CONSERVATION OF TREES THROUGH USE BY LOCAL PEOPLE AND DECENTRALIZED SEED DISTRIBUTION SUPPORTED BY A TREE SEED PROGRAMME

J.-P. Barnekow Lillesø[1]
Danida Forest Seed Centre, Humlebaek, Denmark

L. P. Dhakal
Tree Improvement and Silviculture Component, Natural Resources Management Sector Assistance Programme, Kathmandu, Nepal

E. D. Kjaer, I. Nathan
Danida Forest Seed Centre, Humlebaek, Denmark

&

R. Shrestha
Tree Improvement and Silviculture Component, Natural Resources Management Sector Assistance Programme, Kathmandu, Nepal

Introduction

This paper focuses on the integration of ‘conservation of forest genetic resources’ with ‘development aimed at local people’, and the potential role of seed centres in conserving useful tree species. It is based on an earlier paper by Kjaer and Nathan (2000). The objective of the paper is to suggest how tree seed centres can contribute to conserving and domesticating tree species which would otherwise fall between conservation in national parks and industrial tree improvement programmes. This paper does not give an exhaustive account either of measures to conserve tree genetic resources or of models for integrated conservation and development.

Deforestation and frontier forests

Eighty percent of the forests that originally covered the earth have been cleared, fragmented or otherwise degraded. Those that remain are found in only a few places, mainly in the Amazon Basin, Central Africa, Canada and Russia (WRI 2001). The World Resources Institute (WRI) has described the remaining large and intact forest ecosystems as ‘frontier forests’. These forests are remote and large enough to maintain all of their biodiversity, including viable populations of the wide-ranging species associated with each forest type (WRI 2001).

Globally, tropical deforestation is estimated at 12.6 million hectares per year, or 0.7% of the total forested area (FAO 1997). The depletion and degradation of existing forests and woodlands are major causes of concern. One of the main reasons for this concern is that deforestation and forest degradation dramatically reduce our present and future options for using forests.

[1] Conservation Officer, Danida Forest Seed Centre, Krogerupvej 21, 3050 Humlebaek, Denmark, Tel: +45-49-190 500, Fax: +45-49-160 258, E-mail: qjp@sns.dk.

Remaining frontier forests can be categorized by the degree of threat they face. In threatened frontier forests, human activities such as logging, agricultural clearing and mining are degrading ecosystems. Low-threat, potentially vulnerable frontier forests are not considered under pressure from degradation. However, because they are unprotected and contain valuable natural resources, or because human encroachment is likely, most of these forests are vulnerable to future degradation and destruction. Non-frontier forests are dominated by secondary forests, plantations, degraded forest and smaller patches of primary forest. Such forests are a high priority for conservation and also provide a wide range of economic goods and services. Little frontier forest is left in Southeast Asia, and most of what remains is under threat (Figure 1 and Table 1).

