# II.3. Measuring Greenhouse Gas Sources And Sinks In Slash-And-Burn Systems And Alternatives

Multi-date satellite images (LANDSAT-TM) were used to evaluate land-use change in Jambi Province during Phase I of ASB (see Figures 17 and 18 above). Some 19 land-use classes were identified and then grouped into 5 main land uses. Changes between 1986 and 1992 were quantified and the above-ground biomass change was estimated. It was shown that during that period the province contributed as much as 0.03 Gt C per year due to deforestation (land-use change). More recent studies, with relatively higher spatial resolution, have been carried out in two different ecological zones (piedmont and peneplain) and two different population densities in the peneplains (peneplains of Jambi and Lampung). Estimates of net carbon gains or releases are summarized in Table 8. Rantau Pandan, an area with lower population density and located in the piedmont zone, (where the intensity of land-use change is less) appears to serve as a net sink for atmospheric carbon. This is because increases in carbon stocks through accumulation of above-ground biomass more than offset the carbon released when above-ground biomass was harvested. In Bungo Tebo, forest conversion is rapid (although the population is relatively sparse). Here, carbon release is higher than the gain from accumulation of above-ground biomass. The situation is even worse in North Lampung, with its high population densities and rapid land use change.

**Table 8.** Net carbon release in 3 sites differing by ecological zone and population density.

| Site | General Characteristic | Carbon Release (Mt) | Carbon Gain (Mt) | Net Carbon Release (Mt/yr) |
|---|---|---|---|---|
| Rantau Pandan | Less populated<br>Less conversion | 2.3 | 3.9 | -0.26 |
| Bungo Tebo | Less populated<br>Much conversion | 11.9 | 3.9 | 1.33 |
| North Lampung | Densely populated<br>Much conversion | 13.3 | 3.1 | 1.78 |

Phase I of the ASB project in Indonesia also made a start with the measurement of soils under forests and other land use systems as sinks and sources of greenhouse gasses. The most interesting findings were the role of forest soils as sinks for methane (Figure 21). Considerable effort was spent on the testing and improvement of methods to measure the positive or negative fluxes of greenhouse gasses. The measurements are based on a closed sample chamber, in direct contact with the soil, from which repeated gas samples are taken. The gas samples are transported to the laboratory in 'vacu-tainers' (developed for medical purposes) and analyzed on a gas chromatograph.

### *Hypotheses to be tested:*

- Soils of agroforestry systems can be as effective as those of natural forests as a sink for methane and can thus partly off-set the methane emissions from wet rice (*sawah*) areas.

- The production of nitrous oxide (N2O) is correlated with the effective nitrogen supply in land use systems; it may be lowest in 'degraded' lands.

***Contact person:*** Dr. Yahya Husin, IPB, Bogor

## II.4. Ferns as Biodiversity Indicators in Rubber Agroforests

The 'segregate-integrate' analysis (described in Section I, Part 5), suggests that the role of low-to-medium intensity land use systems for biodiversity conservation can be judged on the basis of their productivity (relative to the maximum feasible) and biodiversity (relative to the maximum which can be conserved) value. In order to obtain such data, the biodiversity of land use systems should be studied in gradients of land use intensity (and related productivity). From the initial studies by ORSTOM we know that plant biodiversity of rubber agroforests can be 50-80% of comparable natural forest. We do not know, however, how we can scale up from these case studies to the total jungle rubber area in Sumatra. It is possible that the local ($\alpha$) diversity is indeed close to that of natural forests, but that all jungle rubber has the same species composition and the larger scale ($\beta$) diversity of these systems is much less than the value found in the case studies.

To test whether or not rubber agroforests reflect the biodiversity of natural forests at a larger scale, a new study was recently started, focusing on ferns as an 'indicator' group. Ferns are relatively easy to recognize and cover a wide range of microhabitats and niches. The study will focus on the peneplain in Jambi.

**Contact person:** Ms. Hendrien Beukema, UNESCO/ICRAF, Bogor

## II.5. Forest Ecosystem Management

Improved understanding of people <-> forest interactions is fundamental to developing effective options for the sustainable management of forested lands. In this respect both the ICRAF Alternatives to Slash and Burn project and the CIFOR Forest Ecosystem Management project share a common goal in building a knowledge base from both agricultural and forestry perspectives. Both are concerned with global, ecoregional studies and both have key study sites co-located in Latin America, Indonesia and Africa. Whereas ICRAF is concerned more directly with farming systems, CIFOR is focusing on wider aspects of land use in natural and modified forested landscapes and in developing spatial models that are concerned more with ecosystem function than with farming systems *per se*. Both approaches are complementary and the assessment methods, analytical tools and models developed in the course of resource evaluation are expected to contribute significantly towards improved methods of integrated natural resource management.

As in the other continental sites, in Jambi ASB and FEM are pursuing two key research lines. One, as yet in discussion phase, is concerned with exploring the functional relationships between biophysical aspects of forest landscapes and related sociological elements such as valuation and property rights. The other deals with the complementary study of plant biodiversity above and below ground. Together with ICRAF in Yurimaguas, Peru, FEM has already completed a field study of biodiversity changes under varying shifting agriculture and agroforestry systems. There, as in Jambi, ICRAF (TSBF) will study the below-ground macrofauna as well as soil nutrients and gas exchange. By combining the information obtained from both studies on the same sites it is hoped to greatly improve our understanding about the impact of different land uses on both the biotic and abiotic components of the natural resource. The accompanying map shows the location of collaborative study sites that include CIFOR's activities both with ASB and NGOs BIOTROP, Worldwide Fund for Nature (WWF Indonesia), the Asian Wetland Bureau (Wetlands International) and the University of Gadjah Mada (Sylvagama forestry concession).

**The Jambi ecoregional study has already paid some handsome dividends. Recently completed baseline studies in forest concessions surrounding the Kerinci Seblat National Park have revealed some astoundingly high levels of plant and animal richness, some of which are two to three times the richness encountered in pristine forest sites in the Western Amazon basin using the same recording techniques. This is illustrated in the accompanying graph (Figure 23) that also represents a newly discovered statistical relationship between the total numbers of vascular plant species and unique plant functional types or *modi* per 40 x 5 m plot. Implications from this study are that under conditions where taxonomic identifications are difficult, the readily observable functional types can be used to estimate directly the vascular plant species richness. This is of considerable potential use for rapid surveys of biodiversity and as a generic tool for comparing geographically remote sites where physical environmental conditions and plant adaptive responses are similar but where the taxa differ.**

The BIOTROP Pasir Mayang site is a study area that will see collaborative research develop between BIOTROP, ASB and FEM. The BIOTROP field station has already produced valuable information about nutrient cycling under different forest environments and with FEM is currently assessing the potential value of Plant Functional Attributes (PFAs) in characterising forest response to varying regimes of light and nutrients. FEM, ASB and BIOTROP intend to establish an intensive baseline study to examine how plant and animal biological diversity varies with different logging pressures. The well documented forest conditions make this an ideal study area for such purposes. CIFOR has recently signed an MOU with BIOTROP to help sustain such research collaboration.

Additional sites under discussion for joint ASB/FEM research are an upland (2,000 m.a.s.l.) forested landscape at Air Dingin. At the other elevational extreme, a site is being proposed in the coastal wetlands near the Berbak national park (Air Hitam Dalam). The latter site has extensive forests on deep peats and the region contains both black and white water systems analogous to those in Amazon river basin - albeit on a smaller scale. Shifting agriculture is practiced in this domain and the deep organic peats represent a significant carbon sink. ICLARM has expressed interest in integrating its research with FEM in this area as part of its proposed systemwide Coastal Wetlands initiative.

By coordinating joint ecoregional baseline studies of this kind within a series of tropical forested landscapes that are widely representative of conditions within the humid tropics, the CGIAR may gain valuable additional insights into the sustainability of production systems. These insights should assist in identifying and refining the parameters needed to conduct cost-efficient research into integrated natural resource management.

**Contact person:** Dr. Andy Gillison
Coordinator, Forest Ecosystem Management project, CIFOR
email: a.gillison@cgnet.com

