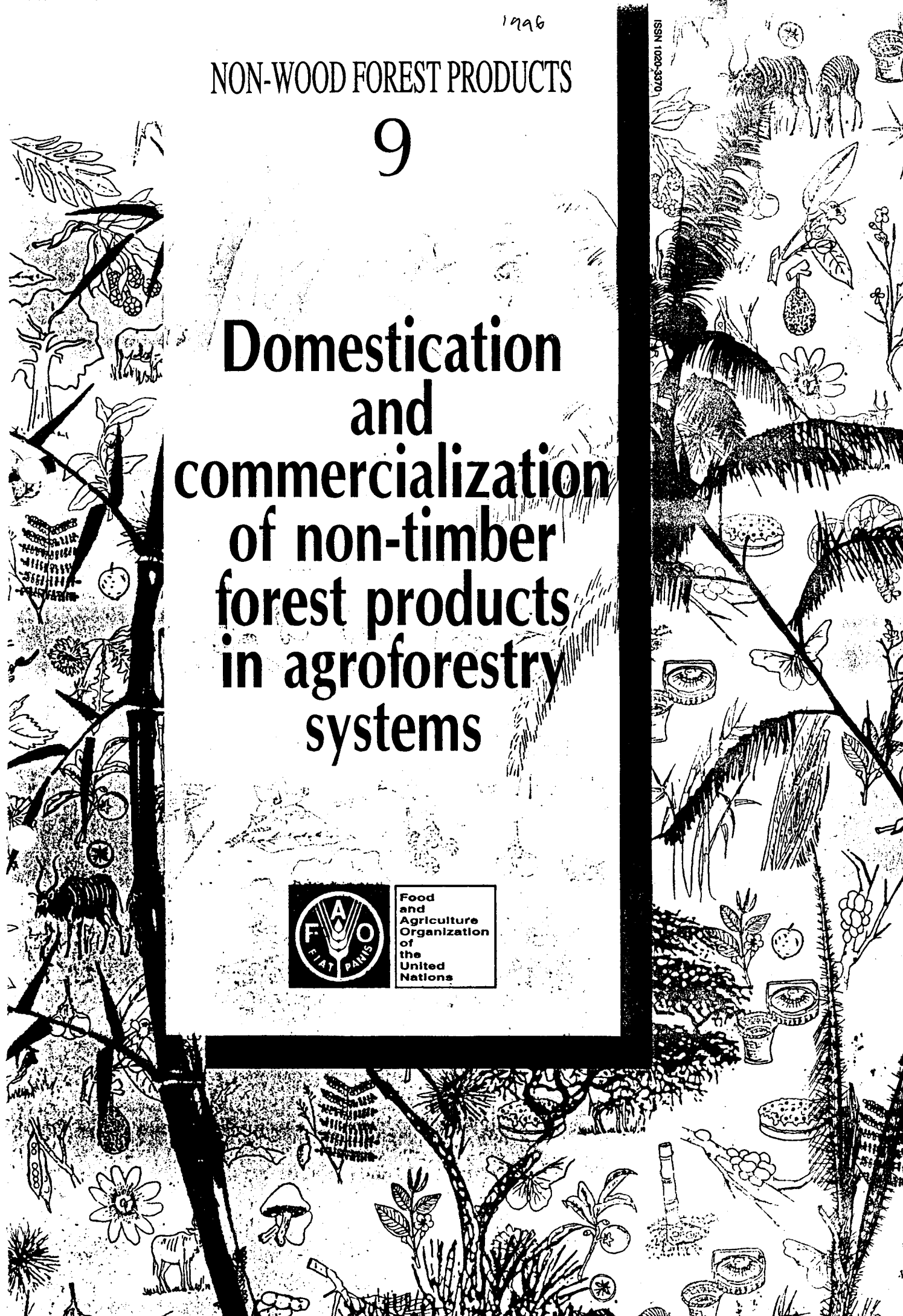
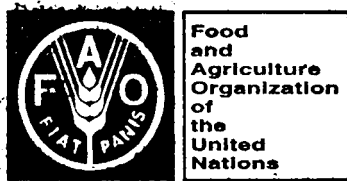


Domestication and commercialization of non-timber forest products in agroforestry systems



Agroforests as an alternative to pure plantations for the domestication and commercialization of NTFPs

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Abstract

NTFP exploitation has recently emerged as a promising alternative to timber extraction in natural forest management. The domestication and the commercialization of these NTFPs tend to emerge as an alternative strategy to their extraction from natural forests.

Incorporating NTFPs in production systems is not a new practice in the tropics. Various forms of agroforestry associations have developed around NTFPs and form the very basis of a suite of indigenous agricultural practices. This agroforestry path to domestication is not commonly considered, in spite of an increasing amount of academic interest in indigenous forest-like plantation models. Furthermore, it is only in recent years that agroforestry research is considering the prospects of these indigenous systems for forest species. To date, nothing in terms of species improvement, for instance, has been done towards the integration of NTFPs into a multistrata or multispecies system, although these are important considerations that need to be taken into account.