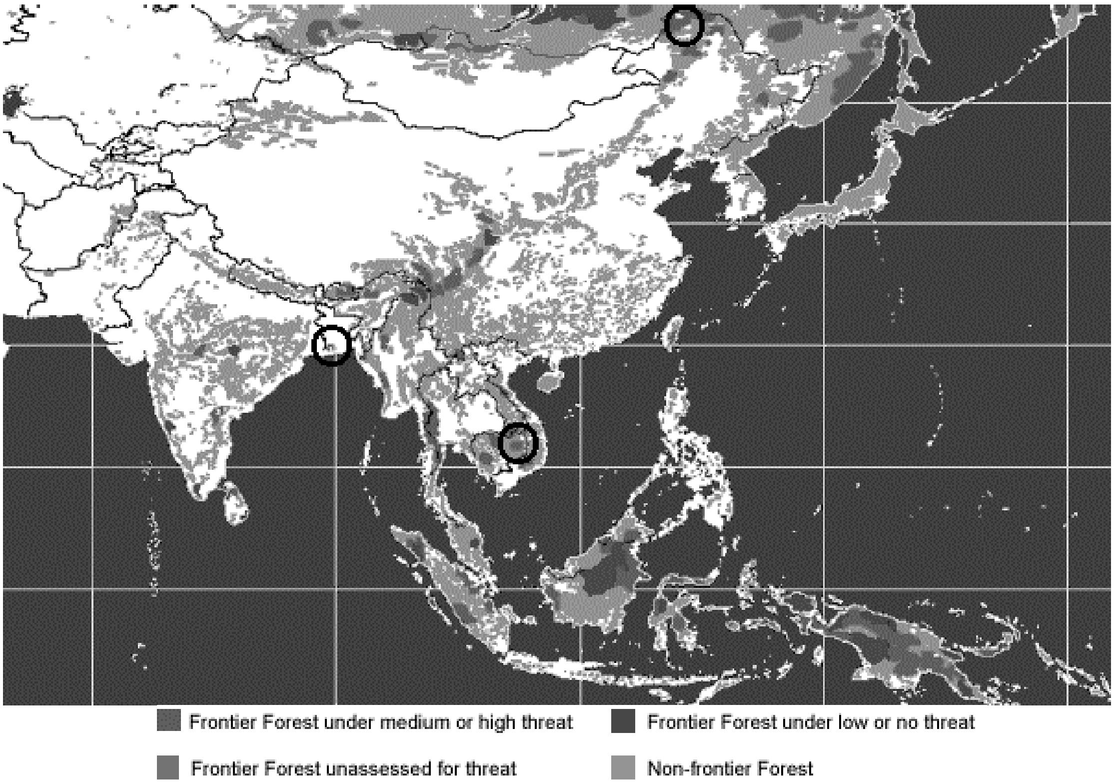

Figure 1. *Frontier forests in Asia. Source: WRI (2001). Circles indicate frontier forests highlighted by WRI: Ratanakiri Province, Cambodia; Sundarbans, Bangladesh and India; and North Heilongjiang Province, China. Note: a colour version of this map can be found at http://www.igc.org/wri/ffi/maps/asia.htm*

Table 1. *Frontier forests in selected Southeast Asian countries. Source: WRI (2001).*

	Frontier forest lost (%)	Frontier forest threatened (%)
Lost It All		
Philippines	–	–
On The Edge		
Lao PDR	98	100
Thailand	95	100
Vietnam	98	100
Not Much Time		
Myanmar	94	56
Cambodia	90	100
Indonesia	72	54
Malaysia	85	48

Conservation approaches

As a result of continued forest loss, approaches to conservation have changed from 'pure conservation' (usually in national parks) to 'conservation through use' (for example see FAO 1975). Creating national parks to preserve whole ecosystems represents the pure conservation approach. Pure conservation is necessary if populations of large animals and intricate food webs are to be maintained (Bawa 1994; Soule & Terborgh 1999). As Figure 1 demonstrates, it is well justified.

Kjaer and Nathan (2000) discussed three different approaches or models for integrating conservation and development:

i) Prevent the use of natural resources (the 'hands-off' model); combine with buffer zone compensation for local communities.
ii) Reduce the use of natural resources in a manner compatible with both conservation and development objectives (the 'sustainable harvest' model). Resources will be protected by regulating their use in a genetically sustainable manner.
iii) Increase the use of valuable genetic resources, thereby conserving them (the 'use it or lose it' model). Planting valuable species or seed sources in forest areas or on farmland can both improve access to their products for rural people and raise their conservation status.

Our concern in this paper is with the third approach—'use it or lose it'—because the livelihoods of millions of rural people in tropical countries depend on access to products and services from trees and forests. These people are now forced to live in the fragmented landscapes of non-frontier forests, from which they obtain products such as timber, building materials, fuelwood, food, medicine, fodder and important services such as shade, shelter, erosion control, watershed protection and soil enrichment. When forests and trees disappear, rural people lose a vital source of livelihood.

Biodiversity of species in use

Biodiversity consists of variation at many levels—diversity between ecosystems, species and genes (CBD 1992). A loss of diversity at any of these levels means a loss of options for future use. Many species used by local people in non-frontier forests are not protected by the formal national parks system (see Graudal *et al*. 1999), and are often underutilized in the sense that their full potential is not recognized nor conserved.

Trees are genetically diverse organisms. In many tree species, substantial genetic differentiation is found between populations and between single trees within populations (Mouna 1990). Better growth, quality and adaptability can be achieved, therefore, through careful selection of the best seed sources when raising seedlings for a given planting purpose.

