GREENHOUSE GAS OFFSET FUNDING FOR ENRICHMENT PLANTING - A CASE STUDY FROM SABAH, MALAYSIA[1]

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SUMMARY

A large scale project for rehabilitation of logged forests to offset CO_2 from the atmosphere was initiated in Sabah, Malaysia. The objective of the project is to rehabilitate 25,000 ha of logged forest by enrichment planting and reclamation of degraded areas using indigenous tree species such as dipterocarps, fast growing pioneers and forest fruit trees. The project is funded mainly by the Face (Forests Absorbing Carbon-dioxide Emissions) Foundation of the Netherlands, an organisation set up by the Dutch Electricity Generating Board to promote the planting of forests to absorb CO_2 from the atmosphere to offset that produced during power generation. The project is being implementated by Rakyat Berjaya Sdn. Bhd. - the operational subsidiary of Innoprise Corporation Sdn. Bhd.- a company with substantial experience in logging operations. A major attraction of the project is that it includes a substantial research and training component integrated with the main operation. Forest rehabilitation practices may thus be improved in a scientific manner. Large field trials employing different systems are being established. The development of the stands will be closely monitored in order to extract the maximum amount of information and allow a better understanding of the problems and difficulties involved with large scale planting of logged over forests. The critical points identified are being addressed by specific research projects in order to elucidate solutions or alternatives for maximizing survival, growth and development of seedlings at a feasible cost. A description of the methods used and results achieved are documented here.

Keywords: carbon offset, dipterocarps, enrichment planting, forest rehabilitation, Sabah.

INTRODUCTION

The last decade has been marked by increasing environmental awareness throughout the world. Pollution, deforestation, global warming and conservation have came into the limelight of environmental campaigning. In Malaysia (and other tropical countries), "sustainable logging", "environmental impact assessment" and "debt for nature" have became jargon for those aiming at better management of natural resources. Simultaneously, pollution, acid rain and industrial waste have started to hound industrialised countries of the North. Meetings such as the Earth Summit in Brazil, have tried to bring such subjects to the discussion table in a global context. Discussions among countries are particularly important, since the problems of some may be the solutions for others. This paper describes an example of such a case.

The logging of dipterocarp forests account for *ca.* 50 to 70 % of Sabah's state revenue (Sabah Forestry Department 1989). In order to maintain the economic returns derived from this sector, forest regeneration must be managed for sustainable yields. The high densities of natural stands in Sabah (Newbery *et al.* 1992) allow extraction rates of up to 120 m^3 ha^{-1} (Silam Forest Products, timber extraction figures). However, this results in substantial disturbance to the residual stand (Nussbaum *et al.* 1993; Appanah and Weinland 1990). In some areas the residual stocking and seedling bank of timber species is much reduced and artificial regeneration needs to be employed (Primack *et al.* 1987; Appanah and Weinland 1990). Enrichment planting is a technique for promoting artificial regeneration in which seedlings of preferred timber trees are planted in the under-storey of existing logged-over forests and then given preferential treatment to encourage their growth (Lamprecht 1986). However,

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the costs involved in artificial regeneration are often prohibitive, and in some cases funds are not available from local sources.

Energy supply in the Netherlands is mainly provided by coal-fired power stations. The burning of coal produces emissions of CO_2 to the atmosphere, contributing to the greenhouse effect. The idea of planting trees to reabsorb CO_2 has great potential. However, it is not possible to find large enough areas in Europe to offset the amount of gases released to the atmosphere, since most of the land is already under agricultural or urban use.

The problems faced by Malaysia and the Netherlands were combined to generate practical solutions for both parties. In Malaysia, extensive areas are available for rehabilitation and/or planting of forests, whilst large industrial corporations in the Netherlands have the funds to invest in projects related to "environmental cleansing". The use of forestry for CO_2 offset is an idea for promoting the transfer of funds from one to the other primarily as a commercial transaction, as opposed to charity (Marsh 1992 and 1993). In brief the idea is that Malaysia plants trees which absorb CO_2 emissions from the Netherlands.