In Southeast Asia, and particularly in Indonesia, complex agroforestry systems for the management of forest resources have been developed for centuries by local people ranging from the production of locally consumed fruits to highly valuable industrial products, such as resins and latexes. This agroforest pathway is presented here as an elaborate process of total transfer, of both selected forest resources and a true forest structure from the sphere of 'nature' to that of 'agriculture'. This process can thus be analysed as a particular domestication strategy, which could integrate conventional species domestication techniques—selection, reproduction and plantation practices—to an original form of ecosystem 'domestication'. Prospects for further developing this agroforest strategy for the domestication of forest species, particularly NTFPs, are then discussed.

The social, economic and institutional implications of such an integration of NTFP resources to agricultural development are also analysed, based on various examples of agroforest development and focusing on the efficiency of this 'appropriation' strategy by smallholder farmers, for the acquisition of forest riches.

Introduction

Domestication of forest species for purposes of commercial cultivation seems to have bright prospects. Forestry definitively needs to find an answer to the exhaustion of wild resources while at the same time rationalizing the production of marketable NTFPs. There is great demand for new crops and new markets. Sustainable development has to mitigate the effects of deforestation by increasing the planting of trees on cleared lands, and tropical farmers have to find substitutes for the natural resources lost through deforestation.

However, domestication is neither a fast nor an easy process. It took centuries of farmers' work to develop a range of food crop varieties and decades of scientific research to create

productive clones of industrial tree crops. Can foresters or farmers wait another 50 years to tame wild rattans, or before they efficiently produce natural resins or marketable 'forest fruits' from improved and domesticated trees? Can we wait for agroforestry research to spend several more decades testing efficient tree-crop associations for forest domesticates and making them acceptable to smallholder farmers?

Modern plant domestication relies on relatively sophisticated techniques. But it should not be restricted to only a set of techniques. Domestication is also, and primarily, a strategy. Domestication techniques are selected on the basis of economic choices and by the initial preference for a given cropping system within a given farming system. In discussions on domestication, this latter aspect is often neglected, probably because of the historical background of the present scientific community. Modern agricultural and forestry science evolved in Europe, in a pastoral and cereal-growing civilization, which influenced most of the present agricultural paradigms and agroecosystem models. Our perceptions of domestication and agricultural development are deeply influenced by a tacit preference for cereal-based models, which may not be the most useful for the domestication and development of tropical forest resources.

The design of the agroecosystem in which domesticated species are grown is as essential as the choice for particular plant selection, breeding and reproduction techniques. This is particularly important when switching from annual crops to trees and from fields to forests. Most 'modern' agroecosystems in the world relate to a single agricultural model: intensive, highly specialized stands of homogeneous crops. However, other available models exist, which should be examined under the new perspective of domestication of tropical forest species. Especially important among these are the native farming systems in the tropics, for which there is academic information already. This presentation will concentrate on the implications that ecological models in such native systems might have for the design of novel domestication strategies for NTFPs, particularly in agroforestry.

An 'ecosystem' perspective of the domestication of forest species could change the approach chosen and lead to changes in techniques and processes. It is essential to understand that the importance of an ecosystem approach to domestication goes far beyond biological or technical considerations. It also has obvious sociopolitical and institutional dimensions. The common preference of governing elites and scientists for the plantation model of domestication for commercial forest resources in the tropics did not only change the face of forest landscapes and national economies. It also deeply affected forest communities and their socioeconomic life. It is essential to analyse in the context of NTFP domestication, this indirect link between the choice of a particular domestication strategy and the fate of local populations. Domestication is part of a resource appropriation process, and resource appropriation by a powerful faction of the population might lead to dispossession of the weaker faction. This aspect of domestication will be examined in the light of the Indonesian history in forest resource management.

From natural resources to cultivated crops

Food crop domestication and agroecosystems

The process of domestication and cultivation of food crops has followed two totally divergent routes: 'agriculture' and 'horticulture', taken in their etymological sense—the cultivation of 'ager' (open fields) and the cultivation of 'hortus' (gardens) (Barrau 1970). Several ethnobotanists and anthropologists (Haudricourt & Hedin 1943, Sauer

1952, Geertz 1966, Barrau 1967) have suggested that relating these 'grain' and 'garden' models to existing cropping systems will help to focus further discussion.

'Agriculture' refers to the 'grain model' developed for cereal domestication in ancient Mesopotamia and around the Mediterranean, and also in ancient rice civilizations from India to China. 'Ager' (literally the tilled or totally cleared field) conquered the forest and is the central platform for domestication and the 'home' of domesticates. It represents a highly specialized and artificially uniform open field, devoted to grain crops, largely disassociated from the pre-existing environment. It involves a massive population of genetically homogenous plant cultivars. The grain model relies on highly specialized and segregated technical knowledge relating to monocultures as well as to intensive use of chemical and mechanical inputs. These are associated with very high energy consumption and minimal labour inputs at the field level. Genetic specialization and manipulation culminate in the widespread use of hybrids, which totally depend on people for their production and regeneration. The grain model perfectly relates to the productionist mentality of modern agriculture. Initially devised for food crops, it has deeply influenced modern commercial tree cropping: both tropical plantation agriculture as devised by European colonialists (e.g., rubber, oil palm, cocoa, or cinchona) and commercial fruit culture in temperate regions. Both situations replicate a modern corn field biologically and technically, as well as in ideology.

