THE USE OF SECONDARY FOREST SPECIES IN REHABILITATION OF DEGRADED FOREST LANDS

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KARTAWINATA, K. 1994. The use of secondary forest species in rehabilitation of degraded forest lands. Extensive and expanding areas of degraded lands, including degraded forest lands, occur in Southeast Asia. Rehabilitation programmes are integral to development programmes in the region, although the rate of deforestation is outpacing that of rehabilitation. This paper reviews methods of rehabilitation using secondary forest species. Assisted natural regeneration, a method of reforestation which exploits the natural processes of vegetation recovery, is a potentially rapid, efficient, and cost-effective means of reforestation. Several community reforestation strategies are also outlined. Directions for future research and the need for information reviews are indicated.

Key words: Rehabilitation - degraded lands - Southeast Asia - secondary forest - reforestation

KARTAWINATA, K. 1994. Kegunaan spesies hutan sekunder dalam pemulihan tanah hutan ternyahgred. Tanah ternyahgred yang luas dan sedang berkembang termasuk hutan ternyahgred terdapat di Asia Tenggara. Program-program pemulihan penting untuk program pembangunan dalam rantau ini, walaupun kadar pembasmian hutan melebihi kadar pemulihan. Kertas kerja ini mengulas kaedah-kaedah pemulihan yang menggunakan spesies hutan sekunder. Pemulihan semulajadi yang pesat, iaitu satu kaedah penghutanan semula yang mengeksploitasi proses semulajadi pemulihan tumbuh-tumbuhan ialah satu cara penghutanan semula yang berpotensi pantas, efisien dan berkesan kos. Beberapa strategi perhutanan semula juga digariskan. Haluan untuk penyelidikan masa hadapan dan keperluan untuk mengulas informasi ditunjukkan.

Introduction

Degraded lands, including degraded forest lands, occur in large areas in Southeast Asia and will continue to expand in the coming years. The FAO estimate of the annual rate of deforestation was 880 000 hectares during the period of 1976-1980 (FAO 1980). In Indonesia it is estimated to be between 700 and 1314 hectares annually. Deforestation has taken place mainly in production and conversion forests (Sutter 1989). This has led to the formation of disturbed forests of different degrees of degradation and in some cases to completely degraded lands. By 1987 the total area of deforested lands, including secondary forests, grasslands and

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degraded lands in Indonesia was about 33 million hectares, while the logged-over forest was 28.3 million hectares (Sutter 1989). About 49% of the area deforested annually in tropical Asia is attributed to shifting cultivation (Lanly 1982), and is frequently associated with logging and logging roads. The association of logging and subsequent clearing is especially strong in the lowland dipterocarp forests in insular Southeast Asia, particularly Sumatra, Borneo and the Philippines, which are richer in commercially valuable species and hence are more intensively logged than other tropical rain forests. Pressure on the remaining forest resources is aggravated by the rapid increase of population.

The rehabilitation of deforested lands is a matter of economic and social importance (Lovejoy 1985). Rehabilitation would not only provide useful productive land but it would also serve to reduce the pressure on remaining primary tropical forests. Various countries have attempted the rehabilitation of deforested lands, although currently the rate of deforestation is outpacing that of rehabilitation.

Rehabilitation through natural succession

At present much degraded land is idle and remains unproductive. Left undisturbed it may slowly revert through natural succession to forests similar to the original. Thus nature can recuperate if there is no indiscriminate human interference. The rate of succession depends, however, on the degree, intensity and frequency of disturbance, as well as on climate, habitat type and presence of propagules in the surrounding areas of degraded lands. The more severe the destruction the slower the rate of recovery. Although degraded forest ecosystems do recover, the recovery takes a long time. In Kalimantan (Riswan 1982) and Puerto Rico (Lugo 1988) it takes 30 years or more for soil organic matter to return to pre-disturbance levels, and about 30-60 years before sizeable economically useful native trees appear in the forest. A secondary forest developed from an abandoned pepper plantation within an East Kalimantan primary forest, for instance, was in no way similar in species composition to the original and neighbouring forests, 35 years after its abandonment (Riswan & Kartawinata 1989) but was instead dominated by fast-growing species not present in the original forest. It is estimated that the site will take 250-500 years to return to conditions similar to the original forest. Severe and extensive destruction leads to the formation of vast areas of *Imperata* grasslands, which take a very long time to return or may never return to forests. This is due to either the absence of seeds or the great distance to seed sources, and also because of the repeated occurrence of fire, which stimulates the growth of the grass.

