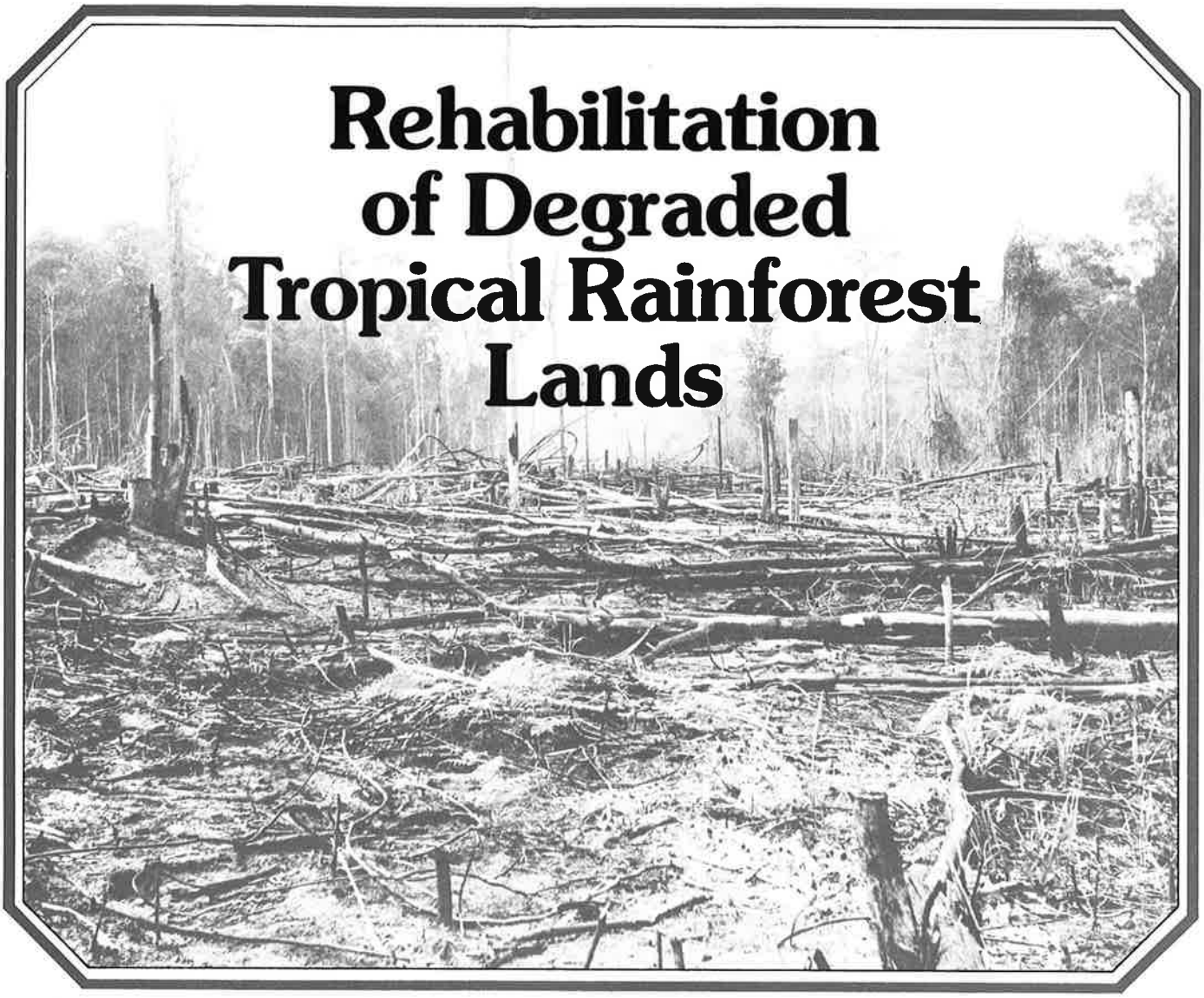
Rehabilitation of Degraded Tropical Rainforest Lands



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IUCN Commission on Ecology

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- mangrove ecosystems,
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- inland waters,
- arid lands,
- tropical rainforests.

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For further information please contact: Executive Officer, IUCN Commission on Ecology, Av. du Mont Blanc, 1196 Gland, Switzerland.