'Horticulture' refers to the management of 'hortus', the garden, which can be characterized by high plant diversity, including tuberous perennials and trees, in somewhat chaotic combinations and configurations. The garden model involves diverse production, from many food crops. Domestication in the hortus, whether in temperate or tropical regions, has operated through the treatment of plants as individuals. It developed countless cultivars of fruits, tubers and vegetables. In the tropics, 'hortus' can be a swidden, an anthropogenic forest, or a homegarden. Management in the garden model plays intensively on ecosystem interfaces and fully benefits from natural vegetation dynamics. Devised for multipurpose production like indigenous agriculture in the tropics, as well as for an optimum management of ecological and economic risks, the garden does not comply with the urgent need for 'productivity' in agriculture. Temperate gardens are nowadays devoted mostly to production for home consumption or to leisure, whereas their tropical relatives are neglected or even denigrated by official agricultural services.

In the one-track mind that characterizes modern rural development, the grain model is considered as the only model that is valuable for efficient agricultural production. Agroforestry research and extension represents the only consistent scientific framework through which the hortus model could be further developed. But this requires innovative approaches, especially as far as domestication and cultivation models are concerned. The open-field preference has often led to reductionist approaches to domestication, which we have to re-examine in the light of agroforestry development. Does domestication unavoidably come down to adapting a wild species to grow in industrial plantations? Are tropical gardens confined to the production of, at best, semi-domesticates? What new perspectives can agroforestry bring to domestication?

Domestication: which models for forestry?

Domestication and cultivation have long been the prerogative of agriculture (here in its widest sense: management of fields and gardens), while worldwide, forests remained the domain of hunting and gathering in support of agriculture. Until roughly the beginning of the 19th century, tropical and temperate forests were managed mainly for integrated, multipurpose use. These practices more or less maintained forest composi-

tion, providing for grazing, hunting, gathering, and wood or timber production. Some species selection did happen, creating useful genotypes that could be substituted for wild ones in niches within the pre-existing biotic community. Among other examples are productive chestnuts and sweet acorn varieties in the Mediterranean countries, and peach palm and Brazil nuts in the Amazon Basin.

Rationalization of forest production and forest culture did not really appear before the industrial era. This coincided with more focused demands for specific forest products: fuel for metallurgy, timber and pulp. The development of scientific forestry induced a strict partition between agricultural and forest development. Productivism applied to forestry created new models of intensive wood production, inspired from the grain model in agriculture, with the multiplication of highly homogeneous, specialized, and productive plantations of pine in the north and of acacia and eucalyptus in the tropics. Today's commercial forestry in the tropics, dominated by the imperatives of wood supply, follows a bipolar model: products are either extracted from natural, more or less managed natural stands, or cultivated in highly specialized plantations.

The monoculture preference stands as the recognized option for domestication strategies for timber trees. Domestication and cultivation techniques devised by forestry research for tree species follow the rules of specialization, uniformity and intensification that have proven efficient for grain crops, simplifying the structure and the function of the cultivated 'forest' to the extreme. But how far does this model extend to NTFPs?

What happened in the domestication and cultivation of tropical NTFPs?

Domestication of non-timber forest products in the tropics developed under three different situations.

The indigenous perspective

The history of management, selection and cultivation of useful forest species by indigenous people for subsistence purposes is as old as that of humankind's use of forest ecosystems. In terms of domestication, the process of interaction between farmers and forests gave rise to a whole range of modified tree varieties, which most authors classify as 'managed species' or 'semi-domesticates'. However, scientists commonly recognize that true domestication occurred through the transfer of edible forest species—primarily fruits and nuts—to agriculture through various types of garden (see for example Clement & Villachica 1994, Sastrapradja 1975). These forest domesticates are presently considered as true agricultural or horticultural crops.

Though not often acknowledged in the literature, commercial gathering of forest products by local people also went along with plant selection, integrated management and even cultivation. This simple domestication developed interesting models of true 'forest culture', which relate to the hortus model and will be discussed further. These models have unfortunately remained neglected in most discussions and are almost never included in development programmes, even in agroforestry.

Colonial interventions

Tropical NTFPs acquired a new dimension during the expansion of the colonial-era. This started with the high demand for spices (nutmeg, cinnamon, vanilla), coffee or cocoa, which created a new but highly specialized commercial perspective. These cash crops boomed with the rise of the industrial era, which needed new products, such as

latexes and resins. For some products, a demand boom and the need for increased control over the resource or over product quality led to domestication through intensive cultivation. The process of domestication and cultivation developed by the colonial plantation managers induced a true movement of disassociation between forest resources and forest ecosystems. Most of the new economic forest resources were transferred to plantation agriculture, through vast estates that reached their peak in the second half of the 19th century and the early 20th century, with oil palm, rubber, cinchona, coffee, tea and cocoa. In transferring forest resources to agriculture, the colonial plantations did not attempt to innovate; they followed the grain model, creating huge areas of specialized, artificial and productive tree monocultures.