Lugo (1988) reviewed and addressed some of the issues in the rehabilitation of the degraded forest ecosystems in the humid tropics and concluded that the key strategy for tropical forest rehabilitation is the use of natural processes and natural subsidies as far as possible. He stressed that ecosystem rehabilitation involves the management of succession, which is the direction and speed of change involving all components of ecosystems including vegetation, soils, animals, and microbes.

Through ecosystem rehabilitation, conversion of degraded lands to productive lands can be attempted. In this case successional processes could be manipulated to make the end product of the successional change useful. He further emphasised, however, that the end product of the successional change is uncertain in terms of species composition, hence the need for flexibility in determining the objective of a rehabilitation project. The goal should be sustainable forest productivity, with species composition a secondary nature (Lugo 1988). An objective to obtain useable forest products will require one group of species, but if the purpose is to achieve species diversity instead of certain forest products, a different group of species will be required. At any rate rehabilitation projects should focus on lands whose values to society can be sustainably enhanced through human intervention.

A basic requirement for successful rehabilitation of forest lands is the conservation and restoration of soil organic matter and soil fertility, sufficient supply of genetic materials as well as favourable substrates. In rehabilitating degraded lands the following strategies suggested by Lugo (1988) may be observed:

- Maintain flexibility in the rehabilitation approach
- Be alert to environmental conditions
- Avoid specificity on the ultimate goals of rehabilitation
- Manipulate existing vegetation before attempting substitution
- Use fallow to do most forest rehabilitation
- Restore tree cover as rapidly as possible
- Develop species mixtures based on their "ecological" combining ability
- Use exotic tree species to foster native tree species through site rehabilitation
- Create nuclei of biotic activity from which habitat rehabilitation occurs under the influence of biotic agents, etc.

Accelerated natural regeneration

A method of reforestation exploiting the natural processes of vegetation recovery, known as Assisted (or Accelerated) Natural Regeneration (ANR) has recently been developed and applied in the Philippines, and is a potentially rapid, efficient and cost-effective means to reforest critical watersheds (Dalmacio 1987). With some modifications the application of this method in Indonesia has recently been explored. ANR is "any reforestation method that relies on natural regeneration and has weed-suppression activities" (Drilling 1989). The approach is site specific, but there are nine common steps to identify requirements at each site, in particular in the *Imperata* grasslands rehabilitation programme:

1. Clarification of the objectives
2. Site selection
3. Protection of the area from fire
4. Identification of existing woody plants
5. Inhibition of the grass layer (intervention)
6. Facilitation of the growth of existing woody plants
7. Continued treatment of the grass layer

8. Enrichment planting of desired species
9. Silvicultural treatments of desired species

In the Philippines, the ANR application has reportedly resulted in good regeneration of secondary forest, and ANR is now implemented on a large scale. Application of ANR in Indonesia is expected to have the following benefits: (1) reduction of forest encroachment by landless people, (2) provision of secure economic opportunities for landless people, (3) reduction of the spread of shifting cultivation and pressure on production forests, (4) land reclamation for long-term hardwood production, (5) lower reforestation cost per hectare, (6) reduction of soil erosion, (7) improvement of water quality and ground water storage, (8) increase of biodiversity, and (9) improvement of general environment. Further research on ANR is still needed, particularly concerning (a) identification of multipurpose tree species, (b) documentation of secondary succession, (c) design of suitable agroforestry systems, (d) species and provenance selection trials, (e) changes in soil fertility, (f) enrichment planting, and (g) firebreaks and community fire regulations. In addition, recent changes in forestry policy and governmental concern for international environmental perceptions have led the Indonesian government to consider more community involvement in reforestation. In addition to ANR, several community-reforestation alternatives are available, including (Drilling 1989):

