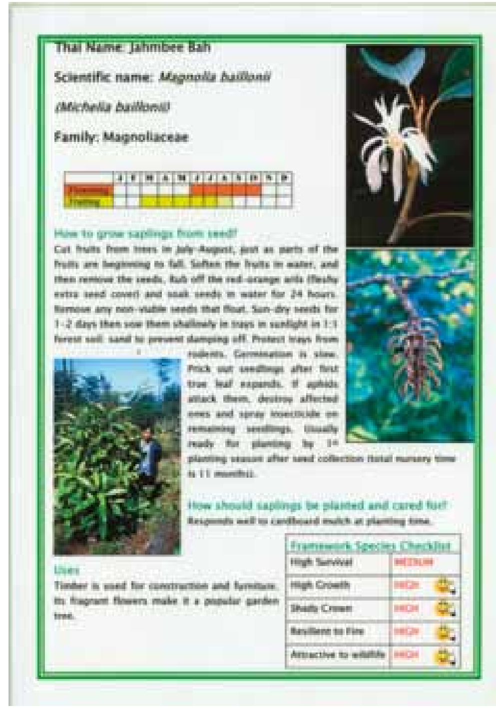
Handouts and pamphlets are one of the first outputs of a FORRU. They are useful for the unit's staff and visitors (particularly existing and potential funders). They should be both informative and help to publicise the unit. One of the first pamphlets produced could simply describe the FORRU's research programme to visitors. As the research programme develops, more technical literature should be produced, such as species data sheets and production schedules. Once this material has been written up, it can be used in other ways, for example in posters displayed in prominent places in the research unit for educational purposes.

Practical manuals

One of the first manuals produced by a FORRU should be an overview of the best practices for forest restoration, which combines the original skills and knowledge derived from the FORRU's research programme with existing knowledge and common sense. The manual serves as a text book for training both stakeholders during workshops and

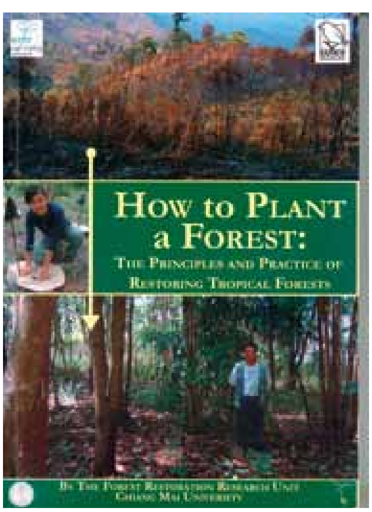


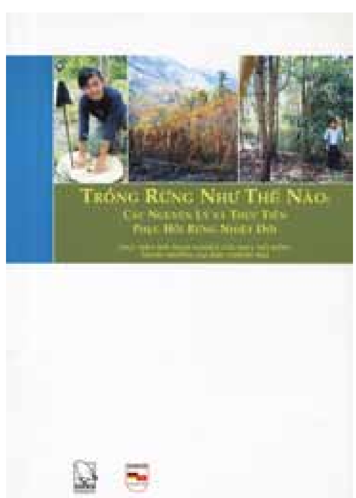
A colourful production-schedule poster helps nursery staff to keep track of what seed species to collect and when to collect them.

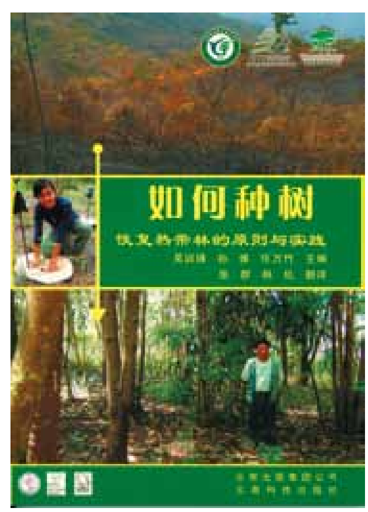


Convert species information into user-friendly formats, such as this species profile card for *Magnolia baillonii*. Then compile information for all target species into a production-schedule poster.

extension events and newly recruited staff or visiting workers. Typically, such a manual should contain i) the basic principles and techniques of forest restoration, ii) descriptions of target forest types, and iii) descriptions and propagation methods for those tree species deemed suitable for restoration projects. It should be written in a format that is accessible to a broad readership. For an example, see FORRU-CMU's "How to Plant a Forest"[2]. This volume proved so popular that it has now been translated and adapted for use in seven Southeast Asian countries.







Practical manuals should be translated into the languages of neighbouring countries, to allow export of the skills and knowledge developed by a FORRU and their adaptation to different forest types and socio-economic conditions.

[2] www.forru.org/FORRUEng_Website/Pages/engpublications.htm

Research papers and an international audience

Original scientific results should be published in international journals or presented at international conferences and published in proceedings. The purpose of publications aimed at an international audience is to share research results with other people working in a similar field. Research papers also promote correspondence, discussion and exchange visits. They assist other researchers in developing their own research programmes. Furthermore, international publications enhance the status of the research unit, both at home and abroad.