The selection of superior individuals (genetic improvement) can increase the productivity of trees considerably (for example see Foster *et al*. 1995 and Graudal & Kjaer 2000). Improvements—even marginal improvements—in the survival rate and productivity of trees will often be of particular importance to subsistence farmers or other tree planters. Selection, however, requires the presence of genetic diversity (Namkoong *et al*. 1988). In this sense, a loss of biodiversity reduces the options for future use.

Similarly, genetic variation within and between species is important to the long-term natural adaptation of species (Falk & Holsinger 1991). Populations under stress may respond through natural selection, but only if genetic variation exists with regard to breeding fitness (Fisher 1958). Within species, low levels of genetic diversity can lead to inbreeding depression and affect growth, survival and adaptation (Kjaer 1997). At the level of ecosystems, species compete and interact constantly. Rapid co-adaptation and development, therefore, are necessary for any species to avoid extinction in the long run (Van Valen 1973). In this sense, too, conservation of biodiversity is important for preserving future options.

Conservation of trees and biodiversity is thus important to development at local and national levels. Conservation and development are linked further in that successful conservation often requires integration with short-term benefits for local people.

The need to protect and conserve natural resources in tandem with social and economic development has been widely acknowledged. It is the experience of the Danida Forest Seed Centre (DFSC) that development and conservation efforts can be improved by integrating conservation with short-term benefits for local users of natural resources. It is also DFSC's experience that conservation and development for people have rarely been integrated fully in the past. A need still exists, therefore, to discuss different ways of integration.

Efforts to conserve forest genetic resources usually begin after a threat to these resources is identified. The nature of such threats, and the options for conservation, both institutional and social, will vary from place to place. The availability of trained staff and financial resources are other critical factors to consider when implementing conservation plans in the field (for example see Graudal *et al*. 1997 and Thomson *et al*. 2001). Conservation strategies and techniques should be selected on the basis of a careful assessment of the context.

Increased use

Tree species often become rare and endangered because they provide valuable wood or non-wood products, and consequently are much sought after. In such cases, one option could be to *increase* the use of the endangered tree species. Increased use of genetic resources in terms of planting in forest areas, watershed areas, degraded areas and, not least, farms, can be a very efficient way of protecting valuable genetic resources. Cultivation of a valuable but endangered tree species can result in the multiplication and distribution of its germplasm. Moreover, planting and using a rare species can often reduce exploitation pressures on its natural populations. From the point of view of rural people, the clear advantage of this model is that cultivation of threatened high-value species can help to meet local needs for tree products and services, or for cash income.

The 'increased use' model can also be effective for tree species with less valuable products. It can be used in planting programmes for land rehabilitation or watershed management. Local species may be suited to such purposes because they have adapted to local conditions and so carry less risk of die-back due to biotic or abiotic factors. Moreover, they will often be suited to mixed species plantations where future management can be reduced to a minimum.

Like other models, the 'use it or lose it' approach has a range of problems. These relate to the genetic resource as well as to people. From a purely genetic perspective, the model involves a series of processes that can (though not do not necessarily) have implications for genetic diversity. Many random as well as intended selections take place during seed collection, seed production, planting, tending and harvesting (El-Kassaby & Namkoong 1997). Hybridization between species can also be a problem. Genetic diversity can be reduced if seed is collected only from a few easily accessible trees (Simons 1996). Seeds may also be moved around different ecological zones without keeping records of their origin. Using a plant species, therefore, is *not a guarantee* of protection of its genetic resources. Any usage must be based on genetically sound principles, otherwise domestication could deplete the genetic resource and lead to a situation where conservation measures are needed simply to avoid the negative effects of domestication.

Provided that genetic considerations are taken into account, genetic diversity can be protected effectively within domesticated plantings (see Namkoong 1984). Other constraints to overcome are mainly technical in nature. Valuable tree species are sometimes not planted because farmers do not have access to their germplasm. A practical solution to this problem could be to mobilize the genepool (for example by establishing locally available seed sources). Another solution could involve improved methods for collecting and handling seed[2]. If the problem concerns marketing of a product, then support for storage, transport or trade may be useful (see Hansen and Kjaer (1999) for a more detailed discussion of technical constraints and options).