Modified tumpangsari (taungya) system

The conventional *tumpangsari* scheme is an approach to reforestation which allows the local farmers to intercrop for two years, which is the initial maintenance period for the establishment of forest plantations. On the other hand, the modified *tumpangsari* known also as the Full Rotation Agroforestry scheme, allows farmers to intercrop throughout the entire cycle of stand development from planting to final harvest (Bratamihardja 1989). It has been adopted by the Indonesian Forest Corporation (PERHUTANI) and applied in social forestry pilot projects over a variety of agroecosystems and forest types in Java.

Concession holders' plantation strategy for shifting cultivation

This approach was designed for the border encroachment areas of a forest concession, but could also be implemented for tree plantation in *Imperata* grasslands. It involves both local farmers and concession holders in planting fast-growing *Albizia falcataria* with a coffee intercrop on an 11-year rotation, and slow-growing tengkawang *(Shorea stenoptera)* on a 33-year rotation cycle. The scheme involves two shifts of short *Albizia*/coffee crop to the long tengkawang crop at year 12 and 23, hence complete conversion to tengkawang takes place after 33 years. The farmers receive wages and income from coffee harvests and the concession holders obtain their income from *Albizia* and tengkawang. A similar programme has been implemented by the Paper Industries Corporation of the Philippines.

Community managed forest

The scheme involves the participation of the local community in management of local forests, under the guidance of the Ministry of Forestry. The local community is responsible for fire protection, enrichment plantings and silvicultural treatments. Benefits to the community include the right to harvest non-commercial tree species and non-timber products such as rattans, cajuput oil, and bamboo. The government is responsible for providing funds for equipment, nursery operations, and nursery labour.

Community regulated enrichment fallow

This scheme is designed to shorten the fallow period by encouraging shifting cultivators to plant trees and cover crops before abandoning a site, so as to reduce the pressure on the production forest. The shifting cultivators are paid to plant tree seedlings and cover crops. They also receive a second remuneration, depending on plant survival, when they are ready to move. A community nursery is used for growing the tree seedlings and cover crops, which are selected by the community. The government provides operating funds for nursery supervision, planting, and fire protection. The method was recommended for use in Indonesia as early as 1928 (Van Rhijn 1928). A similar scheme has been applied by the Kalahan Education Foundation in Neuva Viscaya, Philippines.

Model forest development units

As outlined by Rodenburg (1985), the programme is a financially autonomous operation for a unit of 100 hectares containing a core zone of primary forest and a surrounding supporting zone consisting of logged-over forest or other disturbed forest in various degrees of degradation. The supporting zone may also include waste lands, secondary forests and plantations. The management costs for the support zone and preservation of the core zone are derived from the revenues from such activities as selective logging, cash crops, rattan production, plantations and game farming.

Contract reforestation projects

These are three-year government projects to reforest degraded grasslands and to improve the sustainability of forest resources. The projects are organised and implemented by private companies or non-governmental organisations (NGOs) with the participation of local community. There are three approaches:

a. The corporate approach. This is designed for areas greater than 500 hectares. Reforestation is implemented through contracts between the national government and private companies.

b. The community approach. In this approach the contract is between the local government and an NGO, and applies to areas of less than 100 hectares.

c. The family approach. The contract is also between the local government and an NGO for an area of up to 100 hectares, which is shared among families with each family receiving 1-5 hectares.

Private companies and NGOs submit project proposals for funding to the government. The criterion for final evaluation at the end of the three-year contract is the survival of 2000 trees per hectare. The local people work with NGOs and receive wages until the government issues a stewardship lease agreement of 3-5 ha per family which allows the family to settle on the public land, and under this agreement a farmer has the right to practise agroforestry for 25 years. The scheme was initiated by the Department of Environment of Natural Resources of the Philippines in 1988. The stewardship lease is the primary incentive for local people to participate. The scheme could also be applied in reforestation programmes in Indonesia.