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Rehabilitation of Degraded Tropical Forest Lands

THOMAS E. LOVEJOY*

Vice-President for Science
World Wildlife Fund – U.S.
1601 Connecticut Ave. N.W.
Washington, D. C. 20009, U.S.A.

SUMMARY

The area of tropical forest lands in high rainfall areas that is already degraded is great and growing rapidly. Rehabilitation of such lands is important so their biological productivity can support people and reduce pressures for degradation of additional tropical forest lands. While further knowledge and experience is needed, there is a sufficient basis for trial programs. The economic and social well-being is far better served by focusing on rehabilitation of degraded lands than by additional incursions into dwindling stocks of natural forest.

INTRODUCTION

Perhaps as much as half of lands historically covered by tropical rainforests have been deforested. Vast areas of land formerly under primary tropical forest can be considered degraded, of limited usefulness and little economic worth. In a world of limited resources and increasing human demands on the environment, it is important, both on a national and local level not to lose even one more hectare of useful land. Yet conversion (including deforestation) continues at a rapid and probably accelerating rate. Thus, the rehabilitation of degraded lands, where water is abundant, is a matter of important economic and social value. Not only would it provide useful productive land but it would also serve to reduce the pressures on remaining primary tropical forests, themselves a high priority in international conservation.

Degraded land is land which has been altered so that it does not revert to the original vegetation type when vegetational succession is allowed to occur.

BARREN LAND

Definition:

Barren land is land essentially devoid of plants suitable for agriculture and forestry. For example mine wastes or other processed wastes, excavations, and newly created lands (volcanic deposition, sand dunes, river silts).

Causes:

Some barren areas are created naturally (e.g. lava flow) but most are created by human activities, and it is the latter to which attention is directed. Among the factors involved in creating barren lands are surface compaction, toxic materials, excess of minerals (salinization), excess in acidity or alkalinity, deficiencies in nutrients, air-pollution and animal damage.

Goals:

In rehabilitating barren lands the objective should be stabilization of the soil and restoration of natural biological processes leading to better soil-fertility, soil-structure and moisture relationships, eventually leading to:

- economic products for human welfare;
- environmental services such as reduction of erosion and sediment discharge, and increased amenities including wildlife habitats.

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The following persons participated:
Dr. Th. E. Lovejoy, Convenor, (USA), P. Ashton (USA), G. Baines (Solomon Islands), M. Bijleveld (Switzerland), J. M. Boyd (U.K.), E. F. Brunig (F.R.G.), Chin S. C. (Malaysia), J. Davidson (Australia), S. Davis (U.K.), F. Duhme (F.R.G.), Gong W. K. (Malyasia), M. Hadley (France), L. S. Hamilton (USA), E. Hegerl (Australia), M. Jenkins (U.K.), K. Kartawinata (Indonesia), K. M. Kochumen (Malaysia), Kuang B. C. (China), N. Kwapena (Papua New Guinea), N. Manokaran (Malaysia), Salleh M. N. (Malaysia), N. Sander (F.R.G.), A. Sasekumar (Indonesia), H. Skeat (Australia), W. Smits (Netherlands), Tho Y. P. (Malaysia), Wang M. H. (China), L. Webb (Australia), Wong K. M. (Malaysia), Yap S. K. (Malaysia), Zhu J. F. (China).

Fig. 1. Planted stand of mixed *Acacia mangium* and *Eucalyptus deglupta* is being used to rehabilitate this abandoned logging ramp, Jengka Triangle, Peninsular Malaysia. *Acacia mangium,* a leguminous species, is capable of fixing atmospheric nitrogen which improves the soil. (Photo credit: J. Davidson, 1983.)

Methods, Species and Appropriate Sites:

Physical measures such as gully barriers and matting may be needed for re-establishment of vegetation on actively eroding sites. Stabilization crops such as creeping legumes (e.g. *Leucaena,* wing bean), or grasses and trees with their essential fungi and bacteria (e.g. *Casuarina, Acacia*), also may be required.

Because of specific difficulties of establishment on many barren sites, use of exotic fast-growing pioneer species may be necessary at first to bring a site to a condition where suitable indigenous species are able to grow. (While in most cases vegetation composed of indigenous species is preferable, there may be some special cases where use of final vegetation composed entirely of exotic species may be desirable.) Whenever possible, experimental trials should be conducted using a wide range of native and exotic species particularly on sites with special problems. These may be combined with treatments such as liming, fertilization or inoculation with nitrogen fixing bacteria. Results are usually available in only one to two years.

