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Is multiple-use forest management widely implementable in the tropics?

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ABSTRACT

Multiple-use forest management (MFM) for timber, non-timber forest products and environmental services is envisioned by many as a preferable alternative to timber-dominant management models. It is praised as a more equitable strategy of satisfying the demands from multiple stakeholders, an ecologically more benign harvesting approach, and a way of adding more value to forests making them more robust to conversion. MFM thus represents a common and prime management objective under the sustainable forest management (SFM) paradigm. However, its implementation has been lagging behind the expectations, particularly in the tropics. In this paper, we analyze selected MFM implementation examples to try to explain why. We scrutinize the tropical forestry debate to find that the meaning of MFM has undergone significant changes along the way, and that the topic depends heavily on the scale of inspection. Also, we examine the conditions that either favor or constrain MFM adoption. At the local scale, the factors that set the scene for multiple-use approaches to be successfully adopted are favorable governance conditions relate to land-devolution policies, effective collective institutions, and multi-agent forest-management models. MFM feasibility also depends on the stage of forest transition, i.e. in society's economic development. MFM (at the stand level) dominates in poor subsistence-oriented autarchic forest settings, it typically declines when entering capitalist stages of specialized commodity production, but may then rebound (at the landscape level) in more advanced development stages. Key factors MFM generally is up against range from intricate technical trade-offs to the economies of scale in forestry production and marketing. MFM remains a valid management alternative under specifically favorable local context conditions, especially when practiced at the landscape scale, but these conditions are less frequent than commonly assumed.

1. Introduction

> The elements of what constitutes good forest management change over time, but the bedrock features of forest tend to remain fairly constant. It is human beings' perception of forest and how forest resource base is utilized that shifts constantly. (Wang, 2004, p. 209)

It is these shifts in forest perceptions that heavily influence the current search for new management alternatives to avoid forest conversion to privately more competitive land uses. In the early 1970s, concerns about the environmental impacts of the onslaught on tropical forests and forests' importance for rural communities had a decisive role in the search for novel forest management models (Wiersum, 1999; Poore, 2003). Until then, forests had been seen principally as catalytic agents for industrialization and economic development (Westoby, 1987; Wiersum, 1999; Kant, 2004). Forestry discussions now shifted towards the "sustainable forest management" (SFM) paradigm, which embraced the notion of sustainable development: 'development to meet the needs of the present without compromising the ability of future generations to meet their own needs' popularized by the Brundtland report *Our Common Future* (WCED, 1987). The previously prevailing notion of sustainability, as applied in forestry for over two centuries, had focused on sustaining timber yields (Wiersum, 1999; Kant, 2003). SFM then broadened the scope to both present and future generations' needs, to multiple beneficiaries and stakeholders—but also to multiple products and services (incl. marketed versus subsistence-oriented products), thus also building the case for MFM (Pearce et al., 2003; Kant, 2004).

Over the last decade, MFM has been envisioned as a promising and more balanced alternative to timber-dominated strategies

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(Panayotou and Ashton, 1992; Dickinson et al., 1996; Hiremath, 2004). Proponents of MFM emphasize that the inclusion of multiple values and stakeholders might give SFM a much needed social and financial boost (Campos et al., 2001; Hiremath, 2004; Kant, 2004; Wang and Wilson, 2007). Skeptics question whether in the tropics non-timber values are sufficiently high to outweigh the alleged economic inferiority of SFM vis-à-vis conventional logging (CL) and/or forest conversion, whether MFM is feasible under precarious tropical governance scenarios, and whether it is cost-efficient vis-à-vis more direct conservation models (Rice et al., 1997; Bowles et al., 1998; Kaimowitz, 2004; Wunder, 2005).

This paper addresses the feasibility of MFM in the tropics considering selected current implementation examples, and the key obstacles these have faced. Much of the conceptual development of MFM models has occurred in the Northern Hemisphere and became mainstream thinking in forestry operations in the tropics without regarding the large differences in scenarios. Despite the prolific literature proclaiming the advantages of MFM as a tool to achieve SFM (Panayotou and Ashton, 1992; Hiremath, 2004; Zhang, 2005), its implementation and adaptation to real-world scenarios, particularly in the tropics, has been less prominent (Boscolo, 2000).