New focus on NTFPs

The commercial interest in NTFP declined after World War II, because of the fall of colonial powers and the rise of petrochemical industries, which developed substitutes for natural products. However, a new focus on NTFP exploitation has recently emerged. NTFP extraction is now considered a promising alternative to timber extraction in natural forest management. The justification for this revived interest is not based entirely on economics, although new markets for natural products have emerged, such as phytochemicals in pharmaceutical industries or wild substances in food industries, that have triggered economic interest in NTFP. The other justifications have been ecological and sociopolitical. Ecological interest has focused on reduced disturbance to the forest ecosystem *vis à vis* timber extraction practices—while sociopolitical interests have centred around the promotion of new development models for indigenous forest people and the promotion of 'fair trade' for natural products.

For some of the most coveted products, development through domestication and commercialization tends to emerge as a strategy competitive with extraction from natural forests. Thus, despite the debate about developing new and better models for the domestication and cultivation of useful tree species in farmlands, there is a good probability that the conventional monocultures will persist. This is already obvious for rattan production in Indonesia and Malaysia, where specialized plantations have been established under the strict control of forestry services, and for the Brazil nut in Brazil, where private investors have established large plantations that severely compete with the activities of smallholder farmers and extractivists.

Consequences of NTFP domestication and commercialization for indigenous people: lessons from the past

The era of colonial trade and management had two major consequences for forest people: the displacement of their effective control over the collection and trade of forest resources and passage of the resources either to the governing elite or to private colonial entrepreneurs. This resulted in the local forest communities being overlooked and in the consequent transfer of the commercial benefits to private and commercial planters. This 'dispossession process' continued through most postcolonial governments and is still common today when a traditional forest resource encounters a commercial boom (Dove 1993a). This abuse of native rights commonly starts with restrictions over harvesting practices, develops when traders are acknowledged monopolistic rights for gathering, and culminates with plantation development. This process has political support and is a practical consequence of commercial interests.

The history of natural rubbers in the Amazon and Southeast Asia perfectly illustrates this dispossession process, which transferred control over the resource—from native collectors to powerful traders and then to planters. Caoutchouc (para rubber from

Hevea brasiliensis) was traditionally collected and used by Amerindians in the Amazon Basin. In Southeast Asia, especially Sumatra and Borneo, other wild rubbers (*Ficus elastica* and *Willughbeia* spp.) were harvested and traded by local swiddeners before the 17th century. Commercial interest in Europe and the United States for wild rubbers boomed in the second half of the 19th century, but until 1900, both elastic and non-elastic rubbers remained supplied exclusively by wild species through latex extraction. As prices rose, the control of the rubber areas in Amazonia became concentrated in the hands of the political-economic elite, who 'exerted an absolute rule over native rubber tappers' (Coates 1987). At the same time in Indonesia, the Dutch colonial government progressively restricted exploitation by local tappers, first through imposing a licence to tap the trees, then through granting all tapping rights to foreign concessionaires (Dove 1994). Another period of dispossession of native tappers started with the cultivation of the Amazon rubber tree in Southeast Asia in 1877. By 1913, the supremacy of the wild caoutchouc came to an end and the local tappers in the Amazon virtually stopped working. Cultivated rubber production in the Far East, through large estates, had captured the market (Coates 1987).

Such examples are numerous, starting from the Dutch VOC taking possession of local nutmeg production and trade in the Moluccas in 1621 to the present Indonesian seizure of the birds' nests caves of the local Punan in East Kalimantan, who had owned and managed them sustainably for centuries. To get full control of the nutmeg trade, the Dutch established specialized nutmeg plantations worked by imported slaves while destroying nutmeg trees in surrounding islands. Nobody except VOC was allowed to grow and trade nutmeg any more (Warburg 1897).

What are the prospects for domestication of forest species through agroforestry?

Forestry in the tropics is still looking for technical and economic as well as socially accepted models. Can it escape from the bipolar model of extraction in natural forests on one hand and monospecific specialized plantations on the other? Can domestication of forest trees help to alleviate this situation, or will it contribute to increase the present movement of segregation between forest and agricultural development? Who will benefit from domestication of NTFPs: foresters, planters, or smallholder farmers? How can rural development efficiently and sustainably incorporate the so-called minor forest resources into farmlands?

Agroforestry is often cited as the most favourable means of providing positive answers to such questions. But what type of agroforestry is the best for NTFP development? Is agroforestry research able to fully integrate and develop the potential offered by these 'new' crops? Can it generate 'new' models of agroecosystems, combining both agricultural and forest qualities in an economic as well as ecological perspective? Most agroforestry research until now has concentrated on simple associations, trying to introduce a single tree or shrub species into former grain-model systems. Most agroforestry research has promoted fast-growing trees or shrubs, not old-growth forest species. Agroforestry has been more 'agro' than 'forestry' oriented, more crop than tree based. When dealing with NTFP domestication and cultivation, agroforestry research definitely has to innovate. It has to give new preference to tree-based systems and to look for new ecosystem models (see Leakey 1996). There is room for innovative experimental research. However, a reanalysis of current management practices of forest resources by smallholder farmers might help. Can we find, in indigenous systems, management models that fully integrate forest resource management into farmlands? Can these models inspire novel domestication and cultivation strategies for forest species and thus a new phase of agroforestry development?