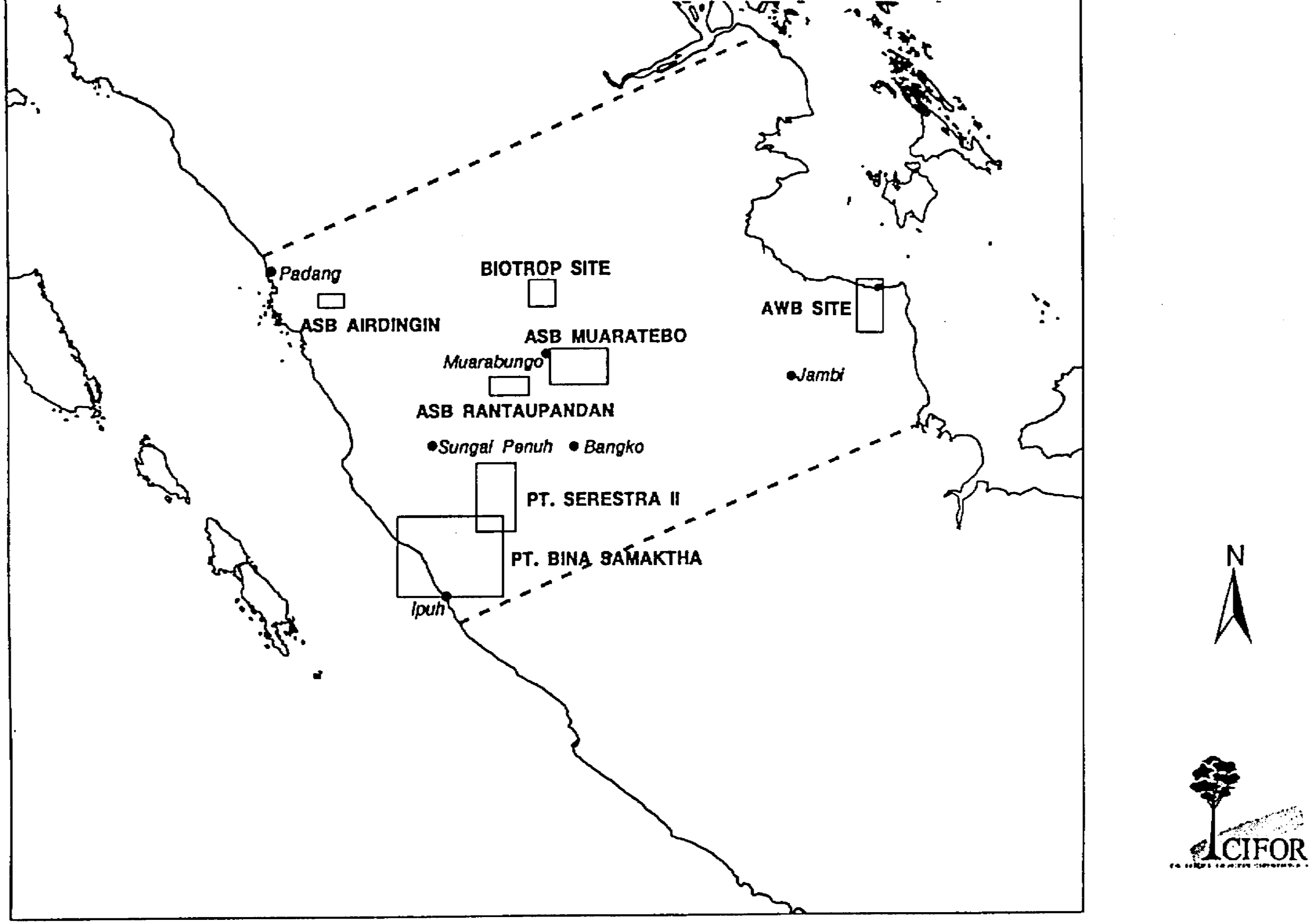

Padang
BIOTROP SITE
AWB SITE
ASB AIRDINGIN
ASB MUARATEBO
Muarabungo
Jambi
ASB RANTAUPANDAN
Sungai Penuh
Bangko
PT. SERESTRA II
PT. BINA SAMAKTHA
Ipuh
N

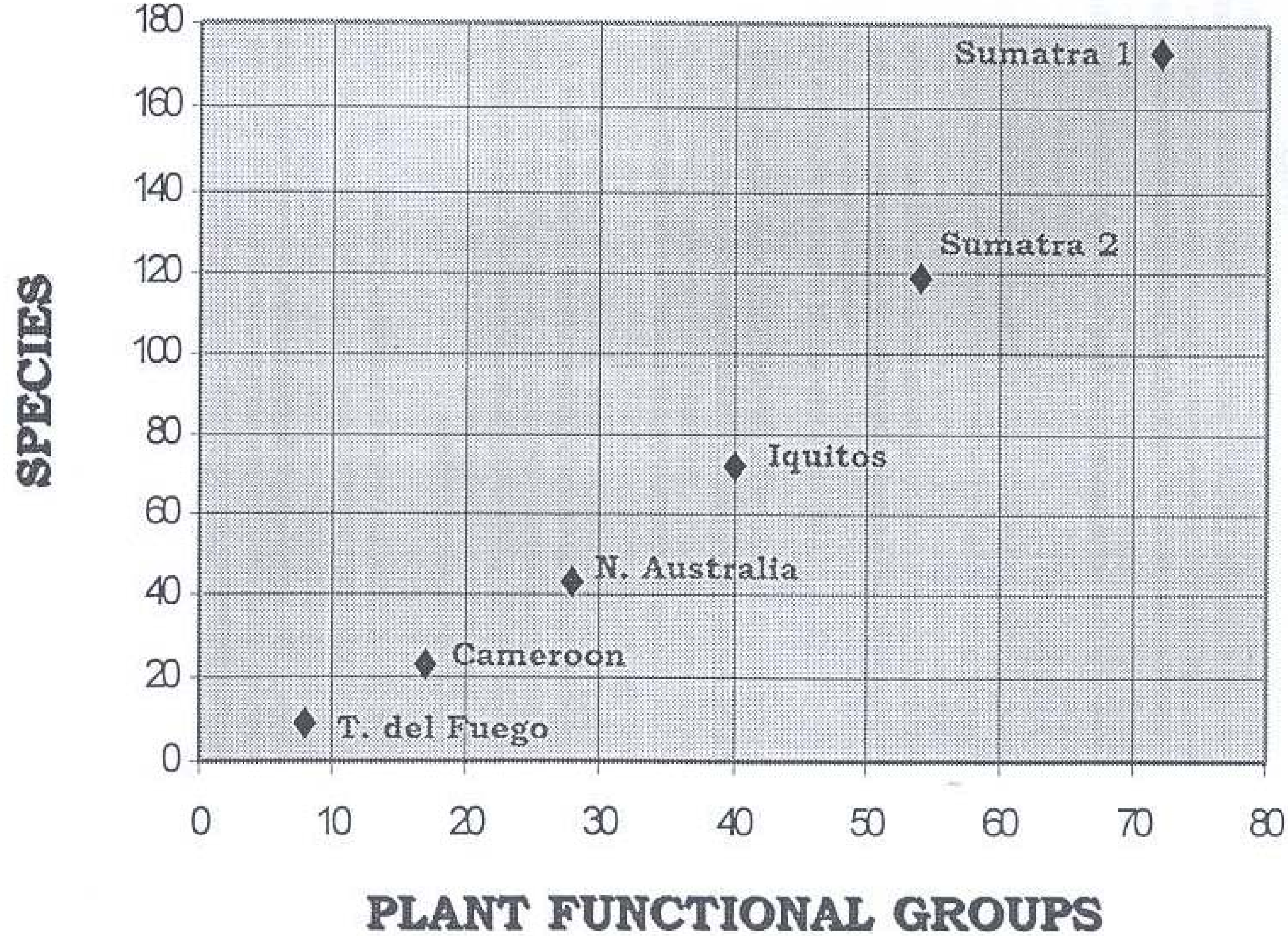
Table 9

## Initial Sample Plot Locations for F.E.M. Biodiversity Assessment.

*Ecoregional Gradsects - Sumatra, Indonesia.*

| Locality | Site-no | Latitude | Longitude | Elevation | Parent material | Soil type | Vegetation |
|---|---|---|---|---|---|---|---|
| **Berbak National Park (AWB - Site)** | | | | | | | |
| Simpang Bayas Air Hitam Dalam | AHD01 | 1 ° 16' 24" S | 104 ° 09' 00" E | 3 | Recent Alluvium | Tropical Forest Peat | Mosaic dryland rice, Orchards |
| Simpang Batang | AHD02 | 1 ° 17' 24" S | 104 ° 09' 24" E | 3 | | | Tall swamp, forest on alluvium |
| Simpang Batu Pahat | AHD03 | 1 ° 17' 16" S | 104 ° 09' 16" E | 3 | | | |
| Sungai Rambut | AHD04 | 1 ° 14' 34" S | 104 ° 09' 34" E | 1 | | | |
| Sungai Akar, Nipah Panjang | AHD05 | 1 ° 02' 45" S | 104 ° 09' 57" E | 0 | | | |
| **Pasir Mayang (Biotrop Site)** | | | | | | | |
| Unlogged, Block G2/20 (1984) | BIO1 | 1 ° 05' 00" S | 102 ° 05' 34" E | 60 | Carbonaceous mudstones | Gibbsitic and kaolinitic | Jambi lowland forest (<150m) |
| Logged, Block 1983/1984 | BIO2 | 1 ° 04' 33" S | 102 ° 05' 34" E | 60 | | ferralitic soils | logged over, mosaic rubber |
| Clear cut 1976 | BIO3 | 1 ° 05' 24" S | 102 ° 05' 32" E | 75 | | | plantations |
| **ICRAF Site A** | | | | | | | |
| Rantaupandan area | ASB01 | 1 ° 38' 40" S | 102 ° 08' 19" E | 100 | Recent alluvium | Gibbsitic ferrallitic soils | Forest upper rawas to B.Hari |
| | ASB02 | 1 ° 34' 57" S | 102 ° 16' 19" E | | Light-grey acidic pumice tuffs | | Jambi lowland forest <150m, |
| | | | | | Quartz sandstone | | logged over, rubber plantation |
| **ICRAF Site B** | | | | | | | |
| Bungotebo area | ASB03 | 1 ° 35' 53" S | 102 ° 21' 48" E | < 200 | Light-grey acidic pumice tuffs | Gibbsitic ferrallitic soils | Jambi lowland forest <150m, |
| | ASB04 | 1 ° 34' 07" S | 102 ° 22' 18" E | | | | logged over, secondary/derived |
| | | | | | | | types mosaic, dryland rice |
| **ICRAF Site C** | | | | | | | |
| Air Dingin Barat | ASB05 | 1 ° 08' 08" S | 100 ° 46' 48" E | 1600 | Undifferentiated volcanic rock; | Gibbsitic & kaolinitic | Secondary/derived types |
| | | | | | tertiary andesite | ferrallitic soils, | mosaic 300-1000m, forest |
| | | | | | | Lowland alluvial soils | |
| **PT. Sylvagama (GMU Site)** | | | | | | | |
| Logged, Block 1984/1985 | UGM01 | 1 ° 34' 16" S | 102 ° 23' 14" E | 15 | Carbonaceous mudstones | Gibbsitic and kaolinitic | Jambi lowland forest formations (<150m) |
| | | | | | | ferralitic soils | logged over. |

# PLANT FUNCTIONAL GROUPS AND SPECIES RICHNESS FOR A RANGE OF GLOBAL SITES



## II.6. Tropical Forest Ecology Research in Pasirmayang

The Southeast Asian Regional Centre for Tropical Biology (SEAMEO BIOTROP) has established a field station in the lowland forest of Jambi at Pasirmayang, just N. of the Batanghari river. On this site Biotrop cooperates with P.T. Ifa - Barito Pacific Timber Group.