The paper presents first the debate about MFM as a desirable management objective under the SFM paradigm (Section 2). Second, we scrutinize main opportunities and constraints in the adoption of MFM (Section 3). We then identify the scenarios where MFM could be a feasible conservation and development strategy, particularly in the tropics (Section 4). Finally, we summarize the potential of MFM strategies (Section 5).

2. Adoption of multiple-use forest management

A progressive forestry vision nowadays requires forests to satisfy multiple stakeholder demands for multiple products and services (Kant, 2004). To accommodate this, SFM has appeared as a new 'Holy Grail' governing forestry agendas in both developed and developing countries (Poore, 2003; Wang and Wilson, 2007). SFM generally aims at promoting conservation and management practices which are environmentally, socially and economically sustainable (Sayer et al., 1997; Poore, 2003). Hence, the SFM concept integrates plural management objectives from long-term planning and maintenance of the resource base to the multiple use of forest values.

Several trends have gradually unfolded under the auspices of this evolving concept transforming current forestry scenarios. The initial focus was on the negative ecological and social impacts of conventional logging operations carried out by timber industries, which was and still is one of the most visible threats to tropical forests conservation. This led to the search for technological packages to minimize the damages of logging and to sustain timber yields (Dykstra and Heinrich, 1996; Pinard and Putz, 1996; Dykstra, 2002). The design and implementation of reduced impact logging (RIL) techniques in the late 1980s was a first practical step to improve timber-harvesting practices by reducing damages to the remaining vegetation and to soils (Pinard and Putz, 1996; Sist et al., 2003). These guidelines are exclusively timber-focused, and were developed to deal with mechanized operations in large-scale logging. They only deal with non-timber forest products (NTFPs) and environmental services (ES) values as passive side-concerns. Hence, more recently RIL guidelines have come to be seen as insufficient to comply with increasingly diverse demands on forests (Sist et al., 2005; Putz et al., this issue). However, RIL are certainly still valid technical guidelines in scenarios where sustainable timber extraction remains the prime management goal. Additionally, some impediments determining the poor adoption of RIL in the tropics (Putz et al., 2000; Applegate et al., 2004) will also be significant obstacles to MFM adoption (Table 1).

While MFM is prominently placed in the SFM concept, it is in no way a new notion: for centuries, forests have been a source of timber, non-timber products, and forest services. It was only after the Second World War that large-scale industrial timber harvesting, the development of plywood manufacturing and sawmills industries, and the accelerating substitution of NTFPs for synthetic derivates initiated a forestry cycle clearly dominated by timber extraction (Sayer and Byron, 1996; Wiersum, 1999; Poore, 2003). In the 1970s, the recognition of the critical role of forests in the life of rural smallholders and local communities refocused attention on multiple values and stakeholders. Yet, while initial multiple uses had referred to low-intensive, broad-based extractivism spread over large areas, MFM was now being reframed in a SFM context of harder and more explicit trade-offs between different, and often more specialized forest uses.

Although the implementation of MFM models has been more widespread in forestry operations in the Northern Hemisphere (i.e. combined management of timber and mushrooms, berries, aromatic and medicinal plants, and wildlife hunting), there are also some examples in the tropics that serve us to explore the conditions that could favor or constrain the multiple-use approach. The integration of xate (*Chamaedorea* spp.), chicle (*Manilkara zapota*) or allspice (*Pimenta dioica*) harvesting with timber

Table 1
Main factors identified in the poor adoption of RIL techniques in logging operations in the tropics, and their potential relevance (+++: highly relevant; +: fairly relevant) to MFM guidelines

Factors	Reasons	Relevance to MFM guidelines
Implementation too expensive	Contested by several studies (Pearce et al., 2003; Applegate et al., 2004), but still part of the conventional wisdom of most loggers	+++
There is no need for the improvement of current practices	Profits of unsustainable logging tend to be high and regulations enforcement too weak	+
Lack of adequate governmental incentives	Tax incentives and other compensation schemes are still rare and untested. If not well planned they can be insidious (Cubbage et al., 2007)	+
Forest will be converted anyway	High short-term timber profits and/or forest conversion to more competitive land-uses, as agriculture or cattle ranching, makes long-term planning unattractive	+
Lack of trained staff	Few applied training programs and materials to disseminate research findings to forest managers and field workers	+++
Opposition against SFM approaches by some environmental groups and researchers	Lobbying for the establishment of parks and other strictly protected areas (Bowles et al., 1998; Rice et al., 2001)	+