NTFPs in indigenous agroforestry practices: a long history of coevolution

Incorporating forest resources in farming systems is not a new practice in the tropics; various traditional forms of agroforestry have developed around NTFPs, constituting the very basis of indigenous agricultures in tropical America, Africa (see Boffa, this volume) and Southeast Asia. Beside fruit-dominated gardens, indigenous farmers have integrated true forest culture into farmlands, and these forms are usually closely associated with shifting cultivation. These 'cultivated forests', which often complement subsistence food cropping in annual fields, are established after total removal of the original vegetation, and they constitute complex, tree-based agroforestry systems, which fully deserve the name of 'agroforests'. Why have they been overlooked in agroforestry research? Perhaps it is a consequence of their appearance: they do not look like cultivated ecosystems and have mainly been mistaken for natural forests.

A focus on Indonesian practices

Many true 'agroforests' in Indonesia have evolved around fruit and nut trees (Michon 1985). But there are other systems that have evolved from former extractive practices in natural forests, through the deliberate incorporation of non-food forest tree species that farmers have cultivated for products to be marketed in international trade.

Among the commercial forest products, cinnamon (*Cinnamomum burmanii* (C.G. & Th. Nees) Bl.) was probably the first to have been incorporated into indigenous agricultural systems. In the central highlands of Sumatra, indigenous stands have been established for more than two centuries. Some form specialized, homogeneous gardens, but others, established on steep slopes, associate cinnamon trees as an understory with higher canopy trees grown for fruits or timber (Aumeeruddy 1993, Michon 1985). Similarly, benzoin (*Styrax*) is known to be managed as a fallow crop in what represents a true rotational agroforestry system in Laos (Kashio 1994). Such rotational systems were also mentioned in North Sumatra as long ago as the 18th century (Marsden 1783). However, other cultivation practices also developed through more complex and permanent agroforestry systems, which associate benzoin trees in a mix of useful timber and fruit trees (Simanullang 1988, Watanabe 1990).

In western Borneo, swiddeners have, for at least 150 years, established highly diversified tree gardens that integrate oil-producing dipterocarps (11 *Shorea* species) together with tens of other fruit and nut species as well as rattans, latex-producing trees and timber species (Momberg 1992, Sundawati 1993, de Jong 1994). In Central and East Kalimantan, rattan, which has traditionally formed the bulk of trade in forest products, has been incorporated into shifting cultivation systems for more than 100 years. Rattan gardens mix the cultivated palms with planted fruit and timber trees, as well as with numerous other useful species that have established spontaneously (Weinstock 1983, Godoy & Feaw 1989, Fried & Sardjono 1992). A century ago in the south of Sumatra, swidden farmers started cultivating damar trees (e.g., *Shorea javanica* K. & V.) for resin production (Dunn 1975) and have established more than 20 000 hectares of complex forest-like agroforests, associating damar with numerous other fruit and timber tree species (Michon 1985, Michon et al. 1993). Native rubber trees also happened to have been planted in complex gardens, but rubber agroforestry really developed with the incorporation of the para rubber tree in local swidden systems at the beginning of this century. The Amazon rubber tree found its ecological niche in complex tree gardens in Southeast Asia, where it is grown with numerous other species, either planted or

spontaneously established. It soon replaced native rubbers in the economic niche of the local swidden farmers (Pelzer 1945, Dove 1993b, Gouyon et al. 1993).

All these agroforests result from farmers' needs and their deliberate choice to improve production and control, or sometimes to protect or even restore useful forest resources. They all present important common features (Foresta & Michon 1991): (1) most of them concern true old-growth forest species, not fast-growing pioneers, (2) they have all evolved from swiddens, through the systematic introduction of trees in cleared lands, (3) most often, they start as specialized plantations that evolve into a permanent mixed stand of planted tree crops and useful spontaneous resources, and (4) they exhibit forest-type structure, including a predominance of large trees, a multi-layered vertical configuration and a closed-cover canopy. Some of these indigenous systems, like the dipterocarp agroforests, hold structural as well as functional characteristics typical of a primary forest ecosystem, with the predominance of big trees, a high species richness, a high ecological complexity, and a closed nutrient cycle. Others, like the rubber agroforests that cover the lowlands of Sumatra and Kalimantan, are more like secondary forests, with dense stands of smaller trees and a rapid turnover of species. These agroforests combine important income-generating strategies based on forest resources and diversified subsistence strategies, but they are not isolated management units: they always complement other agricultural activities, such as food cropping in open fields. Lastly, they rely on local representation and knowledge systems evolved from former forest traditions; they are maintained by simple techniques and integrated practices and are controlled by a well-defined social and tenurial system, which includes rights as well as duties.

How can these indigenous agroforest models contribute to the domestication and cultivation of NTFPs?

Ecosystem domestication: a new perspective?

The current concept of tree domestication (Leakey & Newton 1994) appears poorly adapted to characterize and critically analyse most of the above-mentioned examples of integrating forest resources into agricultural farming systems. 'Domestication' usually focuses more on selection and propagation techniques, making too little reference, if any, to the concepts and strategies developed for the integration of wild resources direct into the farming system. This last point is nevertheless essential when dealing with the domestication of wild forest species. The pre-eminence of the grain model has obscured analyses from other perspectives. Is the conventional model of domestication the best choice for trees that have evolved in a highly diverse and structurally complex environment?