Community involvement in reforestation is in line with the Tropical Forest Action Plan for Asia and Pacific region (FAO 1989). It is emphasised that a strategy for restoration of degraded areas needs to pay particular attention to tackling problems as part of a whole package of rural development and improvement of productivity of common property resources, simultaneously ensuring access for the lower sections of society whose dependence on common property resources is extremely high.

Research

Guidelines for rehabilitation of degraded tropical forest lands covering barren lands, grasslands, low secondary forests and degraded logged forest were formulated by Lovejoy (1985).

At present few native species are used in rehabilitation. In Indonesia, for instance, the Forest Department lists twenty species, many of which are fast-growing species. The most widely used species in rehabilitation of degraded lands and establishment of timber estates are *Albizia falcataria, Acacia mangium, Eucalyptus urophylla* and *Pinus merkusii*. Although guidelines and methods for the use of native species are available and have been applied in Southeast Asia with some successes and failures, research in this direction is still needed.

Another area of rehabilitation research is the utilisation of pioneer and secondary forest species of economic value (see Table 1). Many such species such as *Cratoxylum arborescens, Duabanga moluccana, Macaranga* spp., *Trema orientalis, Peronema canescens, Pometia pinnata,* and *Cananga odorata* grow in early to old successional communities. *Cratoxylum* has good quality wood and is used by natives of Kalimantan for shingles, and no doubt could be used for other purposes. *Duabanga moluccana* has a potentially exportable timber. In Mt. Tambora in Sumbawa it is a dominant species in natural forest and has been exploited commercially. All species of *Macaranga* have light weight wood, and one species has a specific gravity close to that of balsa wood. It has been reported that the wood of *Macaranga* has suitable characteristics for pulp and paper plantations in

Table 1. Examples of secondary forest species that could be used in the rehabilitation of degraded forest lands

Species	Successional status or longevity	Altitude (m)	Specific gravity	Uses and remarks
TREES:				
Albizia falcataria	short-lived pioneer up to 20 years	0-1600	0.38	Uses: (a) commercial: wood used for veneer, kraft paper, paper, pulp, match sticks; shade tree in coffee and tea plantations. (b) traditional: boxes, indoor light construction, furniture, planks, boats. Remarks: Grows on loamy and clay soils in wet to relatively dry climates; much cultivated in rural areas and now used in large scale commercial timber plantations; young monoculture susceptible to pests and diseases; seeds abundant, staggered germination; N-fixer; intraspecific variations exist (cf. Whitmore 1986).
Anthocephalus chinensis	long-lived pioneer up to > 30 years	0-1000	0.42	Uses: (a) commercial: wood used for planks, paper, boxes, hardboard, match sticks, plywood. (b) traditional: shade tree. Remarks: Leaves contain high N & K. (Riswan 1982). It grows on moist, good textured alluvial soils; seeds abundant, need afterripening after which 95-98 % germination, old seeds germinate best in full sun and fresh ones in shade; several provenances exist; in some countries already used in plantations (Whitmore 1986).
Cratoxylum arborescens	long-lived pioneer up to > 30 years	0-1700	0.47	Uses: (a) commercial: wood for plywood. (b) traditional: construction, shingles. Remarks: Grows on dryland, moist climate, on poor to good soils; other species grow on peat swamps; seeds abundant, germination not known.
Duabanga moluccana	long-lived pioneer up to > 50 years	50 -1200	0.39	Uses: (a) commercial: wood for plywood. (b) traditional: boats, indoor construction. Remarks: It grows on moist sandy and clay soils in the lowlands and mountain slopes; seed properties unknown.