Acceptance of papers by international journals and conference proceedings is important for the careers of the scientific staff (as job security in the academic world now increasingly depends on publication record) and raises the profile of the FORRU in the eyes of donor agencies. Research papers strengthen bids for funding.

Develop a communication strategy

In addition to informing and training stakeholders who are directly involved with forest restoration, the education team should also be responsible for reaching out to the broader general public by engaging the mass media. Public recognition for the work of a FORRU helps to build public acceptance of forest restoration and attracts support and funding. It also helps to establish a network of contacts with other organisations that might otherwise be unaware of the FORRU's work. So, it is worth investing some time in planning an effective communications strategy that emphasises those elements of the project that are appropriate for each of the different audiences it wishes to reach.

What questions should a communication strategy answer?

First, determine what the purpose of the communication is, what resources are available, and how to evaluate whether the message has been effectively communicated. Decide on who is the intended target audience. For example it could be the general public, land-holders, staff from government agencies, environmental organisations, teachers and students, sponsors and potential sponsors, industry organisations and so on. Be clear on what issues concern the audience, what message to communicate to them, what tools will be used, who in the FORRU will be responsible for the communication, and by when.

Writing for an audience

Develop the skills needed to present information clearly and concisely. Articles in newspapers, brochures, newsletters and on display boards will be read by people from a wide variety of backgrounds with different levels of technical expertise and language skills.

Developing a logo and promotional style

Develop a FORRU logo and a signature style (colour scheme, font style etc.) for presentations, publications, uniforms and so on. This will help audiences to recognise the FORRU 'brand'.

FOREST RESTORATION RESEARCH UNIT

A recognisable logo helps to build a sense of unit identity and project recognition.

Photography

Good digital photographs can be used for a wide range of communication activities. Attractive, clear photos will increase the probability of having articles accepted for publication. Use a database to catalogue and organise the photo collection so as to make it easier to select the most appropriate photographs for each purpose.

You can never have enough photos. Learn how to take good ones.

Communication tools

Open days, workshops and other events at the unit are all good ways to communicate with the wider public, but publicising your work at international meetings can have a broader impact. Accept invitations to speak at conferences and symposia or present posters, which can later be used around the FORRU. Keep posters short and simple with more pictures than text. Develop handouts to provide more detail.

Learn to use mass media to publicise FORRU outputs beyond the pages of scientific journals.

Use the media. Invite journalists to planting events and the opening of workshops etc. Write a press release or prepare information packs for journalists in advance so they have accurate facts and figures at their fingertips when writing articles. Ask a TV company to make a film about the unit, which can then be used as an introductory video at workshops and training events etc.

Maintain a website for regular communications with a network of interested organisations and individuals. In addition to a general description of the unit and its research and education activities, include pages with announcements of forthcoming events, a picture gallery of recent events and an interactive bulletin board. Publications and educational materials can be also posted on the website, so that anyone requesting a publication can simply be referred to the website for downloads. This saves a fortune in postage costs.

Inspiration for designing a forest restoration website can be found at:www.forru.org, www.rainforestation.ph and www.reforestation.elti.org

For those unable to access the web, a quarterly printed newsletter serves a similar function. Maintain a mailing list for the newsletter and also post copies on the website. E-mail makes it easy to communicate personally with large numbers of people, but do not allow your FORRU to gain a reputation for generating junk mail. A page on one of the web-based social media networks is a less intrusive way to keep people informed of the FORRU's activities and latest findings.

CASE STUDY 6 Chiang Mai University's Forest Restoration Research Unit (FORRU-CMU)

Country: Thailand

Forest type: Lower montane evergreen tropical forest.

Ownership: Government, national park.

Management and community use: 'Community forest' for the protection of the water supply to both Ban Mae Sa Mai village and the agricultural land below it; some harvesting of non-timber forest products.

Level of degradation: Cleared for agriculture, earlier restoration attempts had included planting of pines and eucalypts.

Like all tropical countries, Thailand has suffered from severe deforestation. Since 1961, the kingdom has lost nearly two-thirds of its forest cover (Bhumibamon, 1986), with natural forests having declined to less than 20% of the country's land area (9.8 million ha) (FAO, 1997, 2001). This has resulted in losses of biodiversity and increased rural poverty, as local people are forced to purchase, in local markets, substitutes for products formerly gathered from forests. Increases in the frequencies of landslides, droughts and flash floods have also been attributed to deforestation, while forest fires and other forms of degradation contribute approximately 30% of Thailand's total carbon emissions (Department of National Parks, Wildlife and Plant Conservation (DNP) and Royal Forest Department (RFD), 2008).

Part of the Thai government's response to these problems has been to ban logging and to attempt to conserve remaining forest in protected areas covering 24.4% of the country's land area (125,082 km^2) (Trisurat, 2007). However, many such 'protected' areas were established on former logging concessions, so large parts of them were already deforested before they were gazetted (about 20,000 km^2 (derived from Trisurat, 2007)). A 2008 report by Chiang Mai University's Academic Service Centre, found that about 14,000 km^2 of the country's forestland was "in need of urgent recovery" (Panyanuwat *et al*., 2008).