extraction in community forest concessions in Petén, Guatemala, is generally cited as one of the successful stories of MFM. Combined extraction has had clear social and economic benefits, such as increasing forest revenues, employment, and diversification of households incomes (Mollinedo, 2000; Campos et al., 2001; Mollinedo et al., 2001). The combined harvesting of chicle, honey, wild game and timber in Quintana Roo, Mexico has had similar effects (Snook, 2000). Both situations share characteristics favoring integration: clear regulations to control the extraction of both timber and non-timber, well-defined tenure or usufruct rights allowing commercial harvesting; consolidated local and export markets for both timber and non-timber forest products; communities are well integrated with markets trough transportation network; and presence of relatively strong social organizations and institutions. Additionally, they are examples of MFM in areas under local communities' control, where multiple use represents the most viable strategy to maximize the diversity and number of income opportunities, and to minimize the risks—encompassing communities' dual roles as subsistence and market producers (Toledo et al., 2003).

Two other cases from Asia and Africa perhaps do not constitute MFM models *stricto sensu*, but are examples illustrating both the opportunities for and the obstacles to forests' multi-purpose integration. The '*damar*' agroforests of Krui (South West Sumatra, Indonesia) have been portrayed as a paradigm of integrated forest management (Torquebiau, 1984; Michon, 2005). The system offers a stable and diversified portfolio of incomes to local communities (Wollenberg et al., 2001), where damar trees provide a regular damar resin yield and occasional valuable timber revenues (De Foresta and Michon, 1997; Petit and De Foresta, 1997) in a forested landscape of high environmental value (Michon and de Foresta, 1995; Nyhus and Tilson, 2004). But forest multi-functionality is currently in jeopardy due to a combination of improved transport infrastructure and changing prices: declining demand for damar resin has been accompanied by increasing timber prices, and road building has favor new production options. Hence, revenues from quicker timber harvesting are locally being reinvested in transport equipment to reach new markets for agricultural products and to boost off-farm incomes. This is accompanied by a decrease in traditional cultural values, pushing a conversion process that local people expect to accelerate (Kusters et al., 2008).

In the Congo Basin, integration of timber and non-timber forest resources plays a key role in the subsistence and market economies of rural communities, enhancing their well-being and reducing economic risk (Ndoye and Tieguhong, 2004). However, the increasing pressure from uncontrolled industrial timber harvesting in large forest areas allocated to logging concessionaires has resulted in forest degradation and a decline of local opportunities (Laird, 1995; Laird, 1999; Ndoye and Tieguhong, 2004). The integration of timber and non-timber is hampered by the spatial overlap of actors with different interests and bargaining power – communities and logging companies – in a setting where most timber species also have important non-timber values. Other factors also hampering integration are weak institutional support to communities, inappropriate policies and incentives, poor law enforcement to control timber operations, communities' fragile tenure and use rights.

There are other examples around the tropics where the conflict between timber and non-timber uses has prompted the search for integration. For instance, high-value NTFPs like copaiba oil, sandalwood or rattan are progressively being incorporated in timber inventories and management plans (Guariguata and Mulongoy, 2004). However, it is too early to tell whether this will constitute a successful path towards consolidating MFM adoption.

3. Opportunities and constraints

In this section, we will discuss three critical themes determining the scope for MFM adoption: the economic conditions, the institutional framework, and variable MFM scales.

3.1. From economic rhetoric to markets

Until now, the MFM debate has circled mostly around concepts embedded into sustainable forest management (Kant, 2004, 2007). From an economic perspective, SFM in its various forms implies restrictions on timber harvesting intensity, imposes non-declining flows of products and services over time, and long-term planning principles. Under high time discount rates – a common feature in cash-poor tropical regions – these aspects tend to contribute to lower financial returns from SFM, as compared to conventional logging, focused on short-term timber profits. In economic terms; it is simply not worth while to wait for the second (or any subsequent) timber cut (Putz et al., 2000; Kaimowitz, 2002, 2004; Pearce et al., 2003).