Adequate protection from such human pressures as fire, grazing, and fuel or fodder gathering, is necessary. Controlled use may be possible once the area is stabilized and vegetation well established.

Implementation:

Initial stages of rehabilitation probably should be financed by the national or state government (or through compensation obtained from the body responsible for creating barren land) and not by the local community or private landowners because of likely unfavourable early economic returns. Involvement of local people is important and can be achieved by employing them on the project. It is also important to create public awareness about the benefits of the programme and the reasons why control or utilization are required.

The ownership of the land may present problems but these will be specific to each location. Any such problems must be addressed early in the programme or it could be in jeopardy. This is especially complicated in countries where clan, tribe or customary rights of ownership are involved.

Compatible and Incompatible Uses:

Once vegetation has been established on a site, new, more useful and perhaps local tree species can be planted, if this has not been possible initially. These may provide wood, fodder or fruit, but only very limited use is possible in early phases.

Recommendations:

It is recognized that one will never be able to bring back a tropical moist forest like the original on a degraded site, but something useful could be grown in its place.

In setting priorities for areas to tackle, the following aspects should be considered:

- the need to contain and if possible to reverse off-site damage (e.g. accelerated reservoir sedimentation), and river bed deposition;
- the possible improved cost-benefit ratio of off-site benefits in the long run, although initial economic returns will probably be unfavourable;
- the selection first of areas with the least complicated land tenure.

GRASSLAND

Definition:

Former rainforest land now bearing grasses and possibly undergoing periodic burning and grazing, e.g. *Imperata* grasslands.

Some of these grasslands with useful environmental functions such as maintaining water regimes and soil stability, providing house-wall and roof thatching are of direct use to people (also included are shifting agricultural systems). Here, attention is concentrated on those grasslands which are under intense pressure from human use, with degraded productivity and off-site problems created, or which produce little or nothing of value to society.

Causes:

Such grasslands are created by clearing of tropical

Fig. 2. Conversion of large blocks of tropical moist forest to pasture near Manaus, Brazil. Benefits derived from this type of conversion are transitory since the small soil nutrient reserves are used up in a couple of years and weeds take over from the grass. (Photo credit: J. Davidson, 1982.)

moist forests followed by shifting agriculture or grazing in which fire is employed, resulting in a decline in productivity. The grassland is usually maintained by regular use of fire.

Goals:

The objective is the stabilization of the soil and restoration of natural ecological processes leading to better soil fertility, soil structure and moisture retention properties, eventually leading to re-establishment of economically useful plants and:

- a greater flow of economic products for human welfare, e.g. fodder, fuel and food;
- improved environmental services, e.g. a reduction of erosion, sediment discharge and increased amenities;
- alternative wildlife habitat.

Methods, Species and Appropriate Sites:

The two key aspects are establishment of forest plantations and agro-forestry: i.e. introduction of trees and in some cases food crops into the system in a silvo-pastoral or agro-silvicultural context.

1. Forest Plantations:

In establishing forest plantations there is a need to use species which provide products at an early stage so that local people can see that the land is being put to a beneficial use and so that they will not abuse the area (e.g. through burning).

Species used should be generally selected for fast growth, easy establishment without cultivation, fire resistance, nitrogen fixing ability and climate: i.e. adaptation and other specific site-matching factors. Because of specific difficulties of establishment of many grassland sites, use of exotic fast growing pioneer species may be necessary at first to bring a site to a condition where suitable indigenous species are able to grow. If time is available, it is desirable to carry out trials of a wide range of native and exotic species on sites with particular problems.

Some species that have been used successfully include: *Acacia auriculaeformis* and *A. mangium, Albizia falcataria, A. lebbek,* and *A. procera, Casuarina equisetifolia,* and *C. junghuhniaha, Calliandra callothyrsus, Cassia siamea* (the last does not fix nitrogen) and a few species of *Pinus*. Eucalypts have often been used, but are inappropriate for grassland conversion because of the need to remove grass competition during establishment and because they do not generally shade out such grasses as *Imperata.* Plantation can be of mixed species for risk minimization and for production of a greater variety of products.

Fig. 3. *Eucalyptus deglupta,* a species found naturally in lowland tropical moist forest situations in Mindanao (Philippines), Moluccas and Irian' Jaya (Indonesia), and Papua New Guinea has been used here in Peninsular Malaysia as an exotic to reforest a narrow strip through logged forest which was heavily damaged by cable logging. Its initial very fast growth is able to recapture the site before erosion occurs. (Photo credit: J. Davidson, 1983.)