Usually, domestication has intentionally disassociated the resource from its natural habitat. Transfer of the candidate species to an artificially prepared environment has been seen as essential, to allow increased human control of the plant, as well as to induce and efficiently select useful genetic variations (Narr 1956). But should the artificial cultivated environment be fundamentally different from the natural one? Although a very artificial environment has proven its efficiency in cereal domestication, as well as in colonial tree-crop development (Purseglove 1974) and modern forestry plantations for wood production, there is seemingly no satisfying theoretical answer for NTFPs.

The domestication strategy exhibited in the Indonesian agroforest examples partly relies on conventional plant species domestication techniques (selection, reproduction and planting practices), but it does not involve crop management in highly specialized stands, which are quite different from the original conditions in which the wild species

had evolved. Nor does it involve a major modification of the structural and biological features of the tree species, in which trees are selected to allow their adaptation to homogeneous monocultural conditions. Rather, the agroforest model relies on an artificially induced reconstitution of a true forest-like ecosystem, simulating the basic principles of a natural silvigenetic succession, which allows the selected species to establish, grow and reproduce as in their original habitat.

Establishing an agroforest is conceived as a specialized tree-planting process aimed at controlling and concentrating the selected forest resource; but this process is achieved through the integration of the resource with natural vegetation and through several successional stages that lead to the gradual reconstruction of a diversified forest structure (Michon 1985). The forest tree seedlings are introduced into the forest clearing with other short- or medium-cycle crops (e.g., rainfed paddy, vegetables, coffee bushes, pepper vines) and receive the care given to the crops. After the abandonment of these food crops as the tree canopy closes, the planted trees are strong enough to grow along with secondary vegetation and overcome competition from pioneers. The subsequent tree fallow then freely develops with little damage to planted trees.

The structure of the agroforest becomes more complex over the years, as the consequence of a particular form of management that maximizes the use of natural production and reproduction processes in order to minimize the rarest economic factor: labour. In a maturing agroforest, plant species regenerating from the neighbouring forests, through natural dispersion, can establish while forest animals find shelter and feed. Through selection, farmers favour economic resources, but non-economic resources are allowed to reproduce. And after several decades of such a balance between free-functioning and integrated selection, the mature phase of the agroforest resembles a natural forest more than a conventional tree plantation.

This ecosystem-analogy strategy has proved efficient for quick acclimation of a true forest tree species. For example, forest farmers in Sumatra have succeeded in what most foresters dream about, but have failed to achieve: the establishment, maintenance, and regeneration of a healthy dipterocarp plantation at low cost and on a huge scale (Michon & Bompard 1987). This is a unique example for the whole forestry world. Dipterocarp agroforests rely on selected and planted forest trees; they exhibit high-density stands and good productivity, but they are also characterized by good ecological sustainability, low-cost establishment and easy regeneration over years. This is quite uncommon in conventional plantation forestry.

The agroforest domestication process allows the maintenance of biological diversity in the qualities of the tree, as it does not focus on the selection of single-purpose varieties: the multipurpose dimension of the wild species is not lost through domestication, as usually happens in the conventional process. Low-canopy varieties of durian (*Durio zibethinus* Murr.) or rambutan (*Nephelium lappaceum* L.) selected by plant breeders produce nothing else but fruits, but damar or benzoin trees domesticated for resin production by local farmers in Sumatra are still good timber producers. This multipurpose dimension is also maintained at the ecosystem level. In the plantation model, what is not the crop is a weed. In the agroforest, self-established species are integrated as economic and ecologically beneficial resources or kept as potentially useful species.

But the most original point is how natural biological processes are utilized to support the artificial domestication and cultivation process. In the agroforest, natural vegetation dynamics are channeled, first to speed up and secure the integration of slow-growing trees in the cultivated system, then to maintain a continuous balance between obsolescence and the regeneration of the cultivated stand. Besides domesticating forest species, the agroforest allows the restoration of integral biological and ecological processes, which determine the overall survival and success of the cultivated

ecosystem. These natural processes schematically replace the high technology and energy inputs of forest plantations. Here, it is the agroecosystem that adapts to the plant characteristics. In this sense, agroforests constitute an original attempt of 'ecosystem domestication', through the full utilization of natural ecosystem dynamics to the benefit of a selected, artificially established population of trees. Through this, the agroforest domestication strategy proves to be successful in assimilating the problems associated with the long-term management of forest tree species—or vines, as in the case of rattan. Long-term maintenance and renewal of forest plantations is technically difficult and is invariably costly. The agroforest not only achieves a simple transfer of forest resources and structures. It also guarantees the renewability of these resources and structures, and of the related economic returns.