Continued

Table 1 (continued)

Eucalyptus deglupta	long-lived pioneer up to > 50 years	0-1800	0.44	Uses: (a) commercial: wood for plywood, veneer, indoor light construction. (b) traditional: fuelwood, charcoal. Remarks: Grows on volcanic and loamy to sandy well aerated soils in very wet to dry climate; seeds abundant, viable up to four years in cold storage; used in commercial plantations but liable to insect pests.
Macaranga gigantea	long-lived pioneer up to > 30 years	0-1000	0.37	Uses: traditional: wood for planks, boxes, fuelwood; latex for glue; stem bark for tanning and colouring materials, root bark for medicine. Remarks: Leaves contain high N, P, K (Riswan 1982); grows on sandy to loam clay soils in wet open areas; other biological features are unknown.
Octomeles sumatrana	long-lived pioneer up to to > 40 years	0-800	0.33	Uses: (a) commercial; wood for veneer, plywood, light indoor construction, packing cases, moulding, coffins, pulpwood, chip- and fibre-board. (b) traditional: bark for dye. Remarks: Grows on riverine alluvial soils but resists water-logging and is resistant to fire; seeds lose germinating power fast; other biological properties are unknown; planted in experimental plantations.
Peronema canescens	long-lived	0-900	0.63	Uses: (a) commercial: wood, known as fancy wood in trade, is as good as teak but lighter, used for veneer, furniture. (b) traditional: wood for singles, house and bridge construction, handicrafts; bark and leaves for medicine. Remarks: It grows on clay and sandy soils on dryland and seasonally flooded areas in wet climate; can be propagated by cutting, other biological features are unknown; planted in rural areas as well as large-scale commercial plantations.
HERBS, SHRUBS AND CLIMBERS:				
Amomum compactum	early pioneer	0-1400		Uses (a) commercial: known as cardamon used in large-scale *jamu* (folk medicine) industries. (b) traditional: rhizomes for medicine (rheumatism, cough, cold, liver dis ease, giddiness condiment), food, spice.

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Table 1 (continued)

			Remarks: Grows on a variety of soils in wet to dry climates, often cultivated among trees; propagated by rhizomes.
Blumea balsamifera	early pioneer short-lived	0-1000	Uses: traditional: rhizomes for medicine (headache, stomachache); beverages (tea substitute); camphor oil from leaves. Remarks: Grows on a variety of soils in wet to dry climate, produces abundant seeds.
Curcuma xanthorrhiza	late succession	0-1000	Uses (a) commercial: rhizomes are used in large-scale "jamu" and spice industries. (b) traditional: rhizomes for medicine (indigestion, liver disease, tonic, rheumatism, gall-stone, etc.), as source of carbohydrate for baby food and soft drinks, spice, colouring material. Remarks: Grows on a variety of soils in wet to dry climates, often cultivated among trees; propagated by rhizomes.
Mucuna pruriens	early pioneer short-lived	0-700	Uses: traditional: vegetables (seeds and young leaves); medicine (seeds as aphrodisiacs; roots for tonic and vermifuge); green manure; cover crop, cattle feed. Remarks: A variable species growing in wet and particularly dry areas on a variety of soils; N-fixer.

Africa (Kartawinata *et al.* 1979). *Peronema canescens* is classified as fancy wood and has been exported at a high selling price, and is now one of the preferred species planted in industrial timber estates in Indonesia. *Cananga odorata* not only has good quality wood but also produces oil of commercial use in perfume industries. *Pometia pinnata* is a complex species which has been commercially exploited for its timber. There are nine subspecies and varieties growing in different habitats. Certain varieties growing in Irian Jaya produce delicious fruits which are sold in local markets and which have a potential to be developed commercially. These are just a few examples and no doubt there are many more economically useful species growing in secondary forests.

Information such as that contained in the Biological Flora of the British Islands is very valuable for rehabilitation purposes, but unfortunately no such information base is available in the tropics. A survey of published papers on all aspects of natural regeneration and succession should be conducted. Such papers are numerous and carry a large amount of information which needs to be extracted and synthesised into a body of data constituting the basis for rehabilitation efforts, with the following headings:

1. Location of studies
2. List of species
3. For each species, record should be made concerning:
   a. Uses
   b. Habitat conditions: precipitation (rainfall and fog drips), soils (physical and chemical properties), topography, altitudes
   c. Status in the community (pioneer, later invader, etc.)
   d. Vertical and horizontal position in the community
   e. Tolerance to extreme habitat conditions (drought, permanent and periodic inundation, frost, strong and low light intensity, etc.)
   f. Tree architecture
   g. Growth characteristics
   h. Phenology (including deciduousness)
   i. Seed dispersal mechanism
   j. Sprouting ability
   k. Geographical distribution
   l. Specific and ecotypic variations

The above could be complemented with information from herbarium collections and preferably from further field studies. In essence, the purpose is to collect ecological information for each species (autecology).