Biotrop's research in Pasirmayang is organized in six research activities:

- 'Management and monitoring system for sustainable utilization of forest resources'
- 'Increase and optimization of productivity of forest plantation and natural forest production'
- 'Proper silvicultural and agrosilvicultural techniques for natural forest production and forest plantation'
- 'Establishment of hedge orchards as source of mass planting materials of *Shorea* spp. and *Dyera* spp.'
- 'Providing pest and disease resistant planting materials of timber estate tree species (*Acacia, Paraserianthes, Eucalyptus*) through micropropagation'
- 'Tree improvement of *Shorea* spp. and *Dyera* spp. by means of somatic embryogenesis'

(A brochure entitled 'Biotrop-Barito Pacific Timber Tropical Forest Research Site Pasirmayang, Jambi, Sumatra' gives further details and illustrations.)

Ongoing research of Biotrop's forest ecology division in the Pasirmayang permanent forest plots includes:

- Measurement of litterfall and productivity of logged-over and primary forest,

- Measurement of the decomposition rate of organic inputs in primary and logged-over forest,

- Study of the nutrient cycle of natural forest.

- Study of the vegetation dynamics of natural forest (primary and logged-over forest).

Long term objectives of the research are to know the productivity of natural lowland forest, especially after logging activity, and the best ecological conditions for the regeneration and growth of the forest after exploitation.

Specific objectives :
a. To know the productivity of natural forest (primary forest, logged-over forest and secondary forest) through the littertrap method,

b. To understand and measure the decomposition rate of litter using litter bags on forest floor from various forest condition,

c. To know the nutrient status of the forest through the measurement and analysis of nutrient content of trees, poles, saplings, seedlings, litter, rainfall, soil, as basic information for studying the nutrient cycle of the ecosystem,

d. Forest dynamics : increment of diameter and patch dynamics.

Research methods and initial results :

The form of litter trap used in the forest productivity study is circular with a diameter 1 m, made of kassa nylon, and placed continually and systematically above the soil surface at about 1 m from the ground. The total number of littertraps established in the primary forest are 75 traps in the area of 3 ha, while in the logged-over forest the total number is 25 traps in the area of 200 m x 200 m. Litter has been collected from the traps every month since August 1991 and weighed (after drying). Litter collected from the traps is separated according to tree species and litter components (leaves, flowers, fruits, twigs, barks and others).

Leaves give the biggest contribution of the total litter production in the primary forest (62.1 %) followed by twigs (21.5 %), bark (4.5 %), fruits (2.9 %) and flowers (1.3 %). The total dry weight of the litter production is 10.0 ton $ha^{-1}$ $year^{-1}$. The leaf component increases markedly during the dry months. The highest amount of litter was found during August-September-October 1991. The rest of the data showed relatively stable litter production. A tentative conclusion is that the biggest total litter production is found in the vegetation dynamics phase 'homeostatic II', which consists of big and mature trees with relatively high branches and a wide canopy cover.

For the decomposition study, litter is put inside litter bags of 0.5 m x 0.5 m placed on the ground in direct contact with the soil surface. The total number of litter bags placed in the primary forest is 396, whereas in the logged-over forest there are 72 litterbags. Every two months a series of litterbags is taken into the laboratory to be weighted (dry weight).

To measure the nutrient content of the vegetation, a sample plot of 20 m x 20 m is used for each forest condition. The sample material is taken from each vegetation component of each vegetation stage (such as undergrowth, seedling, sapling, pole and tree), soil, humus, litterfall and rainfall. All these materials are analyzed in the laboratory for the nutrient content ( N, P, K, Ca, Mg, C and C/N ratio). Samples were collected in July 1994 for the dry season and in February 1996 for the wet season aspect.

Measurements of tree diameter in the primary forest for trees with a diameter of 30 cm and up were carried out in 1984, 1987, 1992 and 1994; for trees with a diameter 10 - 30 cm in 1986, 1988, 1990, 1991 and 1994; for trees with a diameter 3 - 10 cm in 1989 and 1991. In logged-over forest, measurements of diameter for trees with diameters of 10 cm up were carried out in 1984, 1987, 1992 and 1994.

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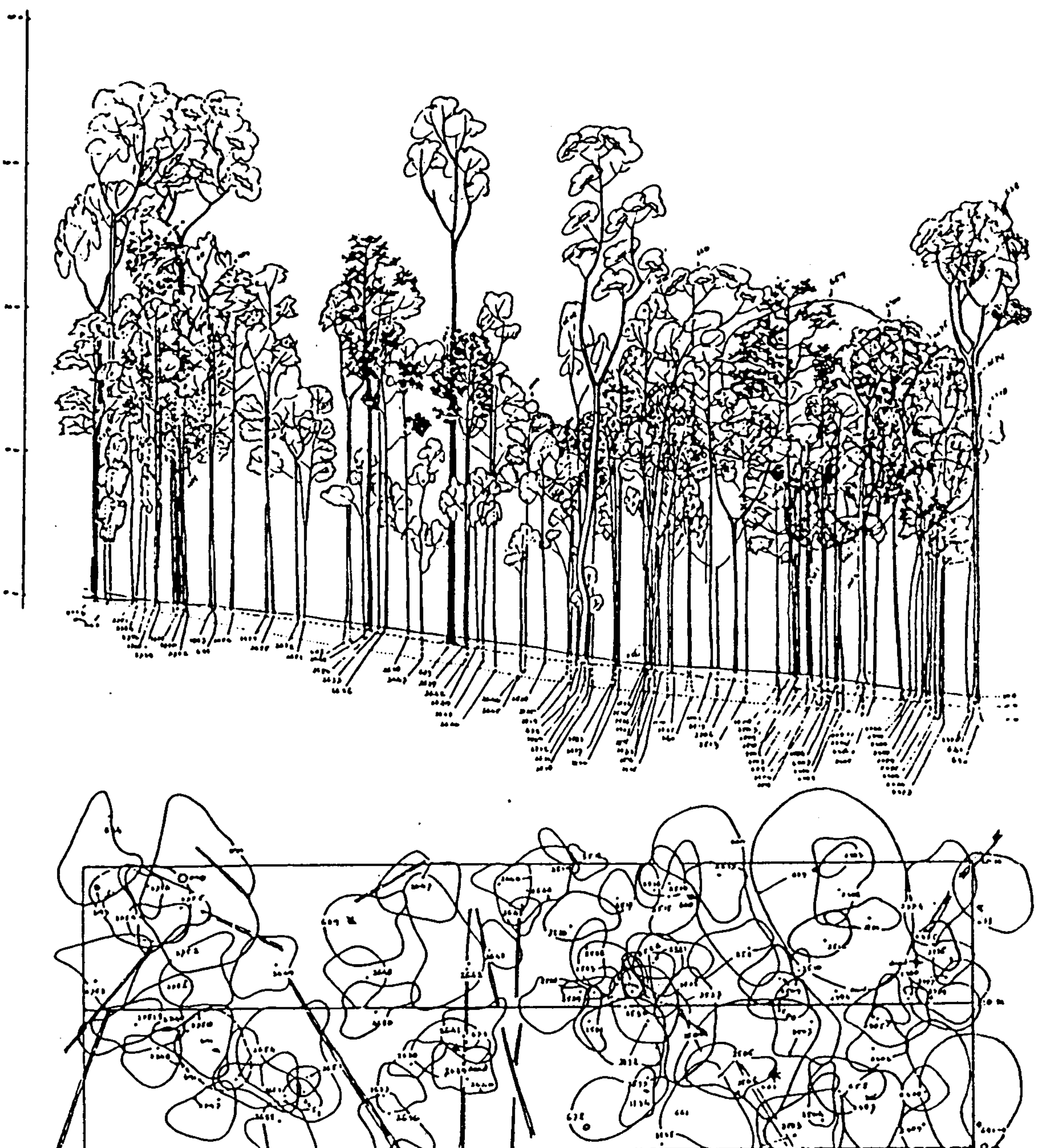
BIOTROP
P.O. Box 116, Bogor
Fax 062-251-326851

**Figure 24.** Profile Diagram of Lowland Dipterocarp Forest at BIOTROP's Permanent Plot, Pasirmayang, Jambi (50 m.a.s.l.)



TC. Monitoring Deforestation (1990)

# II.7. Research on Forest Ecology, Mycorrhiza, and Silviculture in Muara Tebo

*Collaborating Institutions*:
Gadjah Mada University (GMU), Yogyakarta, Indonesia
Kansai Environmental Engineering Center (KEEC), Japan

## *Background*

Deforestation and degradation of tropical rain forests have accelerated and valuable recourses have been lost in recent decades. Mixed dipterocarp forest, the core of rainforests in Southeast Asia, present the problem of whether or not these diverse and rich bio-resources can be utilized in a sustainable way. Furthermore, the decrease in area of rainforests is generally believed to affect the local as well as the global environment. Proper conservation and reforestation of the rainforest is one of the ways to preserve these diverse and renewable resources.

A key aspect in our understanding of mixed dipterocarp forests is the mechanism and pattern of natural regeneration. It is understood that most dipterocarp species live in symbiosis with mycorrhizal fungi forming ectomycorrhiza. In order to promote reforestation of tropical rainforests, it is necessary to advance the silvicultural technology to utilize those natural organisms with tree propagation methods. Such technologies can be investigated through establishing experimental plantations of dipterocarps.

The Faculty of Forestry of Gadjah Mada University (GMU) and KEEC developed a long term program for research, education and training in the forest concession belonging to the GMU Foundation in Jambi Province.

## *Objectives*

1. To advance the methods and (bio)technology for managing tropical rain forest, specifically for regeneration of dipterocarp forests.

2. To prepare a technical manual on intensive silviculture and conservation of the main dipterocarp species.

## *Research activities*

**1. Botanical studies**
1.1 Collection, identification and phenology of dipterocarps,
1.2 Preservation of seeds, plant material and mother trees,
1.3 Develop a technique of growing wildlings as nursery stock, study of micropropagation,
1.4 Genetic analysis using electrophoresis and isozyme analysis.