In Southeast Asia, two valuable timber species that have been heavily exploited in natural stands and are now being recognized for their planting potential are *Dalbergia cochinchinensis* and *Chukrasia tabularis*.

D. cochinchinensis is one of the indigenous priority species identified by the Danida-supported Indochina Tree Seed Programme (ITSP). ITSP, in collaboration with the Lao Department of Forestry, has incorporated this species into planting programmes in Lao PDR in a number of different ways. The wood is extremely valuable, and its value per unit area far exceeds that of fast-growing eucalypts or *Acacia mangium* (often by a factor of ten). Planting *D. cochinchinensis* as an alternative to eucalyptus can thus both provide greater income and protect the genetic resources of the species. In order to provide access to the germplasm, ITSP supports identification of good seed sources and provides support to genetically broad seed collections from natural populations in collaboration with provincial authorities. Part of the seed is reserved for plantings that will serve as seed sources for future commercial seed procurement (Thomsen 2000). Such plantings may form the basis for future domestication of the species across large areas of the country. It is important, therefore, that at this initial stage seeds are *not* collected from a few random trees.

C. tabularis/velutina is another valuable timber species distributed throughout Southeast Asia. The species is now being investigated by a collaborative project between CSIRO (Australia) and Vietnam, Thailand, Lao PDR and Malaysia (A. Kalingare pers. comm.; Thomson, Midgley, Pinyopusarek & Kalinganire in these proceedings). Eco-geographic surveys have been made in Lao PDR, Malaysia, Thailand and Vietnam, and provenance tests have been established in Australia, Lao PDR, Malaysia, Sri Lanka, Thailand and Vietnam (Kalinganire & Pinyopusarerk 2000).

Compared with the total number of tree species in the region, the number of species currently under a formal domestication programme is low. It is unlikely that forestry departments or tree seed centres in the region will have the capacity to launch formal domestication programmes for large numbers of tree species.

[2] A large number of tropical species have recalcitrant seeds, which means that the seed must be handled with care and is difficult to store. Germination capacity is often lost within days (Schmidt 2000).

It may be possible, however, to conserve many species by using more informal seed source establishment and seed distribution programmes, which rely less on direct intervention by government staff and more on collaboration between seed centres and local people. Such programmes should be based on sound genetic principles and a decentralized structure that empowers local seed supply organizations and seed source owners.

Decentralized establishment of seed sources and seed distribution—an example from Nepal

The importance and rarity of the most-valued fodder species

In Nepal, Danida is supporting the Tree Improvement and Silviculture Component (TISC) of a larger sectoral programme, the Natural Resources Management Sector Assistance Programme. One of the main objectives of TISC is to organize the distribution of seed of indigenous tree species to farmers.

Livestock malnutrition is a major constraint to agricultural development in Nepal, and tree fodder is an indispensable part of the livestock system. Tree fodder is thus an important tree product in Nepal, and holds a special key to poverty alleviation. The most highly valued fodder tree species are now rare in natural forests, and survive mainly on private farmland (Table 2). In much of Nepal, therefore, community management of natural forests does not provide the quantity and quality of leaf fodder that would otherwise be expected from Nepal's indigenous species. Similarly, on private land, few agencies are working to provide farmers with access to improved material. Extension services for fodder trees and the diffusion of species among farmers are limited. Furthermore, it is likely that inbreeding reduces the efficiency of tree fodder production on private farmland (Lillesø *et al*. 2001a).

Table 2. *Frequency of species in Nepal's national forest inventory. The inventory recorded 266 species. Source: Data were kindly made available by the Director General, Department of Forest Research and Survey, Kathmandu.*

Two most common species	**Percentage of all stems**
Shorea robusta	16
Quercus sp.	10
Fodder species	
Total 24 highly valued fodder species	4

In terms of biomass, fodder is one of the most heavily used tree and forest products in Nepal. The species used for fodder should appear in a forest inventory if they are contributing substantially to fodder production. What is interesting, however, is that only a few of the most highly valued fodder species actually appear in the national forest inventory (see Table 2 above).