2. *Agroforestry:*

In agroforestry systems, the need is for a mixture of nitrogen fixing, fast growing, coppicing, multiple purpose (including wood, fodder and fuel) species that will grow under the given environmental conditions and combine well with herbaceous crops and/or animals. The design, species combinations and sequence of some such models have been documented elsewhere by the International Council for Research into Agroforestry (ICRAF), Centro Agronomico tropical de Investigación y Enseñanza (CATIE) and East–West Center (EWC).

Among the most useful species are: fruit trees such as *Durio zibethenus, Artocarpus altilis, A. communis, A. heterophyllus, Nephelium lappaceum* and *Anacardium occidentale;* fast growing multipurpose woody perennials such as *Lacaena leucocephala* (not on acid soils), *Sesbania grandiflora, Calliandra calothyrsus* and *Mimosa scabrella.* For commercially valuable products, less perishable items such as rubber, coffee, and pepper will often be preferable to tropical fruits. It is important, at least initially, to give priority to fast growing nitrogen fixing species which will improve the soil.

Some examples of promising agroforestry systems in SE Asia include the multi-species, multi-storey crop combinations of the home gardens found all over the region; integrated, small holder production of plantation crops such as coconut and rubber mixed with agricultural crops, pastures and animals (cattle, poultry); grazing in forest or plantation crop systems (sylvopastoral); and hedgerow, border, or zonal planting of fast-growing, multipurpose leguminous woody perennials such as *Leucaena leucocephala* and *Cassia siamea* in farming systems.

Implementation:

The first requirements in rehabilitating grassland is local support for the project, involving local participation in planning, and selecting species and sites. Only through this local support will it be possible to solve the problems of protection (most importantly from fire).

Usually the establishment of forest plantations will be funded and supported by outside organizations, but this may vary according to tenure of the land. Where there is community or individual ownership of the land, agroforestry systems may be implemented largely with local resources.

In state or community owned sites, some system of regulating product removal must be implemented to prevent over-utilization resulting in rapid decline of the resource.

Compatible and Incompatible Uses:

As well as providing increased environmental service, grassland rehabilitation activity is designed to provide for increased human use and for improved wildlife habitat. Sustainable wood, fodder and fruit harvesting together with controlled grazing (after the initial establishment period) are feasible in some of the systems. The compatibility or incompatibility of various uses will depend on such things as composition, system design, and local needs.

Recommendations:

Land tenure and population pressures will usually determine whether the rehabilitation activity favours agroforestry or forest plantation.

Considering the vast area of anthropogenic grassland in the humid tropics that could be made useful, priorities for action might be:

1. areas where local support and willingness to participate in planning and management have been demonstrated; or
2. areas with critical soil and water problems in degraded grasslands which are eroding.

LOW SECONDARY FOREST

Definition:

Any secondary vegetation such as scrub, bush, thicket, capoeira, that is predominantly woody, but does not include mature phase rainforest components.

Causes:

Low secondary forest can be created by both natural events and human interference. It can be created by any natural event which results in total destruction of original primary rainforest cover, including its regeneration potential, when this is followed by arrested seral succession in the absence of fire, and often by the entry of introduced weeds that further deflect succession.

Initial intervention may include fire, and frequently includes soil surface destruction or loss from such actions as landslips, and vulcanism. Some soils, e.g. from low fertility silicious parent materials and in drier seasonal areas, are more prone to degradation. The condition persists in the absence of nearby source of primary forest diaspores, or where soil alteration has led to conditions unfavourable for germination and/or establishment of mature phase seedlings or where weeds arrest succession. People can cause low secondary forest through forest clearing and cultivation or earthmoving on an extensive scale, overgrazing and some burning.

The degraded condition in areas where traditional dry land agricultural cultures are practised is a symptom that human carrying capacity has exceeded the potential of the ecosystem. This also happens when landless peasants move into a land form to which their traditional methods are ill-adapted.

Rationale:

Some secondary forests are productive. A classic

example is the Burma teak forest. These are old secondary forests which invaded the ancient field system of the Chinese population who fled as a consequence of the Sino-Burmese wars in the late eighteenth century.