**2. Mycorrhizal studies**
2.1 Collection of fungi and ecological studies aimed at selection of efficient mycorrhizal fungi,
2.2 Culture of *mycelia* and preservation of spores of efficient fungi,
2.3 Selection of suitable substances for immobilization of spores or mycelia for inoculum production,
2.4 Testing inoculation methods and controlling environmental conditions for mycorrhizal formation and seedling growth
2.5 Evaluation of the effectiveness of mycorrhiza formation and co-inoculation of mycorhizal fungi and nitrogen fixing bacteria.

**3. Silvicultural studies**
3.1 Field test of inoculation with various tree - fungus combinations,
3.2 Establish silivicultural techniques for planting Dipterocarps
3.3 Analysis of the natural forest ecosystem and regeneration process.

## *Expected results*

- Identified species of dipterocarps and other species in tropical rainforests shall be collected for a gene bank and at the same time selected for use in tree nurseries.

- Biological aspects of the symbiosis shall be clarified and effective fungi and microorganisms shall be collected and stored.

- Nursery techniques for dipterocarp fungi shall be developed and reforestation of devastated areas shall be made possible. Reforestation of tropical rainforests in Indonesia and elsewhere and the required silvicultural techniques for establishing dipterocarp plantations shall be systematically studied.

***Contact person:*** Dr. Suryo Hardiwinoto, Gadjah Mada University

# II.8. Upland Rice Consortium

### *The Upland Rice Consortium*

IRRI and research institutions in India, Indonesia, Thailand, and the Philippines have formed the Upland Rice Research Consortium (URRC). Each of these institutions have agreed to accept different responsibilities to contribute to achieving common goals. The consortium can harness the growing capacity of national research systems and institutes to conduct strategic research and address broad issues vital to improving the productivity and sustainability of highly variable upland rice ecosystems. Appropriate key-sites, selected by each member country and by IRRI, representing the major constraints and opportunities for increasing rice production, profitability and sustainability. Each key-site has its specific mandate of common issues.

### *Program goals and rationale*

The overall program goals are to rehabilitate and sustain upland farming systems and to secure rice production for local communities. About 90 percent of the world's rice is produced in Asia, Africa and Latin America -- where more than half of the world's population lives, mostly at subsistence levels. Diversity of upland areas is a major constraint; they usually have poor or degraded soils with topographies ranging from slopes to well-drained flat land. Limited labor, capital, skill, and high risks of farming are the other major constraints to crop production in upland farming systems. Rice yields average 1-2 ton per hectare or less. Slash and burn agricultural practices open way for serious soil erosion and soil degradation. In Indonesia only about five percent of rice is produced in upland areas. But future rice production will be diverted to unfavorable upland farming systems, especially in the Outer Islands, where the ratio of upland to irrigated lowland rise is 12.6. Improvement of soil productivity and crop productivity can be achieved only by introduction of high input technology. But this has proven to be difficult for resource-poor farmers. A system of soil and crop management, that is sustainable, economically feasible, acceptable to farmers, and environmentally safe, has not evolved yet.

### *Soil management*

The Sitiung key-site has the mandate of soil management. In the first phase (1991-1993), the general objectives are: (1) To generate appropriate sustainable technologies for upland rice and selected upland rice farming systems for upland acid and infertile soils, (2) To improve capability for multi-disciplinary research on constraints to upland rice yield particularly in the area of soil management.

Three major research activities are soil fertility management, upland rice-based farming systems, and rice germplasm management. In the second phase (1994-1996), the general research objectives are: (1) To find upland rice varieties/lines which are more appropriate and adapted to upland infertile acid soils; (2) To prepare basic technologies for establishing the more appropriate sustainable production systems on upland rice-based farming systems in acid soils of Red Yellow Podzolics, with special attention to soil conservation techniques and technology components; (3) To find and clearly understand mechanisms and processes involved in declining soil fertility and productivity in upland acid infertile soils; and (4) To understand processes influencing changes in physical and chemical properties of acid soils. In this phase three major research activities are germplasm improvement, management of biotic and abiotic constraints, and soil nutrient management.

### *Research achievements*

Soil fertility management: High aluminum content causes nutrient imbalance in the Sitiung acid soils. The most important effect of aluminum toxicity is the restricted root growth which eventually reduces capacity of plants to absorb water and nutrient. Both pH and the Al saturation (more than 60%) suggest that liming is required. Complete nutrient supply (N, P, K, Ca, Mg, S and Zn increased upland rice grain yield almost threefold compared to controls. This finding shows the potential of Red Yellow Podzolic soils of Sitiung when well-managed in terms of nutrients. High Al and Mn contents in the rice straw when no nutrients are supplied indicates that the acid soils of Sitiung are highly weathered. Phosphorus is the critical nutrient in upland acid soil. Upland rice initially responds more to applied phosphorus than to lime. With continuous application of lime, Al toxicity will decrease and thus improve the availability of soil nutrients. Soil amelioration indicated that soil chemical status tends to be improved. Further studies to determine the corrected ameliorant in relation to cropping season, and on subsoil acidity amelioration is being carried out. Cumulative crop responses to applied P in relation to soil P fixation characteristics, management and climate are also conducted. Another major constraint of this acid soil is the low organic matter content. Introduction of conservation tillage combine with sowing of centro was beneficial in maintaining the level of organic matter content within the soil.

Upland rice-based farming systems: Understanding of interacting production factors in developing upland rice-based farming systems under acid soil in Sitiung are explored through weeds, blast, nematodes, and alley cropping management. About 41 weed species belong to 15 families were found associated with upland rice. Weed control increases upland rice grain yields by 2 to 5 times. Blast severity was related to rice cultivars and soil nutrient status, or fertilizer application. The root lesion (Pratylenchus zeae) and the root-knot (Meloidogyne spp) nematodes are the most prevalent and reduce rice yield. Alley cropping practices and contour hedgerows reduced soil erosion, increased soil surface stability, and could maintain soil productivity on undulating or sloping land in the long-run.

Rice germplasm management: Eleven upland breeding lines have been identified that are able to produce grain yields of 2.6-3.2 ton/ha with low N and 2.9-3.9 ton/ha with NPK. Neck blast infestation varied between 0-15 percent. The introduced cultural practices perform better than farmers' practices. In-depth studies on introduced cultural practices, cultivars used and soil nutrient management are needed.

### *Improvement of research capability*

IRRI-URRC is providing formal and informal training of scientist involved in the consortium on specific aspects, such as blast management, soil fertility management, data analysis and interpretation. Workshop and key-site visits may broaden knowledge and expertise of scientists.

### *Contact persons:*

Dr. Ahmad Fagi and Dr. Soetjipto Partohardjono
Central Research Institute for Food Crops, Bogor

## II.9. Smallholder Rubber Agroforestry Project (SRAP)

**Project title:** Improving the productivity of smallholder rubber agroforestry systems

**Preparatory phase:** 1994 - 1996, based on funding by ICRAF, CIRAD, GAPKINDO,
**Implementation and extension phase:** 1996 - 2000; pending approval of USAID funding for the initial period, as well as other sources

**Partners in research:**
ICRAF (International Centre for Research in Agroforestry), Bogor, Indonesia,
GAPKINDO (Association of rubber professionals), Jakarta, Indonesia,
CIRAD (Tree crop department, rubber programme) France,
ORSTOM France
IRRI-Sembawa (Indonesia Rubber Research Institute), Sembawa, South Sumatra, Indonesia,
CRIFC (Central Research Institute for Food Crops), Bogor, Indonesia
DISBUN and BAPPEDA in West Sumatra province, Indonesia
SFDP/GTZ project in West Kalimantan, Indonesia
Bangor University (UK) and Leverhulme Trust

**Contact person:** Eric Penot, ICRAF, Bogor

**Locations:**
Muara Bungo (Jambi),
Sanggau and Sintang (West Kalimantan)

**Objectives:**
- Test of 'improved' planting material for increasing productivity of smallholder production systems based on agroforestry as an alternative to the 'block planting' systems for which this germplasm was originally selected,
- Identifying the minimum required input (fertilizer) and management (weeding) regime for benefiting from the increased genetic potential of selected rubber germplasm,
- Testing how the supply of such 'improved' planting material can best be organized.

**Background**
A general introduction to rubber agroforestry systems in Indonesia was given above (Section I, Part 4). In this project the emphasis is on increasing the total factor productivity (considering returns to land, labor, and capital) of smallholders outside the reach of capital-intensive 'projects'.

Since the introduction of *Hevea* rubber in Sumatera some genetic differentiation has occurred and farmers identify a number of rubber types in the seedlings they collect from existing rubber agroforests. Yet, the genetic production potential of these 'farmer selected' seedlings is considered to be low. Normal yields are around 500 kg per hectare per year in the productive stage and it may take up to ten years after planting before production starts.

'Improved' rubber comes in two forms: clones of selected trees, vegetatively propagated by grafting, or 'polyclonal seedlings', collected from a specific garden with a variety of selected clones. The best known polyclonal seedlings are known as BLIG (Bah Lias Isolated Garden from the London - Sumatra estate in North Sumatra).

The price of these 'improved' planting materials ranges from 20-30 Rupiah for GT1 seedlings, via 80-120 Rupiah for BLIG seeds and 500-700 Rupiah for a grafted stump with selected clones to 1200 Rupiah per plant for grafted stumps in a polybag. Production with these planting materials may reach 1500 to 1800 kg per hectare per year and the immature period may be reduced to 5 years.

'Domestication' and selection of 'improved' rubber germplasm has focused on intensively managed plantations. The main question is whether these 'domesticated' trees can still survive in the relatively wild and competitive environment of the low input 'jungle rubber', with its interesting biodiversity-preservation and forest functions, or that they indeed need the intensive care given to them in the plantation system.