A total of 266 species (including unidentified species) in 545 plots were registered in the inventory. The two most common species and genera are *Shorea robusta* (sal) from the upper tropical zone and *Quercus* spp. from the temperate (and alpine) zone. Both *S. robusta* and *Quercus* spp. are dominant members of particular forest types and their commonness is to be expected.

The 24 most highly valued fodder species together account for about 4% of the stems recorded in the plots. This finding runs counter to the fact that fodder tree leaves, in terms of biomass, are the most important products from the accessible forests of Nepal. The two most obvious explanations for this discrepancy are:

i) Fodder from forests generally does not come from the most highly valued tree species because these are rare in natural forests.
ii) A large volume of fodder does in fact come from private land (farmland trees).

Given the intense exploitation pressure on forests in Nepal, it is probable that many of the most heavily used (most highly valued) species have become rare in accessible forests. Furthermore, it is likely that fodder species still survive on private farmland, where they are tended by landowners[3]. This scenario raises two new questions:

i) What is the actual and potential productivity of farmland fodder species? If farmers are moving wildlings around their land and tending natural regeneration, it is likely that the trees are inbred and that even simple domestication measures (such as bringing together unrelated individuals in seed orchards) could increase production significantly within a few years, and that more intensive selection could raise production even further.

ii) What is the conservation status of these species? Given the lack of seed distribution mechanisms for the most highly valued fodder species (Dhakal & Lillesø 2000; Dhakal *et al*. 2001; Lillesø *et al*. 2001a), and the highly diverse ecological conditions in Nepal, it is likely that populations adapted to different parts of the species' environmental range are becoming extinct locally (and that maladapted populations may be used in their place).

Conservation through use

TISC has prepared a nationwide vegetation map (Shrestha *et al*. 2001) that provides the best understanding so far of the ecology of Nepal, and has prepared planting zones in the most densely populated ecological zones for use in a decentralized seed distribution system (Lillesø *et al*. 2001b). The distribution of individual tree species across planting zones can be estimated and seed sources planned accordingly (Figure 2 is an example of a distribution map across ecological zones).

[3] Not only fodder trees but also several fruit tree species may be rare in natural forests. For example, lapsi (*Choerospondias axillaris*) was not registered in the national forest inventory, though it does appear in the botanical checklist compiled in the same survey.