THE RBJ-FACE FOUNDATION REHABILITATION OF LOGGED-OVER FORESTS PROJECT

The RBJ-Face Foundation Rehabilitation of Logged-over Forests (ReLoFo) Project is a cooperative venture between Rakyat Berjaya Sdn Bhd - the operational subsidiary of Innoprise Corporation Sdn. Bhd. - a company with vast experience in logging operations, and the Face (Forests Absorbing Carbon-dioxide Emissions) Foundation of the Netherlands, an organisation set up by the Dutch Electricity Generating Board to promote the planting of forests to absorb CO_2 from the atmosphere and offset the emissions of their power stations. The objective is to carry out large scale rehabilitation of logged forests by enrichment planting and reclamation of degraded areas using indigenous tree species such as dipterocarps, fast growing pioneers and forest fruit trees.

In the initial pilot phase, 2,000 ha of logged-over forests are being planted over three years (1992-1994) as a demonstration unit for sustainable management of natural forest at a cost of about M$ 3 million[2]. A major attraction of the project is the integration of a substantial research and training component with the main operation. Ten percent of the total budget is to be directed towards research with the objective of developing strategies for rehabilitation of logged forests. Large field trials employing different systems are being established. The development of the stands will be closely monitored in order to extract the maximum amount of information required for a better understanding of the problems and difficulties involved with large scale planting of logged over forests. Subsequently, the critical points identified are addressed by specific research projects to generate solutions and alternatives for maximizing survival, growth and development of seedlings at a feasible cost. The results achieved will be used to produce a Management Plan for the Rehabilitation of Logged forests, to serve as a guideline for the second phase of the project. This will aim to rehabilitate 25,000 ha of logged forests over 26 years.

This is the first example of a large scale tropical forestry project with the objective of CO_2 sequestration in the world, and if successful, it may provide an incentive for further North-South collaborations for the management of environmental problems.

PROJECT AREA

The project area comprises 25,000 ha of logged-over dipterocarp forests in the Ulu Segama Forest Reserve, eastern Sabah (Malaysia), 5° N, 117° E, 61 Km from Lahad Datu. Since 1978 this area has been logged on an annual coupe basis; thus, at present, it includes blocks of secondary forests at different stages oregeneration. The geology, soils and topography of the region are variable (Marsh and Greer 1992). Mean annual rainfall is 2,800 mm, and mean annual temperature is 26.7°C.

[2] M$ 3 million = U$ 1.3 million = £ 800.000, February 1993

The operational side of the project is based at the Rakyat Berjaya Sdn. Bhd. (RBJ) branch in Lahad Datu, which provides logistical support and administrative infrastructure. The Research and Development side of the project is situated in the nearby Danum Valley Field Centre (DVFC), a field station created in 1986 which supports research on various aspects of rainforest ecology, disturbance and recovery.

PROJECT IMPLEMENTATION

This section describes the operational side of the project, from planning to implementation. As mentioned before, the initial phase aims to test different strategies and systems, therefore planting is organised in the form of large trial plots testing a range of variables.

Site Selection

The following criteria are used for site selection:

- Density of remaining stand. Sites are selected in areas with low regenerating stocks after logging which require enrichment planting. Selection is based on results of linear regeneration sampling conducted by RBJ.

- Provision of a range of types of planting sites typical to the region, choosing sites with different "ages" of logged forests (years after logging) and which were logged using different timber extraction techniques (tractor or high-lead). These sites differ in terms of remaining vegetation, canopy density, soil damage (compaction, erosion, remaining nutrient levels, etc.) and topography. In this way it will be possible to compare growth and development of dipterocarp seedlings under different conditions.

Maps at the scale 1:16,000 are available for the entire area; these include contour lines, rivers, roads, old logging tracks and landing sites. Enlarged three-dimensional maps are produced from these maps, in order to facilitate planting design. After site selection, a boundary survey is carried out and more detailed maps are produced.