In addition, some secondary successional forests may include pulp and paper species, (this is probably rare as leaf area indices are generally low on favourable sites and fibre characteristics are not suitable).

Secondary successional vegetation is generally the preferred habitat of some larger vertebrates, and thus provides for tourism and controlled cropping for wild meat.

Many local communities depend on secondary forests as a source of food (including uses as hunting grounds) and materials. Such forests are productive for local people; ones which are not should be given greater priority for rehabilitation.

Goals:

Treatment of degraded land with low secondary forest is generally more justified where land shortages exist and should achieve one or more of the following:

1. increased productivity of useful biomass in order, ultimately, to reduce pressure on residual areas of primary forests;
2. increased biological diversity of the forest community, and its conservation and recreational value;
3. increased rate and level of recovery of nutrient reserves.

The option of removing the succession and establishing monoculture in these communities is rarely justifiable, either in terms of initial cost or subsequent high maintenance costs in humid tropical climates (especially pest control), unless it is a choice between establishing plantation forests on such sites and establishing them on primary forest sites. The intensity of treatment must be carefully weighed in terms of the benefits to be gained. Low levels of treatment and management must generally yield low returns.

Methods, Species and Appropriate Sites:

In all but the most fertile substrates in the humid tropics the soil is likely to have been degraded. Restoration of soil structure and nutrients will take a long time and/or be expensive.

Generally, the preferred approach will be introduction of species which simultaneously improve soil conditions and provide useful products. Species which can be harvested (e.g. fruit, coppice) so as to obviate further replanting/soil disturbance are to be preferred. Other desirable attributes include the capacity to fix nitrogen, to develop deep tap roots and to form complete cover. Useful examples are provided in the report on tropical legumes, and fuelwood crops published by the U.S. National Academy of Science, such as *Leucaena* spp, *Calliandra, Sesbania, Glyricidia, Acacia, Prosopsis* (arid climates), other legumes, *Paraspania, Ulmaceae, Gymnostoma (Casuarina) nobile.* Generally, it has been found that pioneer species of the seasonal tropics are the fastest growing, but perform poorly in continuously humid climates.

Mixed species are to be preferred to single species plantings because they will provide greater ecological stability. Invasive species should not be used in spite of their initial advantages as they may form their own deflected climax which may be practically impossible to replace. (*Schinus terebinthifolius* (Anacardiaceae) is one example.)

Introduction of relative shade tolerant commercial food species such as cacao and coffee in secondary forests is sometimes a feasible proposition.

Good management is the key to success. The procedure is as follows:

1. Field assessment of the sites with careful evaluation of physical and biotic conditions.
2. Choice of species appropriate to the site.
3. Small-scale experimental planting. (Never embark on major planting without prior experiment on a reasonable time scale.)
4. Implementation of full treatment.

The planting procedure will depend on the nature of existing vegetation. If low, complete removal may be advisable. If tall, then lines or individual clearings (the latter preferable if browsers are a problem) are advocated and light shade should be maintained, with planting material chosen with this in mind.

Exclusion of fire is imperative.

Implementation:

All treatments require clear policy decisions concerning goals.

Some of the points to consider are:

1. Benefits and costs must be clearly defined and weighed.
2. An agency or individual must be recognized to have responsibility for implementation and maintenance.
3. Adequate funds and manpower must be provided.
4. Previous users of the land must be given alternative means of subsistence.
5. During the process of implementation, browsing must be prevented, but carefully controlled forage and firewood cuttings may be allowed, particularly if they assist growth of the desired species. The canopy must be kept closed.
6. Limited recreation and tourism, if appropriate, is allowable.

Recommendations:

1. Start small, experimentally.
2. Have a clear set of goals.

3. Aim for maximum convergence of uses.
4. Local participation is the key: create a situation in which users recognize problems themselves and invite assistance.
5. Research and more detailed records on traditional uses are needed.

An example:

In a country like Bangladesh, although there is no established rattan (cane) industry, canes are cultivated around village homesteads (especially small diameter canes like *Galamus tenuis*) and taken for everyday use. They are also collected from the 'wild' in marginal areas (e.g. *Daemonorops jenkinsiana,* which thrives in pioneer conditions).

This harvesting is becoming increasingly difficult (i.e. even cane supply for local needs is diminishing) due to overharvesting on the one hand, and lack of tree cover (for early establishment and subseqeunt ease of harvesting) on the other.