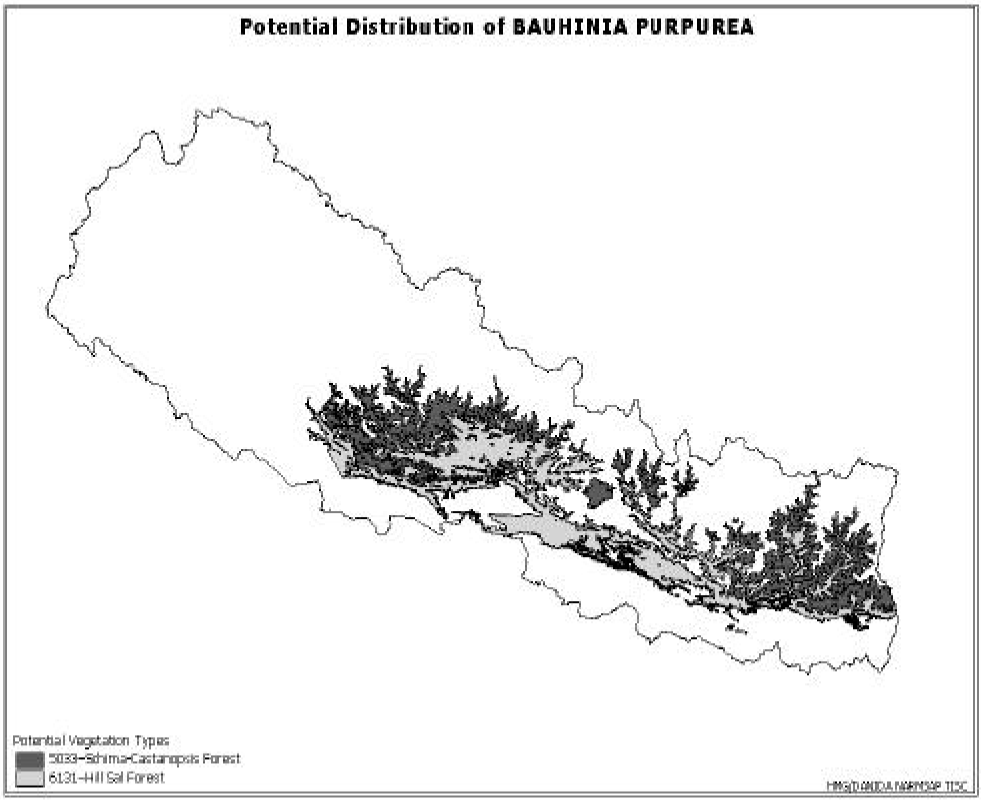

***Figure 2**. Potential distribution and planting sites for Bauhinia purpurea in Nepal*

A substantial number of fodder species are being planted, but many 'new'[4] species cannot be used by farmers because they are not available on the market. This situation is often represented—inaccurately—as a lack of demand for new fodder seeds. In fact, bringing 'new' fodder species onto the market would be the only test of such demand. The market in fodder seeds is distorted because alternatives are not available and cannot tested for their acceptance by tree growers (Dhakal *et al*. 2001).

TISC expects decentralized entities such as farmers' associations or seed cooperatives to be the main tool for distributing tree seed (two seed cooperatives are already functioning and more are expected to follow), and will support the introduction of 'new' species. The objectives of the seed cooperatives will be: i) to collect and supply seeds of known origin and broad genetic base to a transparent market; and ii) to conserve the gene resource base of economically important farmland tree species and improve the desired traits of these species (Dhakal *et al*. 2001).

The five main aspects of the programme are as follows (Dhakal *et al*. 2001):

i) Seed sources should be established in each of the relevant zones in the tree planting zoning system. This system has been established to represent environmental variation in the country. It attempts to minimize genotype by environment (GxE) interactions between seed sources and planting sites.

ii) A relatively large number of species will be distributed through the system[5].

[4] Fodder species known for their benefits but not available on the market because of difficulties in supply or because they are believed to be endangered or extinct in a particular farming landscape.

[5] See Appendix 1 for a preliminary list of species.

iii) The domestication intensity for individual species should reflect the demand for the species. Intensities will range from farmland seed sources to the establishment of different types of breeding seedling orchards.

iv) The process should be demand-driven and decentralized, led by local farmers' associations or seed cooperatives.

v) TISC will provide technical assistance for seed source establishment, seed handling and networking.

The main areas in which TISC will support the seed cooperatives are:

- Species-site matching (seed zoning system);
- Establishment, registration and certification of seed sources of the best fodder species;
- Assistance to organize seed collection and provision of technical advice;
- General extension and awareness raising on the use of quality seeds; and
- Creation of a forum for production and sale of seed. This will involve:
  - Marketing species and seed stands;
  - Creating a network for sale and purchase of seed; and
  - Extension and raising awareness on the use of quality seeds.

The current status of fodder species on farmland in Nepal is largely unknown, but a clearer picture is expected to emerge through the networking of the seed cooperatives. Through the use of fodder species (and from an evaluation of indigenous knowledge on these species), their population structures, flowering and seed production will be analysed.

From a conservation point of view, the decentralized distribution system will ensure the survival of fodder species through use. For poor farmers, the quality and quantity of their fodder production will increase, thereby improving their livelihood. Conservation measures will be carried out for a large number of species simultaneously, but without setting up a network of *ex situ* conservation stands that would have to be maintained by government staff.

Conclusions

There are no simple guidelines for conservation. In this paper, we have discussed the model strategy 'use it or loose it', and have presented an example from Nepal in which this strategy is being implemented.

Other models and strategies exist, but have not been mentioned here. In our experience, strategies based on integrated conservation and development are the most promising in terms of both conservation of a large number of valuable species and local economic development.

The focus of this paper should not distract attention from the importance of selecting models and strategies based on careful assessments of social and ecological contexts. Different models of conservation can often complement each other. For example, a large number of species cannot be protected by planting schemes either because they cannot be cultivated or because they cannot meet the needs of rural communities. Such species will require protection in a network of protected areas (model 1) or managed areas (model 2), or a completely different model, depending on what is technically and socially feasible and appropriate.