Choice of Species

An important factor determining the success of forestry enterprises is the right choice of species. However, apart from basic information about species habitat and ecology, little is known about site-species matching of planted dipterocarps. A further complication regards mycorrhizae, since different mycorrhizal fungi have complex interactions with different tree species and soil types (Smits, pers. comm). For these reasons, we are conducting site-species trials to test the performance of different species in forests of different ages following logging and different soil types. Detailed soil surveys are carried out so that soil factors can be correlated with stand development. Figures of timber extraction volumes are available for each site, and are used for these studies on site-species matching for dipterocarps. So far, the main species planted are *Shorea leprosula* (seraya tembaga), *Parashorea malaanonan* (urat mata daun licin) and *Dryobalanops lanceolata* (kapur paji).

Severely damaged areas such as log landings and skid trails will be planted with indigenous pioneer trees. Logging operations cause severe disturbance to these areas, in terms of excessive removal of canopy trees and soil compaction, with negative effects on the growth of planted dipterocarps. The strategy we are testing is to promote the establishment of canopy trees prior to the planting of dipterocarp seedlings. Trials were initiated this year using selected planting material of pioneer tree species with potential commercial use, such as *Neolamarkia cadamba* (*Anthocephalus chinensis*, laran), *Duabanga moluccana* (magas), *Endospermum peltatum* (marapangi) and *Octomeles sumatrana* (binuang).

Starting from the second year, 10% of the total area has being planted with indigenous fruit trees such as *Durio*, *Mangifera*, *Artocarpus*, *Dacryodes* (kedondong) and some trees of the Leguminosae family (*eg.* petai). These trees grow to a large size, are long-lived and their fruits are edible to humans as well as palatable to primates, ungulates and birds. The objectives are to increase the biodiversity of the plots, create a short term revenue and to attract wildlife.

Planting System Used

The planting system described below is used as a standard on which modifications are being tested for further optimisation. Details of the operations are:

Spacing - for dipterocarps and fruit trees the spacing used is 10 m between lines and 3 m along the lines, giving a density of 333 plants per hectare. The high density of planting allows for reductions caused by damage from browsing and shoot borers without the need for replacement of seedlings, minimising the costs involved in this operation. Pioneer species are planted at 1 x 3 m, giving a density of 3270 plants/ha.

Width of planting line - 2.0 m, oriented in an East-West direction. Trials are being conducted to compare the development of stands planted in a North-South direction, and to determine the effects of different widths of planting lines. In the case of high slope sites, lines are oriented perpendicular to the main slope. In some areas where mammal browsing causes excessive damage, seedlings are planted at the edge of the planting lines. All plants and trees with a dbh of up to 25 cm found along the planting lines are cut, with the exception of natural regeneration of dipterocarps and fruit trees. These are identified during site preparation, and tagged with coloured ribbons to prevent damage during weeding operations.

Fertilisation - a dose of 100 g of rock phosphate is applied in the planting hole. Subsequent application of fertilisers is being conducted experimentally as part of a study to compare the effects of fertilisers on initial establishment of dipterocarps.

Weeding - carried out every three months, for two years, removing lianas and climbing vines. In the case of recently logged areas, weeding is carried out every 2 months, in a total of 6 rounds a year.

Plot Design and Planting Operation

The planting areas are divided into 50 ha blocks. Before planting, a detailed plan of operations is produced for each block, specifying what species to plant and what treatments to apply (fertilization regimes, width of planting lines, direction of planting lines, etc.). The planting design is aimed at allowing statistical interpretation of results and a comparison of treatments both within and between blocks.

After the planting design for a block is completed, it is discussed with other members of the project team in order to incorporate comments and suggestions. A final copy is given to the field staff as the planting guideline.

One month after a block is planted, 100% of the planted area is surveyed to assess initial survival of seedlings. If more than 5 % mortality is observed, the plot is supplied with extra seedlings. During this survey, canopy cover and vegetation around each planted seedling is also assessed.