There is about 9 per cent of original forest left in this country, and certainly practically none around rural homesteads involved in agriculture. It would be of great benefit if some form of tree cover could be re-established in such homestead areas. During the intervening periods before harvesting of the tree crop could commence, the regenerating area could be used to involve local people in activities such as improving the supply situation of canes for local use.

DEGRADED LOGGED FOREST

Definition:

Degraded logged forest are those forest areas which have been logged and which are unable to revert to the original state or to another state adequate for people's needs within a reasonable period of time.

Causes:

The major reason for degradation of a forest area is the use of logging machinery and methods which cause unnecessary damage to soil, water, vegetation and fauna. In addition, poor management and supervision of logging operations and inadequate control by the relevant government agencies can cause decline in forest quality. Often logging in vulnerable conditions (shallow soils, steep slopes) results in a regressive succession leading to low secondary, stagnant bush. Lack of security of tenure for operations on forested land is an important contributing factor to irresponsible logging practices.

Processes in logging operations which lead to degradation (tractor logging):

1. non-directional felling (subsequent extraction causes great damage);
2. skidding (skid trails up and down slopes, as well as too many skidding trails result in excessive damage to the environment);
3. roading (poorly designed roads results in accelerated erosion);

TABLE 1

Type of degraded forest land	Cause of degradation	Rehabilitation measures
Barren land	Surface compaction, toxic materials, excess minerals, e.g. salinization; major ph change, nutrient deficiencies, air pollution and animal damage.	Stabilization crops (exotic species may be necessary); soil treatment, protection from fire, grazing, harvest, subsequent establishment of useful tree species may be possible.
Grassland	Forest clearing by agriculture or grazing of which fire is a part.	Establish forest plantations, agroforestry, desirable species characteristics include nitrogen fixing and deep tap roots, exclusion of fire, grazing controlled.
Low secondary forest	Natural elements destroying primary forest cover – fire, forest clearing, earthmoving, and overgrazing.	Planting of (preferably mixed) species to improve soil and also to give: economic yields, e.g. fruit, coppice; agroforestry with shade tolerant species, exclusion of fire and heavy browsing, research is needed.
Degraded logged forest	Damage to soil and biota from heavy machinery, inappropriate logging sites (steep slopes), non-directional felling, skidding, and poorly designed access roads.	Enrichment planting and rapid re-establishment of vegetative cover on cleared areas.

4. log yards and logging roads become areas where soil compaction occurs;

High lead logging is an even more destructive form of logging and should be phased out.

The degradation caused by tractor logging can be minimized by:

1. directional felling so that extraction causes less damage;
2. preplanned skidding trails and roads to reduce destruction of residual vegetation and minimize erosion;
3. use of as few skidding trails as possible;
4. reduction of log yard and logging road areas to the smallest size possible;
5. keeping an uncut buffer strip along streams;
6. good engineering on roads to prevent erosion and land slips and to minimize damage at stream crossings.

Rationale:

Forest areas should be kept in as good a condition as possible because forest products are valuable and their resource base must be protected to ensure a continued supply to meet various social, environmental and economic needs.

Goals:

The goal in rehabilitating degraded logged areas should be to restore soil fertility (following a single logging, fertility is less of a problem than compaction and erosion of bared areas) in order that plant and/or animal products might continue to provide various community needs, either directly (e.g. timber) or indirectly (e.g. water catchment and/or wildlife protection).

Implementation:

Silvicultural measures, including enrichment planting, to speed recovery should be based on a careful aerial and ground survey of forest and site conditions. Planting nitrogen fixing species (*Acacia, Casuarina*) may be useful.

Natural dynamics of successional development should be considered in deciding on silvicultural measures, and should be utilized to reduced costs of establishment and tending.

Compatible and Incompatible Uses:

Degraded forest would *eventually* recover their protective functions if left alone. But this would be in the absence of any productive function. This could only be resolved by adoption of active rehabilitation measures accompanied by compatible utilization practices, especially of logging.

Recommendations:

More imaginative legal and administrative arrangements are needed to effectively integrate leases for forestry purposes with land tenure systems to provide the necessary security for sustained forestry, with adequate provision for the rights of the landowners. There should be no logging of forests that local experience has shown to be susceptible to regressive succession.