Nevertheless, we maintain that, compared with the hands-off and sustainable harvest models, the 'increased use model' receives less attention than it deserves. This is true in theory as well as in practice. Moreover, as the example in this paper illustrates, true integration of conservation and development objectives will remain a challenge whatever model is selected.

References

Bawa, K. (1994) Effects of deforestation and forest fragmentation on genetic diversity in tropical tree populations. In Drysdale, R. M., John, S. E. T. & Yapa, A. C. (eds.), *Proceedings of International Symposium on Genetic Conservation and Production of Tropical Forest Tree Seed, 14–16 June 1993, Chiang Mai, Thailand*. ASEAN-Canada Forest Tree Seed Centre, Muak Lek.

CBD (1992) *United Nations Convention on Biological Diversity. Basic Text*. Secretariat of the Convention of Biological Diversity, Montreal.

Dhakal, L. P. & Lillesø, J. P. B. (2000) *Fodder domestication issues and use of potential vegetation map in increasing fodder production in the Mid-hills of Nepal*. Paper presented at National Workshop on Improved Strategies for Identifying and Addressing Fodder Deficits in the Mid-hills of Nepal, 5–6 September 2000, Kathmandu, Nepal.

Dhakal, L. P., Lillesø, J. P. B., Jha, P. K., Aryal, H. L. & Kjaer, E. D. (2001) *Addressing small holders demand for propagation material of woody species. Vol. II: Part II: Elements of an operational programme.* HMG/Danida Tree Improvement and Silviculture Component and Danida Tree Seed Centre, Humlebaek.

El-Kassaby, Y. A. & Namkoong, G. (1997) *Genetic Diversity of Forest Tree Plantations: Consequences of Domestication*. Proceedings of IUFRO World Conference, Tampere, Finland, 1997.

Falk, D. A. & Holsinger, K. E. (eds.) (1991) *Genetics and Conservation of Rare Plants.* Oxford University Press, Oxford.

FAO (1975) *The methodology of conservation of forest genetic resources. Report on a pilot study*. Food and Agriculture Organization of the United Nations, Rome.

FAO (1997) *State of the World's Forests.* Food and Agriculture Organization of the United Nations, Rome.

Fisher, R. A. (1958) *The Genetical Theory of Natural Selection*. Dover Publications, New York.

Foster, G. S., Jones, N. & Kjaer, E. D. (1995) Economics of tree improvement in development projects in the tropics. In Shen, S. & Contreras-Hermosilla, A. (eds.), *Environmental and economic issues in forestry: Selected case studies in Asia*. World Bank Technical Paper No. 281, The World Bank, Washington, DC.

Graudal, L. & Kjaer, E. D. (2000) *Can national tree seed programmes generate economic, social and/or environmental benefits to cover their costs? Considerations on economics, sustainability and challenges ahead for tree seed centres in tropical countries*. A presentation given at the SAFORGEN Regional Training Workshop on the Conservation and Sustainable Use of Forest Genetic Resources in Eastern and Southern Africa, Nairobi, Kenya, December 1999. http//www.dfsc.dk.

Graudal, L., Kjaer, E. D., Suangtho, V., Saardavut, P. & Kaosa-ard, A. (1999) *Conservation of genetic resources of teak (Tectona grandis) in Thailand*. Royal Forest Department, Bangkok and Danida Forest Seed Centre. Technical Note No. 51, Danida Forest Seed Centre, Humlebaek.

Graudal, L., Kjaer, E. D., Thomsen, A. & Larsen, A. B. (1997) *Planning national programmes for conservation of forest genetic resources*. Technical Note No. 48, Danida Forest Seed Centre, Humlebaek.

Hansen, C. P. & Kjaer, E. D. (1999) *Appropriate planting material in tree plantings: opportunities and critical factors*. In Proceedings of International Experts Meeting on the Role of Planted Forests in Sustainable Forest Management, 6–10 April 1999, Santiago, Chile.

Kalinganire, A. & Pinyopusarerk, K. (2000) *Chukrasia: Biology, Cultivation and Utilization*. Technical Report TR49, ACIAR Publications, Victoria.

Kjaer, E. D. (1997) *Sustainable Use of Forest Genetic Resources*. The Arboretum/Danida Forest Seed Centre, Humlebaek.