The research project (and related activities) consist of a number of elements:

1. A series of on-farm tests of the 'improved' germplasm in comparison with the 'local' germplasm, in various intercropping patterns ('rubber agroforestry systems' RAS 1, 2 and 3 - see Figure 10, p.14),
2. Experiments to identify the minimum weeding regime required to secure establishment of various types of rubber germplasm,
3. Experiments to test the role soil fertility and fertilizers can play in modifying the interactions between rubber trees and other components (weeds),
4. Studies of financial profitability of the various planting materials and management regimes,
5. Studies of the farming systems in which local and 'improved' rubber germplasm are used,
6. Studies of the marketing of improved rubber planting material,
7. Research on consequences for biodiversity of the management intensity in various forms of rubber agroforestry.

## On-going experiments in Jambi

**Rubber Agroforestry System 1 (See Figure 25)**

*Weeding intensity trials*

Farmer participatory trial to asses the required weeding intensity. The trial includes a treatment with legume cover crops to represent the environment for which the rubber clones were selected. Low weeding levels may be attractive from a labor supply and biodiversity point of view, but may cause unacceptable delays in the initial growth period.

*Soil fertility by weed interaction*

Fertility by weeding experiment at Sepungur. If competition between rubber and 'weeds' is specifically for nutrients, supplying the rubber trees with additional nutrients (fertilizer) may reduce the need for weeding, and this allow higher biodiversity levels to be retained. See the trial layout in Figure 26.

Figure 25. RAS 1: clonal rubber in an agroforestry environment

***RAS 1 : a low input and labour rubber based complex agroforestry system with high biodiversity***

***Hypothesis :*** a minimum level of weeding and fertilization may allow clonal rubber planting material to grow in "jungle rubber " conditions , thus with higher biodiversity, similar to that of jungle rubber.

**Jungle rubber biodiversity is relatively close to that of primary forest (De Foresta, Thiollay)**

***Objective :*** identify the minimum level of weeding for a given low level fertilization in order to maintain a good rubber growth

***Target :*** farmers with no limitation on land but limited ressources in cash and labour

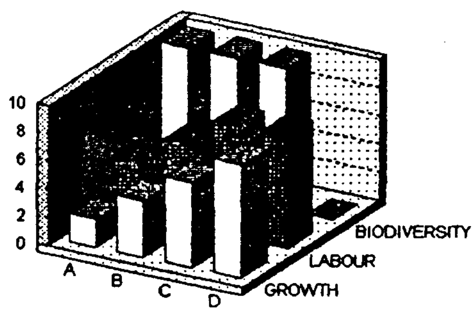
TREATMENT

| 4 levels of block | weeding per year | inter-row |
|---|---|---|
| A | 4 | forest regrowth |
| B | 6 | forest regrowth |
| C | 8 | forest regrowth |
| D | 9 | covercrops/Control TCSDP system |

**CLONE GT 1**

Fertilization : P at planting, N every 3 months for the first 2 years

**type of results**




A good growth is essential for clonal rubber survibility. A delay in growth induces a delay of opening, thus a delay in production and a less total production. Clonal planting material production is more depending of germplasm than growth in itself compared to seedlings. Clones are a more fragile type of planting material and require more weeding than local unselected seedlings to survive in a complex agroforestry environment.

**DESIGN**

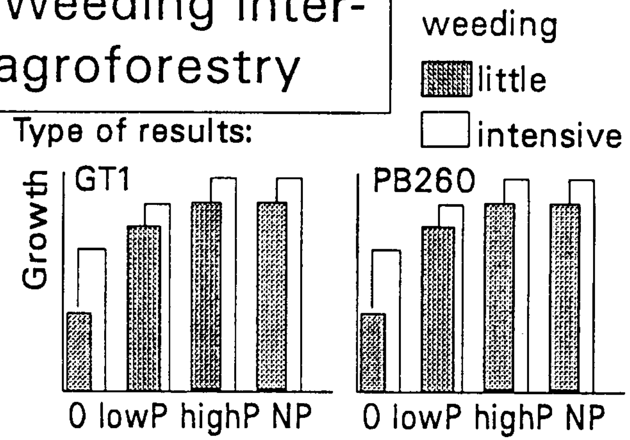
| A | B | C | D control |
|---|---|---|---|
| 4 WEEDING/YEAR in the row | 6 WEEDING/YEAR in the row | 8 WEEDING/YEAR in the row | 8 WEEDING/YEAR in the row COVERCROPS |
| Forest regrowth in the inter-row | Forest regrowth in the inter-row | Forest regrowth in the inter-row | TCSDP system ruber monoculture |
| High biodiversity | High biodiversity | High biodiversity | 0 biodiversity |
| Very low labour average to slow growth | medium labour average growth | medium/high labour good growth | high labour good growth |

"TCSDP type" is the current high input rubber monoculture model developed by the Tree Crop Smallholder Development project (WB).

# P and N fertilizer * Weeding interaction in rubber agroforestry

***Hypothesis:***
P fertilizer can reduce need for weeding and thus allow higher biodiversity

Type of results:




*Main test: interaction of F * W per G

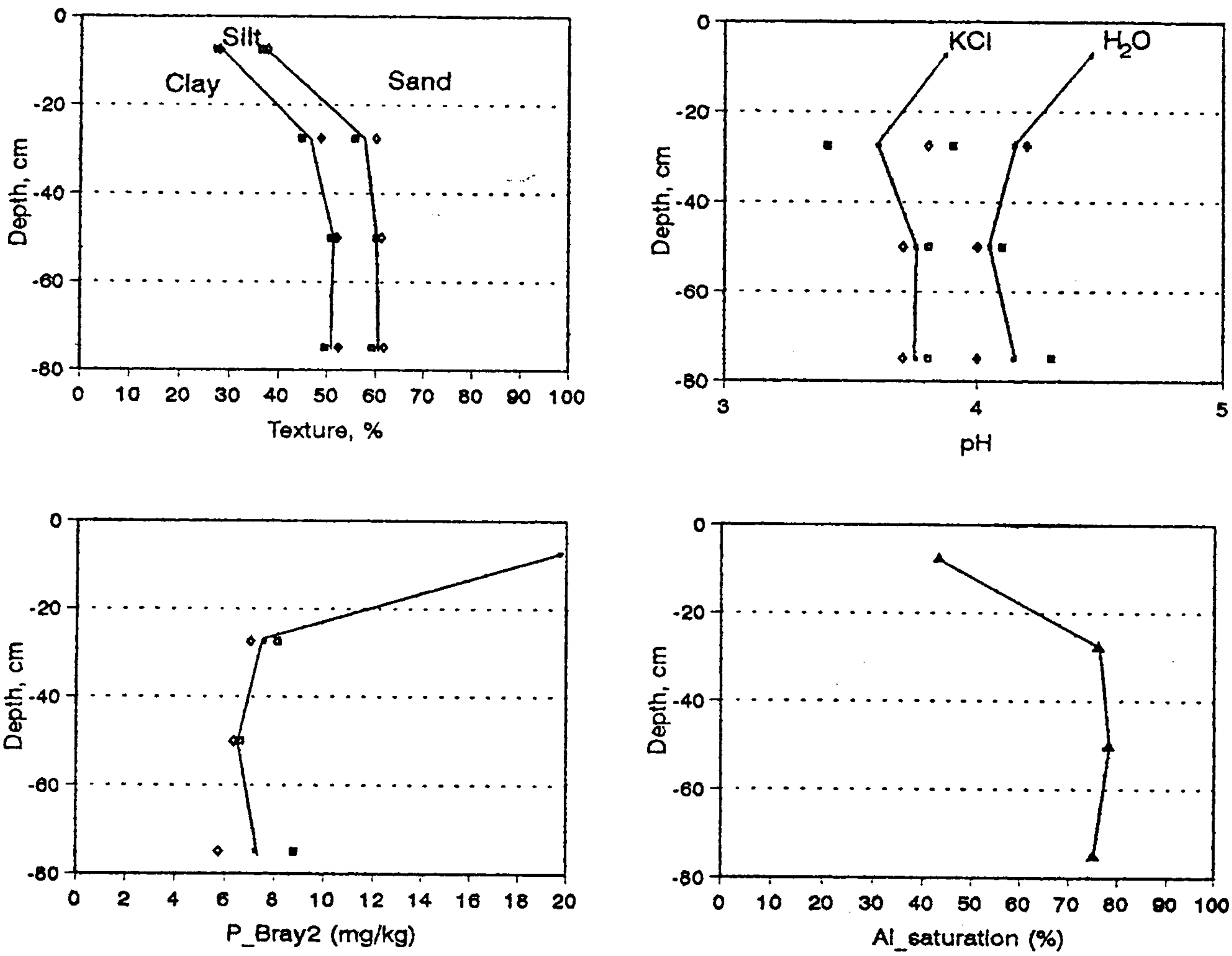
Treatments:

1. Germplasm (GT1 seedlings, PB260 budded stump)
2. Fertilizer
   - F0 = no fertilizer
   - F1 = P at planting (12 kg/ha)
   - F2 = High P
   - F3 = High P, High N
3. Weeding (L = low, H = high intensity)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ***GT1*** F0 L | ***GT1*** F3 H | | | | | | |
| ***PB260*** F2 H | ***GT1*** F3 L | ***PB260*** F1 L | ***GT1*** F2 H | ***GT1*** F0 H | ***PB260*** F2 H | | |
| ***GT1*** F2 H | ***PB260*** F2 L | ***PB260*** F0 H | ***PB260*** F3 L | ***PB260*** F1 H | ***GT1*** F3 L | ***GT1*** F1 L | ***PB260*** F0 L |
| ***PB260*** F3 L | ***GT1*** F1 H | ***GT1*** F2 L | ***PB260*** F3 H | ***GT1*** F2 L | ***PB260*** F2 L | ***PB260*** F3 H | ***GT1*** F3 H |

N

**Figure 27.** Soil characteristics at Sepungur



*Analysis of tree-weed interactions above- and belowground*
Below- versus aboveground tree-weed interaction trial at Rantau Pandan (Figure 28). This trial is aimed at separating above- and belowground factors in competition between rubber and other trees (weeds). This trial forms part of the PhD research of Ms Sandy Williams (Univ. of Bangor, UK).