Monitoring of Growth and Development

During the initial phase of the project, plots will be intensively monitored. Ten to twenty percent of the seedlings in stands are measured for height and diameter, firstly at 3, 6 and 12 months after planting, and then on a yearly basis.

Apart from routine monitoring, further assessments are carried out either by project researchers or other scientists at DVFC working in collaboration with the project. These include more specialised measurements of light, physiology, water relations, photosynthesis, nutrient dynamics, growth allocation and insect and mammal damage. Sample sizes for these studies are much smaller than for the routine monitoring mentioned above.

Data Analysis and Interpretation of Results

After data have been collected and entered into computers, preliminary statistical analyses are performed. Later, more sophisticated analyses are carried out, trying to correlate the growth and development figures with more specialised measurements of light, photosynthesis, soil factors, etc.

A geographical information system (GIS) is being used to generate maps containing all the information gathered. This system works by super-imposition of maps and a data-base containing different information, providing a powerful tool for visual identification of correlations between factors and the presence of localised phenomena.

The results are compared with research findings and discussed with the project team and other scientists at DVFC in order to draw conclusions and provide recommendations for the following planting seasons. In this way, results are rapidly incorporated into field procedures.

PLANT PRODUCTION AND NURSERY FACILITIES

For the first three years of the project a total of 600,000 dipterocarp plants, 50,000 fruit trees and 154,500 pioneer trees will be required. This section describes the infrastructure and the methods developed for producing planting stock.

Nursery Facilities

A large scale operational nursery was established specifically to supply planting stock for the project. The nursery area is 3,600 m^2, and it has capacity to produce 600,000 plants per year. The nursery is centrally located in the project area, at 61 km from Lahad Datu and 11 km from Danum Valley Field Centre. In addition, a research nursery was established in DVFC for more specialised work on the improvement of nursery techniques and methods for vegetative propagation of dipterocarps by cuttings.

Seeds and Wildlings

Whenever they are available, seeds and wildings will be used to supply planting stock for the project. During the fruiting season, collection must be carried out daily in order to avoid predation by insects or mammals. In the case of dipterocarps, seeds must be taken immediately to the nursery for germination. When fresh seeds are used, germination rates of up to 97 % may be achieved after 2 weeks (results of batches of *Dryobalanops lanceolata*, *Shorea leprosula* and *Parashorea malaanonan* seeds). Sharp decreases in germination rates were observed when seeds were kept for more than two weeks, with less than 50 % germination (Moura-Costa *et al*, 1993).

Seeds not collected from the forest quickly germinate, and the resulting wildings may then be collected and cultivated. Wildings are simply pulled from the forest floor in the most efficient way (one person can collect up to 180 wildings per hour) but this often damages their root system. Thus, special care must be given during an acclimatization period after transfer to the nursery. Wildings are watered and kept in plastic covered chambers with high humidity until a new root system is formed. Satisfactory rates of survival have been obtained with this system (*e.g.* 94.4 % for *Shorea parvifolia* and 88.2 % for *Dryobalanops lanceolata*), after a 4 week acclimatization period (Moura-Costa *et al.* 1993).

Vegetative Propagation

An inherent difficulty related to the large scale planting of dipterocarps is the availability of planting material. Dipterocarps exhibit mast fruiting, with 1 to 10 years between seeding years (Ashton *et al.* 1988); furthermore seeds have brief viability preventing long term storage (Sasaki 1980; Tompsett 1989). Wilding availability depends on the occurrence of seeding years, and is therefore unreliable.

The use of vegetative propagation by cuttings is an alternative method of supplying dipterocarp planting stock. Techniques for the vegetative propagation of dipterocarps have been developed in Danum Valley Field Centre (Moura-Costa and Lundoh, 1992) based on the methods used by Smits (1983) and Leakey (1982). For some species (*eg. Dryobalanops lanceolata*, kapur), up to 95% rooting was achieved after keeping cuttings for 12 weeks in sand beds in a mist propagator (Moura-Costa 1993). The methods developed are being adapted to minimise the number of operations required for cutting production, and therefore the costs. This will allow its use for large scale production of cuttings in our operational nursery (Moura-Costa 1993).