Conclusion

The rehabilitation of deforested lands requires urgent and serious attention in order to (1) outpace the rate of deforestation, (2) restore biological diversity, (3) diversify the products and increase the productivity of deforested lands, (4) provide socio-economic benefits to both government and rural community, and (5) supply raw material to the wood industry so that the pressure on remaining primary forests can be reduced and even eliminated. While there is sufficient knowledge and experience that can be used as a basis for trial programmes, further research is needed, in particular concerning the use of economically valuable fast-growing species of seral communities.

References

BRATAMIHARDJA, M. 1989. Agroforestry on forest lands in Java.Pp. 141-146 in Kartasubrata, J., Tjitrosomo, S.S. & Umaly, R.C. (Eds.) *Symposium on Agroforestry Systems and Technologies.* BIOTROP Special Publication No. 39.

DALMACIO, M.V. 1987. *Assisted Natural Regeneration: A Strategy for Cheap, Fast, and Effective Regeneration of Denuded Forest Lands.* Philippines Department of Environment and Natural Resources Regional Office, Tacloban City.

DRILLING, N. E. 1989. *Research Priorities for Reforestation in Indonesia with Emphasis on Accelerated Natural Regeneration.* USAID, Jakarta.

FAO, 1980. *Forest Resources of Tropical Asia.* Technical Report No. 3 of the Tropical Resources Assessment Project, FAO, Rome.

FAO, 1989. *Tropical Forest Action Plan in the Asia-Pacific Region.* Asia-Pacific Forestry Commission, Fourteenth Session, 4 - 8 December 1989, Manila, Philippines.

KARTAWINATA, K. and five others. 1979. *Indonesian Timber.* LBN-LIPI, Bogor. 115 pp. (In Indonesian).

LANLY, J. P. 1982. *Tropical Forest Resources.* FAO Forestry Paper No. 30. (Technical Report of the Tropical Forest Resources Assessment Project). FAO, Rome.

LOVEJOY, T. E. 1985. Rehabilitation of degraded tropical forest lands. *The Environmentalist* 5: 13 - 20.

LUGO, A. E. 1988. The future of the forest: ecosystem rehabilitation in the tropics. *Environment* 30: 17 - 20; 41 - 45.

RISWAN, S. 1982. Ecological studies on primary, secondary and experimentally cleared mixed dipterocarp forest and kerangas forests in East Kalimantan, Indonesia. Ph.D. thesis, University of Aberdeen.

RISWAN, S. & KARTAWINATA, K. 1989. A lowland dipterocarp forest 35 years after pepper plantation in East Kalimantan, Indonesia. Pp. 1-39 in Soemodihardjo, S. (Ed.) *Some Ecological Aspects of Tropical Forest of East Kalimantan: A Collection of Research Reports.* Indonesian National MAB Committee, LIPI, Contribution 48.

RODENBURG, W. F. 1985. *Establishment of Model Forestry Development Units in Indonesia.* Project proposal to IUCN, Gland, Switzerland. (Cited by Drilling 1989)

SUTTER, H. 1989. *Forest Resources and Land Use in Indonesia.* Directorate General of Forest Utilisation, Ministry of Forestry and FAO, Jakarta. 414 pp.

VAN RHIJN. 1928. Rapport over de maatregelen te nemen in het brongebied der Palaka en Patirorivier (Report on the measures to be taken in the catchment area of the Palaka and Patiro rivers, South Sulawesi). In Goor, C.P. & Kartasubrata, J. (Eds.) *Indonesian Forestry Abstracts: Dutch Literature Until About 1960.* P. 553, #5475.

WHITMORE, T.C. 1986. *Tropical Rain Forests of the Far East.* ELBS/Oxford University Press, Oxford.