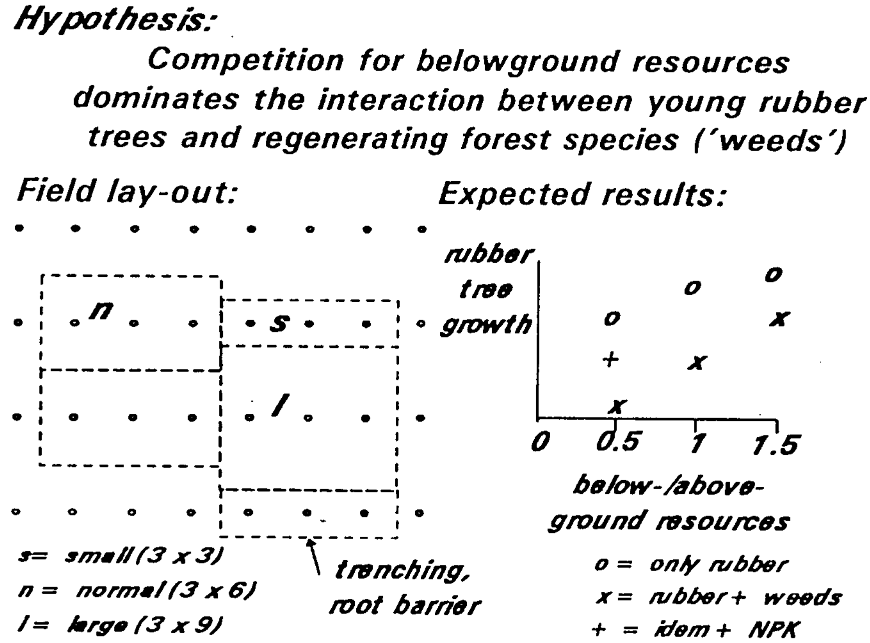



**Figure 28.** RAS 1: layout of tree-weed interaction trial

*Analysis of tree-tree interactions in the productive stage of jungle rubber*
The purpose of this research is to better understand the nature of competitive interactions in more mature rubber stands and to identify above- and below ground tree architectural traits which are important for the success of rubber germplasm.

**Rubber Agroforestry System (RAS) 2**
Intercropping of rubber and cinnamon, compared to the respective monocultures under on-farm conditions in Rantau Pandan (Figure 29).

Figure 29. RAS 2.5: trial of clonal rubber intercropped with cinnamon

***Hypothesis :*** with a minimum level of weeding and fertilization cinnamon can grow in a clonal rubber plantation in the inter-row : thus weeding and maintenance profit to both crops.

***Objective :*** identify the effect of association on both crops and compare clonal rubber in RAS 1 type (with 6 weedings per year) with the association rubber + cinnamon and cinnamon only in traditionnal system.

***Target :*** farmers with no limitation on land but limited ressources in cash and labour

*LOCATION:* In the Jambi province , in the piedmont of the Barisan moutains (Rantau Pandan).

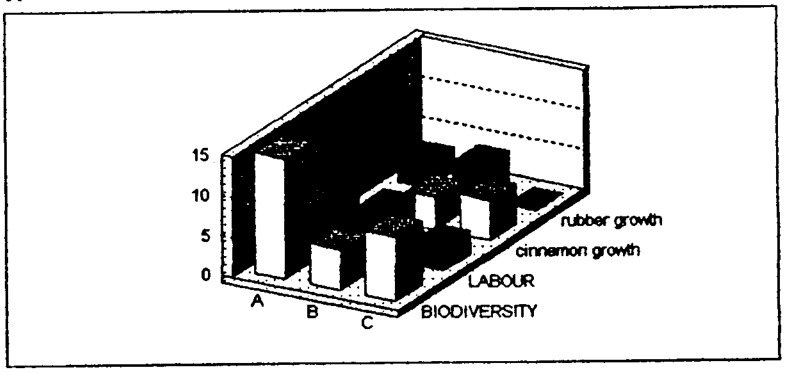
**TREATMENT**

| block | CROPS |
|---|---|
| A | RUBBER (RAS 1 type) |
| B | RUBBER + cinnamon |
| C | cinnamon (traditionnal) |

**CLONE GT 1**

Fertilization of rubber: P at planting, N every 3 months for the first 2 years

**type of results**




A good growth is essential for clonal rubber survibil
Weeding to both cinnamon and rubber increase ret
to labour compared to cinnamon only.
Biodiversity islow to medium according to the speci
that the farmer will allow to grow in the inter row
with cinnamon.

**DESIGN**

| A | B | C |
|---|---|---|
| **RAS 1 type control**<br>6 WEEDING/YEAR in the row<br><br>Forest regrowth in the inter-row<br><br>High biodiversity<br><br>Medium labour average growth | **RUBBER + CINNAMON**<br>6 WEEDING/YEAR in the row<br><br>Some trees allowed to grow in the inter-row<br>Medium to low biodiversity<br>medium labour | **CINNAMON ONLY**<br>TRADITIONNAL SYSTEM<br><br>low managemen,t very extensive<br><br>medium biodiversity<br><br>low labour |

# II.10. Policy Research on Community Forestry

### *Background*

Policy work began in mid-1994 in Indonesia as an integral component of ASB research. Priorities for policy research are driven by the needs of two broad groups of clients: *smallholders* living in the forest margins and on degraded forest lands and the *policymakers* who influence the range of choices available to these smallholders.

Land and tree tenure, including community forestry, currently are the priority issues for policy research because strong demand by policymakers has created good prospects for research to support an ongoing process of policy change. (There are two other main elements of ICRAF's policy research agenda. One is research on the role of agroforestry systems, with a focus on Indonesia's complex agroforests, as a component of a sustainable land use mosaic in the uplands. The other element of the policy research agenda addresses the broader forces driving land use change, including public investment in road construction (Section II.12) and certain trade restrictions that affect marketing opportunities (e.g., Section I.6).)

### *Objective*

Exploration of options for community participation in forest resource management, undertaken with the participation of various stakeholders, is aimed at enhancing prospects for poverty alleviation, efficient production, and conservation of resources. The objective is to synthesize the base of knowledge and institutional experience for a new generation of tenure policies.

#### *Research Partners*

Bogor Agricultural University (IPB)
Directorate General of Replanting and Land Rehabilitation (RRL)
Forestry Research and Development Agency (FORDA)
Gadjah Mada University
ICRAF SE Asia, including scientists seconded from ORSTOM
LATIN, WATALA, Bina Swadaya (Indonesian NGOs).

### *Policy Questions*

Do formal and informal institutions and the regulatory framework create incentives that are compatible with sustainable resource management? In particular, do tenure institutions and regulations establish and enforce clear resource access and property rights? If not, what (if anything) can governments do to better support improved functioning of tenure institutions?

### *Forest Policy Domains*

Policy problems and institutional challenges distinguish three distinct forest policy domains: (1) buffer zones of protected forest areas, (2) margins of production forests, and (3) degraded production forests and watersheds. Policy objectives (regarding the mix of forests' environmental and production functions) and policy problems differ significantly by forest policy domain.

- **Buffer zones of protected areas**. Clear property rights are necessary to establish incentives for natural resource management, but they may not be sufficient to protect all of the functions of parks and nature reserves. While community management of buffer zones may be a more effective means of monitoring and enforcing restrictions on forest encroachment by spontaneous migrants ('forest squatters'), little is known about tradeoffs and complementarities among multiple goals in the implementation of programmes.

- **Margins of Production Forests.** Devolution of rights and responsibilities of production forest management (including logging) to local communities could improve natural resource management compared to the *status quo ante,* but devolution by itself may not create sufficient incentives for local communities to supply some forest services, including abatement of externalities felt at the regional level and global public goods.

- ***Imperata* Grasslands.** Some form of tenure (either in trees or in land) for local people who convert *Imperata* grasslands (*alang-alang*) to more productive uses is a necessary condition for smallholder rehabilitation of these grasslands. A stake in preventing damage to personal property creates incentives for appropriate action to prevent and control the fires that establish and sustain alang-alang's competitive advantage. Secure tenure also is necessary as an incentive for people to undertake the hard work to establish trees in the first place. Evidence from Indonesia and elsewhere in Southeast Asia demonstrates that local people invest on their own to plant trees for timber and other products if (a) they have secure claims over the products, (b) natural risks, such as fire, are not too high, and (c) they have access to a markets.

### *Methods*

Just as participatory methods help us to understand smallholders' objectives and constraints, consultation with policymakers at various levels is a hallmark of ICRAF's client-driven approach to policy research. The focus of consultation is to obtain crucial insights from policymakers about their perceptions of problems, opportunities, and constraints in order to guide the iterative process of research to identify and develop feasible policy options. This participatory, client-driven approach expands opportunities to translate research results into direct support for the policy reform process and, ultimately, into positive impact on smallholders' welfare and on natural resource management. Work on this component will emphasize the lessons to be drawn from involvement in ongoing pilot projects and from comparative analysis of current policies and recent institutional experience.

### *Pilot Project Sites*

Krui, Lampung Province, Southern Sumatra
West, Central, and East Java (Java Social Forestry Programme)
Proposed site for next phase of ASB: SilvaGama Concession, Bungo Tebo ASB site

### *Other Sites for Comparative Research*

Proposed: Jambi, Lampung, North Sumatra, West Kalimantan, West Java

***Contact persons:*** Chip Fay or Thomas Tomich, ICRAF SE Asia

# II.11. Policy Research on Indigenous Land and Tree Tenure Institutions in the Bufferzone of Kerinci Seblat National Park

*Research partners*: ICRAF, IFPRI, and Jambi University

*Contact person:* Suyanto, ICRAF SE Asia

### *Background*

Forest conversion and ensuing conflicts between park managers and the local population are in evidence in the zone surrounding Taman Nasional Kerinci Seblat (TNKS). TNKS encompasses the largest contiguous primary forest in Sumatra with the area of over 14,000 $km^2$, including forest areas near the ASB benchmark area at Rantau Pandan. These villages traditionally have followed a matrilineal inheritance system with joint ownership that limits individuals' rights to dispose of land and other assets.