Kjaer, E. D. & Nathan, I. (2000) *Three approaches for integrating conservation and development. A presentation and discussion based on the experience of Danida Forest Seed Centre (DFSC) within forest gene conservation*. http://www.dfsc.dk/publications.htm.

Lillesø, J-P. B., Dhakal, L. P., Jha, P. K. & Aryal, H. L. (2001a) *Addressing small holders demand for propagation material of woody species. Part I: Analysis and Strategy proposal*. HMG/Danida Tree Improvement and Silviculture Component and Danida Tree Seed Centre, Humlebaek.

Lillesø, J.-P. B., Dhakal, L. P., Shrestha, T. B., Nayaju, R. P., Shrestha, R. & Kjaer, E. D. (2001b). *Tree Planting zones in Nepal*. HMG/Danida Tree Improvement and Silviculture Component and Danida Tree Seed Centre, Humlebaek.

Muona, O. (1990) Population Genetics in Forest Tree Improvement. In Brown, A. H. D., Clegg, M. T., Kahler, A. L. & Weir, B. S. (eds.), *Plant Population Genetics, Breeding and Genetic Resources*. Sinauer Associates, Massachusetts.

Namkoong, G. (1984) Strategies for gene conservation in forest tree breeding. In Yeatman, C. W., Kafton, D. & Wilkes, G. (eds.), *Plant Gene Resources: A Conservation Imperative*. Westview Press, Boulder.

Namkoong, G., Kang, H. C. & Brouard, J. S. (1988) *Tree breeding: principles and concepts*. Springer Verlag, Berlin.

Shrestha, T. B. *et al*. (2001) *Overview of the Elaboration of Iso-potential Forest Type/Ecological Zone Map and Species Database*. HMG/Danida NARMSAP/TISC, Kathmandu.

Simons, A. J. (1996) Delivery of improvement for agroforestry trees. In Dieters, M. J., Matheson, A. C., Nikles, D. G., Harwood, C. E. & Walker, S. M. (eds.), *Tree*

Improvement for Sustainable Tropical Forestry. Proceedings of QFRI-IUFRO Conference, 27 October–1 November 1996, Caloundra, Australia.

Soule, M. E. & Terborgh, J. (eds.) (1999) *Continental Conservation: Scientific Foundations of Regional Reserve Networks*. Island Press, Washington, DC.

Thomsen, A. (2000) *Integrated tree seed supply strategy for Lao PDR*. Draft report from technical consultancy. Lao Tree Seed Project/Danida Forest Seed Centre, Indochina Tree Seed Programme.

Thomson, L., Isager, L. & Theilade, I. (2001) Management of protected areas. In *Guidelines to conservation of forest genetic resources. Part 2*. Danida Forest Seed Centre, FAO, IPGRI. In press.

Van Valen, L. (1973) A new evolutionary theory. *Evolutionary Theory* **1**: 1–30.

WRI (2001) *World Resources Institute Forest Frontiers Initiative*. http://www.wri.org/wri/.

***Appendix 1**. Priority species for the decentralized seed distribution and species conservation system in Nepal*

Farmland species	Natural forest species
Mainly fodder:	Mainly timber:
Albizia lebbeck	*Alnus nepalensis*
Albizia procera	*Anthocephalus chinensis*
Artocarpus lakoocha	*Celtis australis*
Bauhinia purpurea	*Cordia dichotoma*
Bauhinia variegata	*Dalbergia latifolia*
Brassaiopsis glomerulata	*Dalbergia sissoo*
Brassaiopis hainla	*Garuga pinnata*
Bridelia retusa	*Gmelina arborea*
Celtis australis	*Michelia champaca*
Ficus auriculata	*Michelia kisopa*
Ficus glaberrima	*Pinus roxburghii*
Ficus hispida	*Prunus cerasoides*
Ficus lacor	*Pterocarpus marsupium*
Ficus neriifolia	*Toona ciliata*
Ficus semicordata	
Ficus subincisa	Mainly non-timber:
Garuga pinnata	*Cinnamomum tamala*
Grewia optiva	
Litsea monopetala	
Premna interrupta	
Prunus cerasoides	
Saurauia napaulensis	
Mainly fruit:	
Aesandra butyracea	
Choerospondias axillaris	