To overcome these financial barriers, several authors have pointed to the need for extending the boundaries of forest economics to incorporate the new set of social, economic, and ecological demands that would be key to late 20th century forestry operations (Panayotou and Ashton, 1992; Pearce et al., 2003; Wang, 2004; Cubbage et al., 2007; Kant, 2007): past economic theories, models and tools are seen as too limited in dealing with the pluralistic nature of MFM regimes. Ecological and evolutionary economics have established the basis to develop Total Economic Value (TEV) techniques, designed to translate the wide range of use and non-use values from forests into monetary terms (Pearce et al., 2003). Fig. 1 represents the various forests benefit categories according to the extent they have consolidated mechanisms (such as markets) to allocate an economic value (x-axis), compared to the degree to which they are driven by financial returns (y-axis). Extractive use values (i.e. pulpwood, timber, game, and other NTFPs) are, to a variable degree, traded or potentially tradable in well-developed markets (right-hand side), non-extractive uses (i.e. recreation services, bird watching, carbon sequestration and other environmental services) imply an intermediate category where tradability recently has increased. Non-use values, including option values (willingness to pay for future uses), bequest values (value for keeping forests for future generations) and existence values (value placed on the resource for its existence), are currently barely reflected in market prices (Cubbage et al., 2007; Wang and Wilson, 2007).

In practice, non-use values, in particular, often require heroic assumptions for quantification, mainly because of underlying biophysical uncertainties and lacking prices. Most evidence shows that "business as usual", i.e. conventional logging and/or forest conversion, remains economically more attractive than SFM or MFM models, be that because time-discounted profits are higher and/or because less upfront investments in planning and capacity building are needed (Pearce, 1996; Pearce et al., 2003). As Poore (2003, p. 24) has pointed out: "arguments based on theoretical economics are often less persuasive than those based on real-world financial considerations." Some of the basic profitability gaps in forestry operations have remained unsolved. Thus, a need was perceived to develop appropriate mechanisms for capturing and prioritizing the wider range of benefits forests provide to compensate for profit differentials between conventional logging and SFM.

Market-based approaches like forest certification, payments for environmental services and the introduction of corporate social responsibility practices in forestry businesses have thus emerged

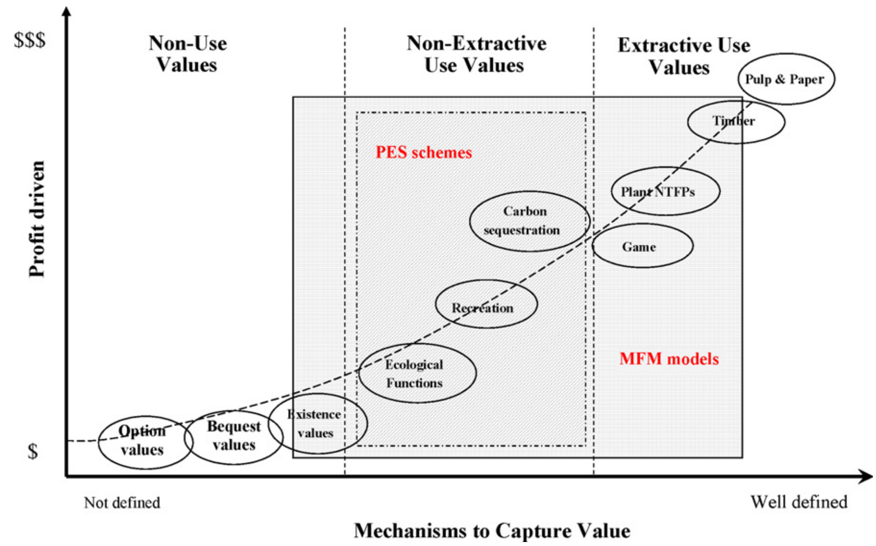

Fig. 1. Forest benefits, profit orientation and value capture mechanisms: defining the scope for MFM.

as promising ways to combine biodiversity conservation and social responsibility with competitive financial returns (Powell et al., 2002; Scherr and White, 2004; Cubbage et al., 2007). However, each benefit category has its own opportunities and constraints, which shape its potential contribution to MFM models (as discussed below).