Areas prone to mass erosion should not be logged. The following measures are needed to avoid unnecessary degradation and to promote recovery of degraded logged forest:

1. improved systems of logging and logging planning;
2. applied research into methods of promoting recovery of degraded logged forests, e.g., ripping and replanting of compacted areas;
3. identification of critical soil erosion-prone areas, particularly those susceptible to mass movement;
4. leaving uncut buffer strips along streams;
5. improved policy, operational guidelines;
6. better training and supervision of logging managers and machinery operators.

Fig. 4. *Acacia mangium* planted on a harsh site in Peninsular Malaysia. Logging operations have stripped the soil down to the sandstone parent material. Only this species' ability to fix atmospheric nitrogen has enabled it to survive such conditions. Once the site is rehabilitated by this leguminous tree crop, other species can be grown on the site. (Photo credit: J. Davidson, 1983.)

SUMMARY

There is a large amount of degraded tropical forest

land in relatively high rainfall areas and it continues to increase. It is economically nonsensical to leave the land in such an unproductive state, contributing little to the support of people. Some knowledge and experience already exist for rehabilitating the various forms of degraded lands. Only in the case of barren lands, where there often has been a legislative impetus, can the knowledge base be considered as approaching the adequate. In many instances, experience is limited, arguing for modest initial trials of particular approaches before application on a vast scale. In other instances, further research, such as in root biology, can make an appreciable difference. In all instances it is important to take cognizance of the local social context to ensure local support and involvement.

Generally the degraded site requiring rehabilitation was initially marginal and unsuitable for the use to which it was put. However, because of population pressures, marginal sites are likely to continue to be used for food production at the expense of implementing a cycle of reclamation. It is often considered expedient to clear poor sites again and live on the ephemeral improvement in soil fertility for a year or two despite the further long term cost. Degradation is thus likely to continue and is now one of the greatest conservation problems facing the world.

Most important of all is the need to recognize the importance of rehabilitating these degraded lands. The world is less capable of maintaining resonable standards of human welfare because of the loss of much land from its original estate. It is in the interests of all to rehabilitate such lands, so they and remaining tropical forests lands can be used wisely and sustainably in support of society.

The following papers of the IUCN Commission on Ecology have been published:

No. 1 **Ocean Trench Conservation**
by Dr. M. V. Angel, Chairman of the Working Group on Ecology of the Oceans of the IUCN Commission on Ecology.

No. 2 **Ecological Mismanagement in Natural Disasters**
by Prof. L. D. Pryor of the IUCN Commission on Ecology in cooperation with the League of Red Cross Societies.

No. 3 **Global Status of Mangrove Ecosystems**
edited by Dr. P. Saenger, E. J. Hegerl and Dr. J. D. S. Davie of the Working Group on Mangrove Ecosystems of the IUCN Commission on Ecology in cooperation with the United Nations Environment Programme and the World Wildlife Fund.

No. 4 **Impact of Oil Pollution on Living Resources**
by Dr. J. M. Baker, Chairman of the Working Group on Oil Pollution of the IUCN Commission on Ecology in cooperation with the World Wildlife Fund.

No. 5. **Ecological Structures and Problems of Amazonia**
Proceedings of a Symposium organised by the Department of Biological Sciences of the Federal University of São Carlos, and the IUCN Commission on Ecology at São Carlos, Brazil, the 18th of March 1982.

No. 6 **Future Hazards from Pesticide Use**
by Ir. F. Balk and Prof. Dr. J. H. Koeman, Chairman of the Working Group on Environmental Pollutants of the IUCN Commission on Ecology in cooperation with the World Wildlife Fund.

No. 7 **Traditional Life-styles, Conservation and Rural Development**
Proceedings of a Symposium organised by the Institute of Ecology, of Padjadjaran University, Bandung, and the IUCN Commission on Ecology held in Bandung, Indonesia, on the 4th and 5th of October 1982.

No. 8 **Conservation of Ecological Processes**
by Prof. R. E. Ricklefs, Prof. Z. Naveh and Dr. R. E. Turner of the IUCN Commission on Ecology.

Commission on Ecology *Occasional Papers:*

No. 1 Changes and Development in the Science of Ecology and other Reports.
No. 2 Precipitation and Water Recycling in Tropical Rain Forests (with Special Reference to the Amazon Basin) and other Reports.
No. 3 Population and Natural Resources and other Reports.
No. 4 Why Conservation?
No. 5 Rehabilitation of Degraded Tropical Rainforest Lands.

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