Hedge orchards with stockplants are being established in DVFC to guarantee a steady supply of plant material for cutting production. Stockplants are managed to increase the number of orthotropic shoots produced by each plant. The apical shoot is excised and the stem bent over (Leakey 1983; Leppe and Smits 1988), in order to break apical dominance and induce the sprouting of dormant stem nodes. Using this system, up to 30 shoots can be formed by each stockplant monthly.

Tissue Culture

Tissue culture techniques for *in vitro* propagation of dipterocarps are also being investigated in collaboration with the Forest Research Centre (Sandakan, Sabah). The methods used for shoot multiplication of dipterocarps follow those of Linington (1991). Experiments for rooting micropropagated dipterocarp plants have been carried out using *Dipterocarpus intricatus* plantlets from cultures provided by I.Linington (Kew Gardens, U.K.). By applying 0.8 % IBA talcum formulations to the basal end of the plantlets, 35% formed roots after 12 weeks in the mist spray sand beds. This method is being improved to attain better multiplication rates *in vitro*, as well as better percentages of rooting and establishment of plants *ex vitro*. Successful tissue culture systems would enable the large scale rapid multiplication of clonal genotypes with an enormous advantage for commercial forestry (Bonga and Durzan 1987). A further improvement would be the study of somatic embryogenesis for artificial seed production (Suharyati and Umboh 1987; Redenbaugh *et al.* 1988; Moura-Costa *et al.* 1992), with potential for the mass propagation of tropical trees at a low cost (Mascarenhas 1988; Moura-Costa and Mantell 1993).

RESEARCH PROGRAMME AND OBJECTIVES

As mentioned previously, the project incorporates a strong research component, so that different methods for rehabilitation of logged rainforests may be developed and tested. Ten percent of the budget of the project is directed specifically towards research. Research priorities are identified and scientists approached to pursue particular investigations.

The project employs two full-time researchers, one data analyst and three research assistants. It maintains links with other institutions working with forest rehabilitation, such as the Forestry Department of Sabah, the Forest Research Institute Malaysia (FRIM, Kepong), Wanariset Research Station (Samarinda, Indonesia) and the ASEAN-Canada Forest Tree Seed Centre (Thailand). Another important source of expertise and scientific advice comes from researchers linked to other organisations currently working at Danum. DVFC is partially funded by The Royal Society, London, which sponsors an average of 10 researchers yearly, working on different projects related to tropical rainforest ecology and biology.

Two types of research are carried out. Firstly, research on large scale rehabilitation of logged forests, which aims to test different strategies in the form of large planting trials, as described throughout this paper. The second type of research involves more specialised investigations of plant physiology, light and photosynthesis studies, soil dynamics, plant nutrition and mycorrhizae, genetic improvement, plant propagation and tissue culture, entomology and pathology. These subjects are either directly addressed by our research team or pursued in collaboration with other scientists at DVFC, FRIM or the Forest Research Centre.

CONCLUSIONS

The rehabilitation of degraded logged forests for CO_2 offset is a novell concept. The RBJ-Face Foundation project has therefore being structured in such a way that research and field operations are fully integrated, so improvement of methods may be achieved relatively rapidly. For this reason, we also actively pursue collaboration with other institutions so that relevent research findings may be incorporated. Additionally, we try to divulge our results as soon as they become available, so that other foresters can make use of our experiences.

One obvious question raised is whether our forests can really offset the amounts of CO_2 produced by a power station ? Moreover, is this the most effective way of doing so ? We are aware that much uncertainty still surrounds the greenhouse effect and that planting trees is only a partial solution. A research project has recently been initiated in DVFC to quantify CO_2 offsets in logged forests, which should provide us with some answers. In any case, the planting of trees will not do any harm, and it undoubtedly accounts for the offset of some CO_2. Furthermore, the practices developed during the project will increase the local expertise in forest rehabilitation and management of natural resources. Finally, the project creates a precedent for the development of joint initiatives to tackle environmental problems.

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