3.1.1. Timber in MFM

Globally, timber will probably remain the most significant forest output, except for some forest areas with remarkably high NTFPs or ES values (Pearce and Pearce, 2001). But the price premium for sustainably produced timber and other wood products is unlikely to match the incremental costs of SFM (FAO, 2005b; Sengupta and Maginnis, 2005). So far, the most successful incentive for SFM appears to be forest certification, which is gradually becoming a standard requirement for timber suppliers and timber markets to many developed-country markets. In terms of forest certification, in 2006, approximately 270 million hectares of forests were certified worldwide by one or another of the major certification systems (Cubbage et al., 2007). However, this area amounts to only 7% of global forest area, the great majority of which is located in boreal and temperate zones. Evidence about the size of consumers willingness to pay price premiums for certified timber remains inconclusive (Forsyth et al., 1999; Siry et al., 2005); but certification and eco-labeling are increasingly becoming a *sine qua non* for producers' access to timber markets in developed countries, through greater emphasis on corporate responsibility mechanisms. In other words, how much consumers pay extra for certified produced wood is dubious, but not being certified can become an effective obstacle to market access.

3.1.2. The role of NTFPs

NTFP markets were proposed as a local development alternative, or complement to timber, in order to boost returns to standing forests. The renewed interest in NTFPs started in the 1980s, following social concerns about local communities' needs to increase their share of forest benefits (Falconer and Arnold, 1988; Balee and Posey, 1989; Stiles, 1994; de Beer and Mc Dermott, 1996). The aggregated value of NTFPs was in some studies found to be higher than that of timber, and particularly relevant to the poorest members of local communities (Myers, 1988; Cavendish, 2000; Shanley, 2000; Demmer and Overman, 2001). This led to a polarization between timber and non-timber that lasted for over a decade (Dickinson et al., 1996). Yet, gradually the promotion of NTFPs re-evolved as a potential to complement timber revenues in order to increase the financial benefits from forests (Panayotou and Ashton, 1992; Dickinson et al., 1996; Auer and Farley, 2003). In fact, there is a great variety of non-timber products, and harvesting cycles are generally much shorter than those of timber rotations. NTFPs were also considered a promising way to combine conservation with development objectives (Nepstad and Schwartzman, 1992; Plotkin and Famolare, 1992; Redford and Padoch, 1992; Evans, 1993). These joint features made NTFPs an ideal fit to MFM prescriptions (Repetto and Gillis, 1988; Salick et al., 1995; Campos et al., 2001; Hiremath, 2004).

Nevertheless, numerous subsequent studies have given a more sobering assessment of the real potential of NTFPs (Arnold and Ruiz-Pérez, 1998; Wunder, 1999; Neumann and Hirsch, 2000; Lawrence, 2003; Ros-Tonen and Wiersum, 2003). NTFP-based strategies are jeopardized by a combination of species usually occurring in low densities, with irregular distribution patterns, and small and uneven yields per area (Panayotou and Ashton, 1992; Phillips, 1993). Harvesting is generally labor-intensive, supply can fluctuate unpredictably between harvests, and products are thus susceptible to substitution for synthetic derivates. NTFPs markets have proven to be more opaque and less expansive and dynamic than anticipated by the optimists (Belcher, 1998; Belcher and Schreckenberg, 2003; Marshall et al., 2003). Overall, the trade of NTFPs has increased steadily but slowly (FAO, 2006). The potential benefits to local communities have been questioned, both in terms of their high opportunity costs, and of to what extent local people can benefit from their promotion (Peluso, 1992; Dove, 1993; Godoy et al., 2000; Ruiz-Pérez et al., 2004). Finally, claimed conservation benefits have been confronted with the classical trade-offs between the income gains from intensification of the production and the negative environmental impact on species ecology (Boot and Gullison, 1995; García-Fernández et al., 2003; Ticktin, 2004).

3.1.3. New approaches: payments for environmental services

The awareness about the ES provided by forests is deeply rooted in all societies. As environmental problems and our knowledge about them have evolved, so has the appreciation of forest ES. With increasing environmental degradation, benefits that before were taken for granted now arguably emerge as key market-oriented conservation strategies (Scherr and White, 2004; McCauley, 2006). Perceived scarcity has made ES potentially tradable in new forest markets and payment schemes, creating great expectations about their potential to curb environmental degradation (Cubbage et al., 2007). Of the many types of benefits, carbon sequestration and storage, biodiversity conservation, watershed protection and landscape beauty are the four types that stand out as most dynamic, since they represent the clearest examples of valuable forest externalities (Landell-Mills and Porras, 2002; Wunder, 2007).