However, the agroforest strategy, empirically devised by swidden farmers all over the Indonesian archipelago, bears important weaknesses that could be solved by integrated research. The population of cultivated trees in the agroforest is usually genetically rather diverse, which affects the productivity of the crop. Though farmers do select the best producing individuals for reproduction, they cannot reliably capture genetic variation. Vegetative reproduction methods remain simple, and sanitary control in nurseries could be improved. Technical research aimed at these weaknesses could reorient NTFP domestication for agroforestry in two ways. First would be the development of improved plant material specially designed for a complex, forest-like environment, rather than for conventional monocultural plantation conditions. Plant selection and breeding could be aimed at taking advantage of the 'forest' characteristics of the species for both ecological and economic benefits and adapting them to farmers' technical, as well as energetic standards. The second direction for research would be to test high-yielding plant varieties—wild or improved—in agroforest conditions, as is being done by ICRAF in jungle rubber agroforests. This would expand the agroforest model to new areas and improved plant material into existing systems.

Agroforest domestication: a socially empowering strategy for farmers

The analysis of the agroforest domestication process should not be restricted to its technical or ecological aspects. While the transfer of the wild resources of nature to the cultivated lands of agriculture is an essential process—capturing variation in natural genetic characteristics, increasing population density, stimulating cross breeding, or escaping from natural competitors and pests—it must always integrate these with major economic and sociopolitical or policy implications. This could, in future NTFP business, enable smallholders to do more than extract products from wild ecosystems, as they do now.

From the forest to the fields: who owns the resource?

By switching from the management of wild resources in traditional extractive systems to their adoption as new crops in farming systems, farmers often aim at maintaining or re-establishing their traditional authority over the forest resource base. This is obviously important when, because of overexploitation or deforestation, wild economic resources are vanishing from natural forests, or when commercial demand increases. But it might also be an important option for native farmers when politically induced dispossession threatens their livelihood.

In most ideologies and political regimes of tropical countries, agriculture secures social and legal rights over land or natural resources for smallholders better than does forestry. Integrated forest management, as empirically conceived by indigenous forest

tribes all over the planet, however sustainable or profitable it is, has never been seriously considered by the governing elites and their technical councils. This is reflected in the widespread lack of legal recognition of native rights and traditional property regimes concerning forest lands and resources in tropical countries. To gain official support, native resource management systems have to evolve in a way that complies with the conventional models. Domestication and plantation are important steps in this process; transferring wild resources to cultivated lands is both a symbolic and a political act of appropriation. But beyond this conceptual aspect lies the legal context of appropriation. Most forest lands in the tropics, and the resources they contain, are under state control; they are 'public goods'. This usually prevents any evolution towards 'privatization' and facilitates tacit 'appropriation' of profitable forest resources, traditionally controlled by indigenous people, by those who are close to power. Private property—for either collective or individual owners—is more readily acknowledged and expected on agricultural land. Thus, cutting the forest and planting trees might be enough to secure, if not property rights, at least the right to claim for such rights. In Indonesia, establishing agroforests has often been a major strategy for land and resource appropriation; establishing production structures and property rights that will be transmitted to further generations is an essential aspect in this particular domestication and cultivation process (Michon et al. 1994).

For example, farmers in Sumatra initially planted damar-producing dipterocarp trees, in response to the depletion of wild damar trees and the need to establish a profitable forest-based economy. But as their relations with forest authorities deteriorated, the establishment of agroforests became a strategy for legal resource appropriation. Thus, presently agroforests are also established as a claim against the closure of forest lands and resources to local communities. Through domestication and tree growing, farmers claim that they have purposefully restored and protected not only damar but the entire forest resource, in the middle of agricultural territory, upon which they hold a firmer control and rights (Michon et al. 1993).

'Global forest resource' appropriation is an essential component of the agroforest domestication strategy. Specialized plantations might secure the appropriation of a given forest resource, but the agroforest strategy goes far beyond that: as it recreates forest structures, it allows the restoration of the landscape in a form that conforms better to the farmers' rights and interests (Michon et al. 1996). In Indonesia, therefore, the relationship of local populations with forest resources is now more closely associated with one or more types of agroforest than with the natural forest. This allows them to maintain an economy and an associated lifestyle that remain in continuity with their forest culture, from which the agroforest directly evolved; but it places it firmly in an agricultural context. The agroforest, therefore, clearly opens the way for other novel models of improved resource management in forest lands throughout the tropics.

Domestication and cultivation: knowledge and capital

The choice for a particular domestication and cultivation strategy is as important as the transfer of forest resources to farmlands, in determining who holds the authority over a particular resource. Domestication and cultivation integrate technical knowledge and capital investments as well as technical, labour or energy inputs; all of these may be inaccessible to smallholder farmers. Colonial plantations have clearly demonstrated how domestication can adversely affect indigenous 'managers' of NTFPs. Will indigenous farmers be similarly spoiled when NTFP domesticates are made available by research institutes through markets or credit schemes? This seems likely when capital-intensive processes of crop establishment and maintenance lie far beyond smallholders'

financial and technical capacities, and when the high productivity from plantations leads to a fall in prices of natural products and to the economic collapse of any business collecting those products. The domestication of NTFP through these sophisticated techniques and modern knowledge might only intensify the exclusion of smallholders from the management of forest resources. In contrast, however, the domestication of NTFPs through the agroforest strategy will probably be better integrated into indigenous populations, as it relies on simple techniques, is based on local knowledge shared by every farmer, and does not imply high energy inputs.