An (often implicit) assumption of many so-called integrated conservation and development projects (ICDPs) is that establishing sustainable land use management practices in an adjacent bufferzone will reduce pressure on the protected area. A major question is the role land tenure plays in establishing sustainable land use practices. More secure land tenure may stimulate farmers to adopt more efficient and more sustainable land uses, including agroforestry. But it has often been argued that the indigenous tenure system in Indonesia based on customary law (*hukum adat*) is breaking down because of population growth and agricultural commercialization. If there is in fact a tendency toward individualization of land tenure, this institutional shift could have a powerful influence on the intensity of land use and the development of agroforestry.

### *Policy Questions*

Ongoing surveys in Indonesia (conducted as part of a multi-country study led by IFPRI) should yield basic insights about the evolution of land and tree tenure institutions. These informal institutions affect resource access and property rights. Little is known about what (if anything) governments can do to support efficient and equitable functioning of these community-level institutions. **Better understanding of how these institutions respond to population growth, the transition from land abundance to land scarcity, and other pressures is directly relevant to the search for workable policy options that improve smallholder welfare and enhance prospects for sustainable resource management.**

### *Hypotheses*

The central hypothesis of this research is that these institutions are a key determinant of incentives (and disincentives) for sustainable natural resource management. Specific hypotheses include:

- Greater profitability of tree crop production leads to greater individualization of tenure.
- Greater individualization of tenure leads to intensification of agroforestry; less individualized tenure slows development of agroforestry.
- Individualization of tenure leads to more efficient and more sustainable land use through adoption of agroforestry.

*Methods*
Data collection is to be undertaken in two phases: an extensive survey at the community level and an intensive household-level survey. Each survey involves a stratified random sample drawn from the park buffer zone. The objective of the extensive survey is to characterize land and tree tenure and inheritance practices for a wide range of communities in the ASB benchmark area at Rantau Pandan, in Kerinci District of Jambi Province, and in some adjacent districts of West Sumatra Province (Figure 30.) The extensive survey of 60 villages is nearly complete and its results have been used to determine the sample frame for the intensive survey. The objective of the intensive survey is to identify the determinants of the decision to plant trees and to compare the economic efficiency of land use under different land and tree tenure rules. A total of 160-200 farmers from four villages in Rantau Pandan and two villages in Kerinci will be interviewed in the intensive survey.

***Preliminary results of the extensive survey***
There are a variety of land tenure types in Kerinci and Rantau Pandan. Table 10 shows the major tenure categories and their characteristics, with the tenure categories arranged from weakest individual ownership rights to the most individualized. Tenure institutions in the park bufferzone appear to be evolving toward greater individualization, but traditional inheritance systems still are very much in evidence.

**Table 10.** Land tenure types and their major characteristics

| Land Tenure Type | Members | Inheritance Rules | Joint ownership |
|---|---|---|---|
| 1. Communal | A group of lineages or all people in the village | No inheritance allowed | Yes |
| 2. Lineage | Lineage coming from the same grandmother. | Inherit only use rights, not full rights over land | Yes |
| 3. Joint Family: | | | |
| - Among daughters | Members of nuclear family. | - Daughters | Yes |
| - Daughters and sons | | - Daughters and sons | Yes |
| - Among sons | | - Sons | Yes |
| 4. Joint with other people | Family members and non-family members | Daughters or Daughters and sons | Yes |
| 5. Divided: | Family members | | |
| - Among daughters | | - Daughters | No |
| - Daughters and sons | | - Daughters and sons | No |
| - Among sons | | - Sons | No |
| 6. Private land | Those who have acquired land privately (purchased or opened new land) | Daughters/ daughters and sons / sons | No |

Figure 30. Map of Tenure Survey Areas

### *Land Inheritance*

The extensive survey found three different sets of rules of land inheritance (Table 11). First is the matrilineal system, where land and crops are inherited by daughters. In this system, sons can borrow land from parents but they must relinquish it to sisters or nieces after the parents die. Second is an undifferentiated system where land and crops are inherited by sons as well as daughters. Finally, inheritance rules in the third system vary by type of land and by crop. Under this third system, wet rice fields are inherited by daughters, land planted with trees (rubber and cinnamon) is inherited by sons, and other upland plots (often reserved for food production) are inherited by sons and daughters. Land ownership under these three inheritance rules could be either joint or divided (individual).

Table 11. Inheritance rules

| Rule | Inherited by | Land Use / Crop Type | Ownership |
|---|---|---|---|
| 1. Matrilineal | Daughters, sons can borrow | All types of land and crops | Joint or divided |
| 2. Undifferentiated | Daughters and sons | All types of land and crops | Joint or divided |
| 3. Dependent on type of crops | Daughters and sons | - Wet rice fields inherited by daughters<br>- Trees plots (rubber and cinnamon) inherited by sons<br>- Other upland fields inherited by sons and daughters | Joint or divided |

Table 12. Percentage of Villages by Inheritance Rules and Land Type

| Inheritance Rules | Wet Rice Fields | | Dry Land | |
|---|---|---|---|---|
| | Kerinci | Rantau Pandan | Kerinci | Rantau Pandan |
| Matrilineal | 35 | 100 | 22 | 38 |
| Undifferentiated | 35 | 0 | 50 | 0 |
| Matrilineal and Undifferentiated | 30 | 0 | 28 | 0 |
| Depends on Crop Type | 0 | 0 | 0 | 63 |

Table 12 shows the percentage of villages by inheritance rule and site. For wet rice fields, the matrilineal system of land inheritance is dominant in Rantau Pandan (100 % of village sample). On the other hand, at the Kerinci site the matrilineal system, the undifferentiated system and the combination of matrilineal and undifferentiated systems are present in almost the same proportions (35 %, 35 % and 30 % respectively). In the Kerinci Valley undifferentiated inheritance of upland fields prevails in a larger proportion of villages

(50%) than the matrilineal system (22%) and the combination of matrilineal and undifferentiated (28%). Note the unique land inheritance rule found in villages in the eastern part of the Rantau Pandan benchmark area, where 63% of sample villages have an inheritance rule for upland fields that depends on the type of tree planted. Major tree species, such as rubber and cinnamon, are inherited by sons while other types of upland fields are inherited by both sons and daughters. In contrast, the matrilineal system of inheritance predominates for upland fields in the western part of the Rantau Pandan site (38 % of sample villages). **The sampling design for the intensive survey takes advantage of the opportunity to explore links between land use and tenure provided by the differences in inheritance rules between neighboring villages.**

### *Land Use Distribution*

Major land uses in the bufferzone include irrigated rice fields, rainfed rice fields, upland fields for food crops, upland fields that will be planted with tree crops, tree crop plots, bush fallow, and forest. The proportion of sample villages where these land uses are found is given in Table 13. Shifting cultivation is practiced on upland fields reserved for food crops. Farmers open forest or bush fallow for planting food crops for a few years and leave it as fallow. After several years, they plant food crops again. In the Kerinci sample, only 4% of villages have this land use, but the proportion of villages where shifting cultivation is practiced is 75% in the ASB site at Rantau Pandan. The category 'upland fields for tree crops' refers to the ubiquitous practice of planting food crops among young tree crops; this is found in 89% of sample villages in Kerinci and 100% in Rantau Pandan. Mature tree crop plots are found in 95% of sample villages in Kerinci and 100% in Rantau Pandan. The main tree crop differs, however: rubber is dominant in Rantau Pandan, while cinnamon is dominant in Kerinci. In Rantau Pandan, bush fallow and forest were reported in 100% and 88% of sample villages, while in Kerinci these land uses were found in 68% of the sample.

**Table 13.** Incidence of land use types (as a percentage of the village sample)

| Land use | Kerinci | Rantau Pandan |
|---|---|---|
| Irrigated Rice Field | 79 | 100 |
| Rainfed Rice Field | 47 | 63 |
| Upland Fields for Food Crops | 21 | 75 |
| Upland Fields for Tree Crops | 89 | 100 |
| Tree Crop Plots | 95 | 100 |
| Bush fallow/Secondary Forest | 68 | 100 |
| Forest | 68 | 88 |

### *Land Use by Land Tenure Type*

Both in Kerinci and Rantau Pandan, the biggest proportion of rice fields are categorized as joint family tenure, with cultivation organized either jointly or in rotation (Figures 31 and 32). Sale of rice fields is strongly regulated by customary law, requiring approval from the lineage leader and senior male family members. Therefore, the percentage of rice fields under private land tenure is small (less than 10%). Communal, lineage, and joint family land account for 57% of upland fields reserved for food crops in Rantau Pandan and 54% in Kerinci while the percentage under private tenure is 31% in Kerinci and only 9% in Rantau Pandan. **Shifting cultivation seems more likely under land tenure that is less individualized. In contrast, most tree crops are planted on land with a higher degree of individualization** (divided land and private land). The share of tree crop plots categorized as 'divided' and 'private' is, respectively, 38% and 54% in Rantau Pandan and 50% and 31% in Kerinci. On the other hand, only 18% of tree crop plots are categorized as communal, lineage, or joint family land. Tenure patterns for bush fallow are a puzzle that will be explored further in the intensive survey: in particular, it unclear why the proportion of bush fallow in Kerinci is higher for more individualized tenure. Almost all of the forest land inside sample villages is state land or communal land. There is an exception in Rantau Pandan, however, where 21% of forest is as private land. This is private land that is in a government reforestation project.