Compensation paid by the beneficiaries for the externalities provided from standing forests could in theory make sustainable forestry financially more attractive. Thus, payments for environmental services (PES) have emerged as an innovative mechanism to compensate service providers for the cost of maintaining healthy forest environments (see Fig. 1) (Scherr and White, 2004; Wunder, 2007). As defined by Wunder (2005), PES represent a voluntary transaction in which a well-defined environmental service (or a land use likely to secure that service) is bought by a (minimum of one) buyer from a (minimum of one) provider, if and only if the latter continuously secures ES provision (conditionality). These criteria seem easy to meet in theory, but in reality relatively few projects fulfill all of them.

At the global level, PES are still incipient and limited in scope and scale, especially in developing countries (Landell-Mills and Porras, 2002; Pagiola et al., 2002; Powell et al., 2002; Scherr and White, 2004). The implementation of PES schemes has probably so far faced three fundamental problems. First, lacking scientific knowledge may not device clear relationships between forest presence/management and services provision, especially for watershed protection. The heated debate about forest's hydrological functions (Bruijnzeel, 2004; FAO and CIFOR, 2005; Bradshaw et al., 2007) clearly reflects this. Second, high upfront transaction costs of creating the informational and institutional preconditions for PES (i.e. negotiations and trust-building between buyers and sellers) can potentially offset the benefits. Finally, in many productively marginal and environmentally sensitive areas in the tropics, land and resource property rights are unclear and uncertain. Under such circumstances of open agricultural frontiers with active 'land grabbing' processes, implementing PES is impossible—and trying to do so may create perverse incentives (Wunder, 2005).

Payments for biodiversity conservation, watershed management, or amenity values provided by forests are relatively well-established systems in developed countries—and typically performed by the State on behalf of service users. However, their extension and mainstreaming to global environmental values has so far fallen short of the high expectations created (Smith and Applegate, 2004), in particular in relation to carbon sequestration under the Clean Development Mechanism of the Kyoto Protocol. This is due to market uncertainties, so far low carbon prices, but also the Kyoto rules disfavoring forest carbon markets compared to the energy sector (Johansson et al., 1996; Carpenter, 1999; Smith et al., 2003). In the 13th Session of the Conference Parties (COP13) in Bali, Indonesia, the idea of compensating for Reducing Emissions from Deforestation and Degradation (REDD) has been endorsed. This could also become a renewed incentive for MFM approaches. But REDD is controversial, and many questions about its use remain unanswered (Shamsuddoha and Chowdhury, 2008).

3.2. The policy and regulatory framework

The extension of the boundaries of forestry has contributed to changes not only in terms of concepts and new markets, but also vis-à-vis policies and institutions dealing with forests. There are some examples in the Northern Hemisphere of regulations promoting multiple-use forest management on public forest lands. The implementation of the Multiple Use Sustained Yield Act (MUSYA) in the USA or the British Columbia Forest Act in Canada used regulations to pursue integrated forest management (Zhang, 2005). There are also some more recent examples of legal reforms in tropical countries like Brazil, Costa Rica or Guatemala, the impacts of which remain to be assessed in the future.

Insecure forest tenure has been identified as one of the drivers of environmental problems in developing countries, being a disincentive for investing in long-term forest management (White and Martin, 2002; Kaimowitz et al., 2005; Cubbage et al., 2007). While public ownership is still the dominant type of forests tenure, the last decades have seen an unparalleled redistribution, with indigenous groups and other local communities now owning or administering 22% of forests in developing countries (White et al., 2004; Siry et al., 2005). Demand for greater accountability and greater participation in public planning and decision-making is pressing decentralization processes around the world, with municipalities and communities taking a more prominent role in forestry administration (White et al., 2004; FAO, 2006).

However, decentralization and devolution processes *per se* do not necessarily ensure, or even promote, SFM or MFM. The evidence regarding the impacts of decentralization on forest is rather mixed: there is no sign that decentralization generally leads to more forest conservation (Tacconi, 2007). Sometimes, this can be blamed on deficiencies in the decentralization process itself, e.g. only partial delegation of power and resources to the lower level, or local elite capture. As for devolution, even when it gives complete tenure security and power to the landowner, it can actually sometimes lead to accelerated deforestation. This is because secure tenure and other enabling conditions (e.g. good governance, credit access, or market information) tend to promote the long-term most profitable land use. In many Latin American frontier settings, these best long-run returns may come from land conversion to pastures or agriculture, rather than from MFM (Wunder, 2000; Kaimowitz, 2002).