In the process of NTFP domestication, the evolution of rubber cultivation in Indonesia illustrates how plantation and agroforest development can have totally divergent effects on smallholders. Technical and financial constraints associated with the plantation model put rubber cultivation out of the reach of smallholders. Thus, intensive rubber cultivation in colonial estates led to the exclusion of native tappers, in both Amazonia and Southeast Asia. However, when swidden cultivators in Sumatra and Borneo adopted the para rubber plantation techniques to their production system by planting rubber trees in their swiddens, the trees grew with the fallow vegetation and soon evolved into a forest-like rubber garden. The trees were tapped if the prices appeared interesting, and they created an agroforest system that was much less demanding in labour and technical inputs than the current estate model. This production system soon became much more competitive than the estate plantations, and since 1945 it has gained the largest share in Indonesian rubber production. Through the rubber agroforests, former indigenous rubber collectors, evicted by the plantation owners, regained their place in the rubber trade and their share in the benefits of rubber development (Pelzer 1945, Dove 1993b, Gouyon et al. 1993).

The forest preference in NTFP domestication: some economic considerations

Domestication should not be disassociated from the global economic strategy of farmers. Future NTFP plantations, whatever their model, will be part of lands claimed and developed through agricultural techniques. They will be integrated into agricultural territories and agricultural production systems. They will support the local agricultural economy.

The advantages of the agroforest model did not, until now, succeed in reliably capturing the trade of products from highly commercial species. Short-term benefits are usually much higher when trees are grown in systems conforming to the plantation model. But so too are the risks and the energy consumption, with all its global ecological and economic consequences. The agroforest model, which by contrast emphasizes economic and ecological sustainability, should thus be evaluated in terms of long-term productivity, energy efficiency and economic security. It may then prove to be much more 'productive' and 'profitable' than the currently accepted models.

Agroforests, in contrast to trees crop estates, allow of numerous tree resources to grow together and to diversify the farmer's income. If encompassed in the framework of agricultural strategies, agroforest development represents a process of forest conversion that does not go along with economic reductionism and that does not irreversibly close the economic potentialities formerly linked to the presence of natural forest. On the contrary, through the restoration of biodiversity in the agroforest, farmers maintain a whole range of economic choices for both the present and the future. Maintaining these options appears indispensable in view of the need for sustainable development. This multipurpose aspect must be kept in mind if systematic research on the domestication of NTFPs for agroforestry systems is to be carried out. An important aspect to consider in this respect is the potential for timber production. Timber will probably

become a strategic commodity for farmers in the near future, with potential benefits that might be much higher than those provided by NTFPs. Many NTFP species also have good timber, but species domestication options, and the agroecosystem design, will unavoidably influence the capacity of the candidate forest species to produce quality timber. Investing in NTFP plantings will unavoidably lead farmers to some degree of specialization for a given product. However, opting for 'multipurposeness' in domestication and keeping in mind other potential forms of production, at both the species and the agroecosystem level, will help to avoid the irreversibility of future economic and ecological choices by smallholders.

Conclusion: domestication: technique or strategy?

As a domestication strategy based on forest resources, agroforest development represents an interesting alternative to the two common options devised for non-timber forest product management: harvesting from natural stocks or domestication for specialized plantations. Like specialized plantations, agroforests secure the conservation and multiplication of the planted-forest resources and increase the income-generating capacity of the forest. But they also ensure the restoration of a diverse forest ecosystem, as well as its integration into local agricultural production systems, while allowing local communities to maintain authority over its management. Plantations fail on several of these scores.

NTFP domestication through agroforestry should not confine itself only to technical considerations. Besides field experiments, agroforestry research for NTFPs should focus on devising new strategies for better integration of forest resources into farmland, into rural economies and their related sociocultural, political and institutional systems.

Until now, agroforestry research has never really dealt with long-lived trees, nor with true forest resources. Experimenting with long-lived trees obviously requires much more time than with fast-growing species, and new experimental designs will have to be found. The integration of NTFP forest resources in better forms of land use will require not only new forms of experimentation but also new forms of conceptualization and implementation.

Agroforests still lie on the margins of the conventional agroforestry research, despite the growing academic information about them. However, they touch the very heart of agroforestry, where *forests* and *agriculture* really meet and where forest structures and agricultural logic intersect. But agroforests are too close to forests for agriculturalists and too much embedded into farmers' activities for foresters. This probably explains why conceptualization of agroforests is still denied by agriculture and forestry research. To deny their conceptualization is also to deny their existence and more importantly their future and then impact on future land use and forest resource management strategies. May the current research trends in domestication and commercialization of NTFPs give new opportunities for further development and integration of the agroforest concept.

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*Plate 18. A damar (*Shorea javanica*) agroforest in Sumatra. Planted by farmers and intercropped with rice, coffee and other crops, the damar trees are tapped for resin. These agroforests are highly productive and profitable, while also providing many of the environmental services of tropical forests. (photo: R.R.B. Leakey)*



*Plate 19. Resin flowing from the tapping point of a *Shorea javanica* (damar) tree. (photo: R.R.B. Leakey)*