Figure 31. Distribution of land use by land tenure in Rantau Pandan

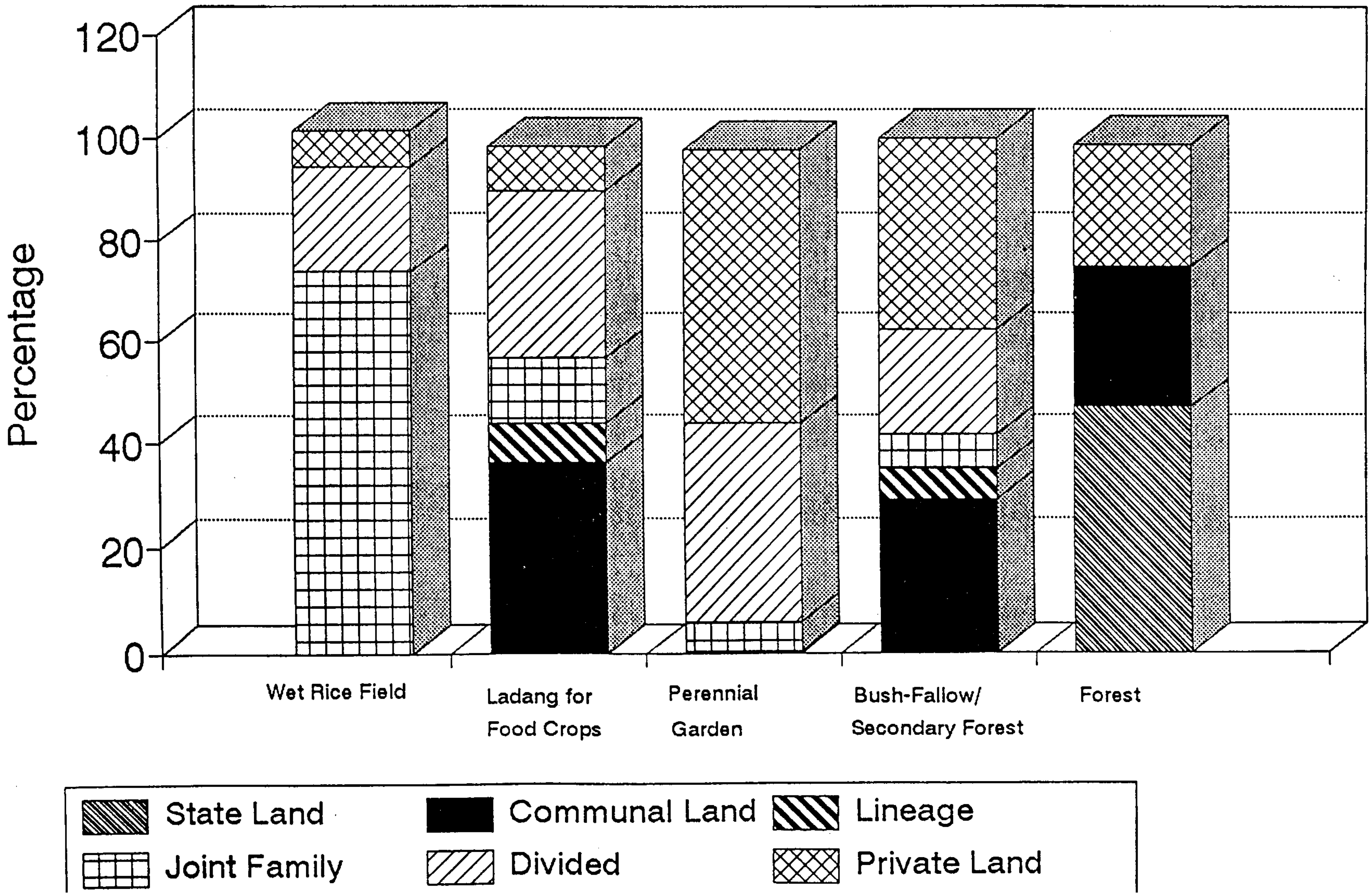
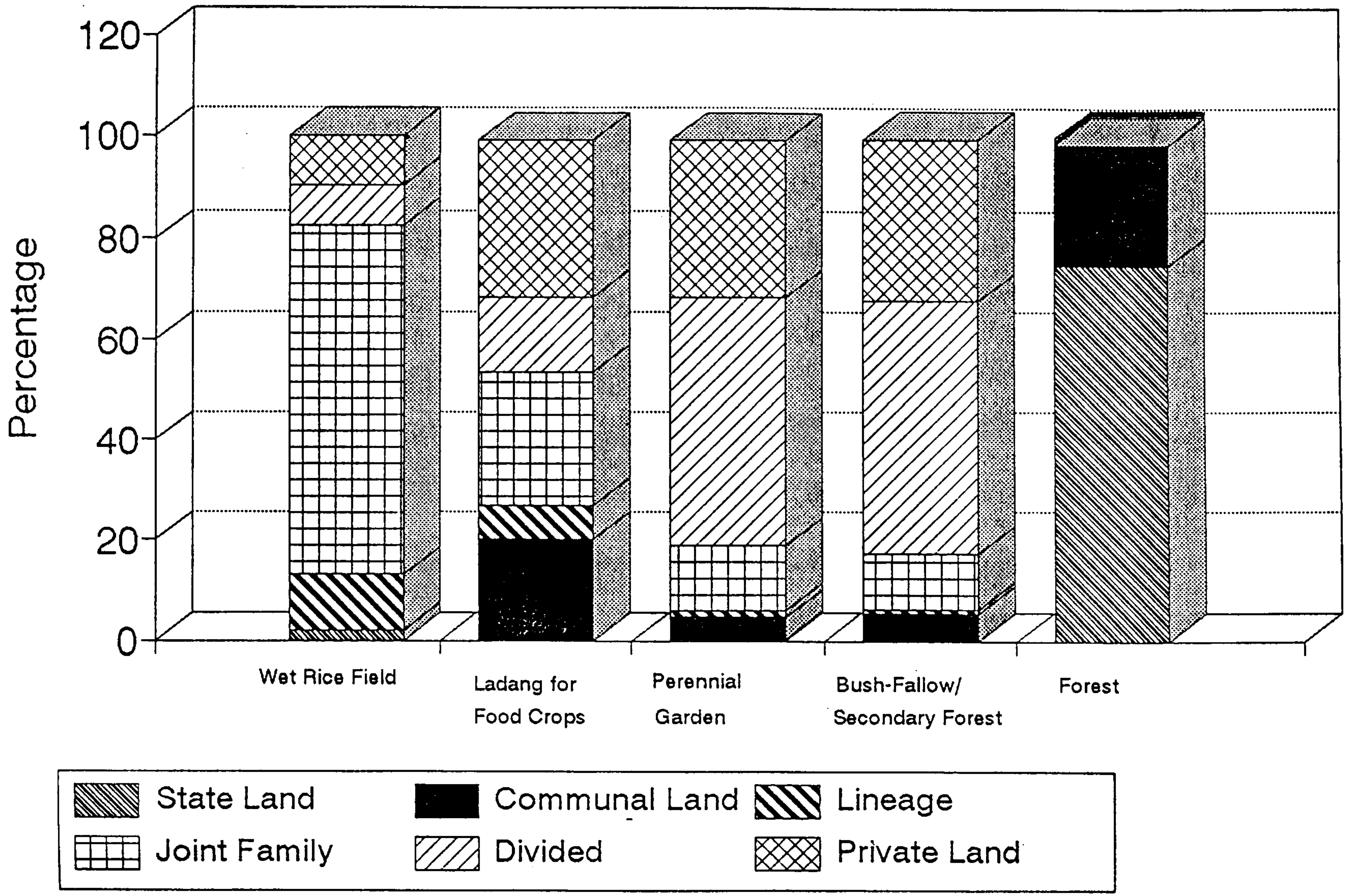


**Figure 32.** Distribution of land use by land tenure in Kerinci



## II.12. Linking Policy and Land Use Change at the Landscape Level

### *Background*

The major part of Sumatra is classified as state forest land, but a substantial portion of this land is no longer under forest cover. The transformation from primary to secondary forest types is largely due to timber extraction, with a smaller role for traditional shifting cultivation systems. Subsequent transformation of secondary and logged over forest types generally is based on 'slash-and-burn' practices undertaken by a variety of actors (large-scale as well as smallholders) for a variety of reasons. Other once-forested areas have been converted to (temporary) crop land, either by local smallholders, or in government-sponsored schemes such as the transmigration programme, or by spontaneous migrants. These lands can evolve into *Imperata* grasslands (*alang-alang*) or into permanent tree-based production systems, including agroforests.

In the case of Jambi, the flow of migrants, apart from government-sponsored transmigrants, can be seen as a sort of spill-over from Java and elsewhere in Sumatra, including especially the ASB area in Lampung Province. Most of the ASB benchmark areas in Jambi are easily accessible, as there are relatively good feeder roads that connect the Trans Sumatra Highway to the sites. Apart from that, logging roads made by concessions provide access to forest land. Both types of roads have also created good access to markets and enable traders to come to the sites.

### *Role of smallholders versus role of large-scale projects in deforestation*

- **Research objective:** Test the hypothesis that slash-and-burn by smallholders contributes significantly to deforestation.

Work has begun to compile spatial data necessary for a geographic information system (GIS) on forest cover, land uses by smallholders, and land uses by large projects in Jambi Province, including tree crop estates, transmigration projects, industrial timber estates, and forest concessions. The objective is to improve information on the proportion of deforestation that results from slash-and-burn and other activities by smallholders and to analyze interactions between smallholder activity and large projects.

### *Distinguishing rubber agroforests from secondary forest*

- **Research objective**: Obtain reliable information on the extent and location of rubber agroforests.

It is apparent from fieldwork at the ASB sites in Jambi and elsewhere in Sumatra that official statistics (and even vegetation maps based on satellite images) misclassify much of the area of rubber agroforest as secondary forest. For example, data from the 1993 Agricultural Census for eight villages in the Rantau Pandan benchmark area indicates that 60% of the land is secondary forest and only 32% is planted with perennials. In fact, much of this 'secondary forest' is planted with rubber trees. Aside from general ignorance stemming from outsiders' attitudes toward indigenous systems, the undercounting of Jambi's dominant land use system arises because these agroforests replicate important aspects of forest cover. Ability to use remote sensing techniques to distinguish rubber agroforests from secondary forest would be a breakthrough in our efforts to analyze land use change at the landscape level.