Early attempts at reforestation involved the establishment of plantations of pines and eucalypts. For environmental protection and biodiversity conservation, forest restoration (as defined in **Section 1.2**) is more appropriate, but its implementation has been limited because of a lack of knowledge about how to grow and plant native forest tree species.

Therefore, in 1994, the Biology Department of Chiang Mai University established a Forest Restoration Research Unit (FORRU-CMU), in which to develop appropriate techniques for the restoration of tropical forest ecosystems. The unit consists of an experimental tree nursery and trial plot system in Doi Suthep-Pui National Park, which adjoins the university campus.

In 1997, FORRU-CMU began research to adapt the 'framework species' approach to restore evergreen forest in the park, having learnt about how this concept had been used in Australia (see **Box 3.1**). An herbarium collection and database of the local tree flora, established by J. F. Maxwell at the CMU Biology Department Herbarium (Maxwell & Elliott, 2001), provided an invaluable starting point, as well as a species identification service and information on the distribution of indigenous tree species.

The unit established an office and a research nursery at the park's former headquarters compound, near intact examples of the target forest types. There, a phenology study determined optimal seed collection times and provided opportunities for regular seed collection.

Experiments in the nursery developed methods for the production of containerised trees of a size suitable for planting by the optimum planting date, which is mid-June in the seasonally dry climate of northern Thailand. Germination trials (Singpetch, 2002; Kopachon, 1995), seed storage experiments and seedling growth trials (Zangkum, 1998; Jitlam, 2001) were used to develop species production schedules (see **Section 6.6**). The research facility was also used by CMU research students, who tackled more detailed research on propagation from cuttings (Vongkamjan *et al*., 2002; see **Box 6.6**), the use of wildlings (Kuarak, 2002; see **Box 6.4**) and the role of mycorrhizas (Nandakwang *et al*., 2008).

Every rainy season since 1997, experimental plots, ranging in size from 1.4 to 3.2 ha have been planted with varied combinations of 20–30 candidate framework tree species to: i) assess the potential of planted tree species to perform as framework species; ii) test tree species' responses to silvicultural treatments designed to maximise field performance; and iii) assess biodiversity recovery.

Field trials tested various silvicultural treatments, including fertiliser application, weeding and mulching. Cardboard mulch mats were particularly effective in dry, degraded sites.

The plots were established in close co-operation with the people of Ban Mae Sa Mai village (see **Box 8.1**). This partnership with a local community provided FORRU-CMU with three important resources: i) a source of indigenous knowledge; ii) an opportunity for local people to test the practicability of research results; and iii) a supply of local labour. At the request of the villagers, FORRU-CMU funded the construction of a community tree nursery in the village and trained villagers in basic tree propagation methods and nursery management. The villagers now sell native forest tree seedlings to other restoration projects.

The output of the project was an effective procedure that can be used to restore rapidly lower montane evergreen in northern Thailand. The best-performing framework tree species were identified (Elliott *et al*., 2003) and optimal silvicultural treatments determined (Elliott *et al*., 2000; FORRU, 2006). Canopy closure can now be achieved within 3 years after planting (with a planting

In experimental plots, all trees are tagged and measured 2–3 times each year: height, root-collar diameter and crown width are recorded each time. This has resulted in a large database containing information on the field performance of native forest tree species, and has allowed those that function as framework tree species to be identified.

School children from all over the world now visit FORRU-CMU's nursery and field plots to learn forest restoration techniques.

density of 3,100 trees per hectare). Rapid biodiversity recovery was also achieved. Sinhaseni (2008) reported that 73 non-planted trees species re-colonised the plots within 8–9 years. When combined with the 57 planted framework tree species, the total tree species richness in the sampled plots amounted to 130 (85% of the tree flora of the target evergreen forest). The species richness of the bird community increased from about 30 before planting to 88 after 6 years, including 54% of the species found in the target forest (Toktang, 2005).

The techniques developed were published in a user-friendly, practitioner's guide entitled "How to Plant a Forest", in both Thai and English (FORRU, 2006), and subsequently translated into five other regional languages. The project also resulted in a set of protocols that could be applied by researchers in other tropical regions to develop techniques for the restoration of any tropical forest type, taking into account the indigenous tree flora and local climatic and socio-economic conditions. These were published in a manual for researchers, entitled "Research for Restoring Tropical Forest Ecosystems" (FORRU, 2008), also in several languages. Both books can be downloaded free from www.forru.org. These manuals have subsequently been used to replicate the FORRU concept in the restoration of other forest types, largely with the support of the UK's Darwin Initiative: in southern Thailand (http://darwin.defra.gov.uk/project/13030/), China (http://darwin.defra.gov.uk/project/14010/) and Cambodia (http://darwin.defra.gov.uk/project/EIDPO026/).

The most important output of the project was a set of techniques for the restoration of evergreen tropical forest on abandoned agricultural fields at altitudes greater than 1,000 m above sea level. Eight and a half years after planting 29 framework species, weeds were eliminated, humus had accumulated, a multi-level canopy had developed and biodiversity recovery was well underway.