Furthermore, progress on additional reforms to improve forest law compliance has been less rapid than that of forest ownership and governance, which has created a gap not favoring the investment in sustainable management regimes (Molnar et al., 2004). Forestry regulations required to protect the long-term external values that are not well provided by markets, such as forest retention, regeneration, biodiversity, or sustainable timber and non-timber products supply, are poorly enforced (Cubbage et al., 2007). In general, poor compliance in developing countries can be due to complex bureaucratic procedures and legal requirements, lack of incentives to comply with regulations, weak law enforcement capacity, and high transaction cost of enforcement in vast remote forest areas (FAO, 2005a, 2006).

3.3. Multiple-use forest management: landscape level versus management unit

Although MFM has become a mainstream concept in forestry, how to achieve it on the ground, particularly in tropical forests, remains unsolved (Boscolo, 2000; Zhang, 2005). Some proponents suggest that diversified demands on forests under MFM models can be achieved at the landscape level by spatially segregating demands, with forest units specialized in a single dominant use, be it the provision of timber, NTFPs, or ES (Vincent and Binkley, 1993; Binkley, 1997; Rayner, 1998; Boscolo, 2000; Zhang, 2005). Others argue that multiple goods and services should be produced at the same management unit or forest-stand level (Panayotou and Ashton, 1992; Campos et al., 2001). In sum, MFM could be met in two different ways: (1) at the landscape level; or (2) at the stand level.

Integrating the production of all three forests-benefit categories in the same management unit only makes sense when the complexities of MFM techniques are low enough to keep cost-benefit ratios at bay. Boscolo (2000) indicates that most of the studies on trade-off curves between competing timber and non-timber outputs have focused on temperate forests, and lack empirical testing. He ran a simulation model using data from a 50-ha research plot in a primary tropical forest in Malaysia, and found that in most situations dominant use is likely to yield superior returns to multiple use at the stand level. This is due to high fixed cost of forestry operations (infrastructure planning, inventories, mapping, etc.)—combined with technical complexities of MFM (lack of silvicultural knowledge and expertise to integrate multiple products). However, in circumstances where the influence of these aspects is reduced, i.e. logged-over forests with lower fixed costs associated to re-harvesting, or community forestry at smaller scales and with less need for infrastructure, multiple uses within the same management unit may yield superior returns to land-use specialization. Similarly, Vincent and Binkley (1993) analyzed a model using two forest stands and made a strong case in favor of specialization at the stand level and multiple-use management at the landscape scale: as long as returns to management do not diminish too quickly, specialization would prevail whenever one of the outputs is more responsive to management effort than the other and markets correctly value both timber and non-timber outputs. They indicated the need to allocate forest lands to the individual use they are economically and ecologically most suitable to provide to optimize management effort and improve forests chances. Zhang (2005) revised this model in terms of cross-spatial interaction, changes in technologies and prices, and ecological and economical thresholds of production and management. He also found that land-use specialization was superior in most situations, either at the stand or at the landscape level.

4. Development scenarios

The implementation of SFM has been far more effective in improving forest management in Northern Hemisphere countries (Poore, 2003). Hence, it does not come as a surprise that MFM has followed a similar trend. The lower adoption rate of MFM models in the tropics thus also sets the scene to discern potential scenarios for multiple-use approaches: in addition to the local factors listed above, perhaps more systemic higher-level framework conditions need to be considered to explain the disparate feasibility of MFM adoption.

In our view, the scope for MFM feasibility is, *inter alia*, closely related to the different stages of the forest transition processes. This alleged U-shaped curve relates forest-cover changes to countries' economic development phases (Rudel et al., 2005; Cubbage et al., 2007), providing a framework to understand how different forest management models tend to adjust along these stages (Fig. 2). Initially, in hunter-gatherer societies, and others with limited market contact, the multiple use of forest resources is a rational way to satisfy the demands for diverse autarchic needs. As societies or regions develop and move into a commodity-producing capitalist phase, technologies to exploit forests and soils improve, population grows, thus pushing countries down the environmental Kuznets curve of decreasing forest cover. Forests shrink as a result of pressing needs for capital and land to invest in alternative sectors with higher financial returns, and strategies of land-use specialization on agriculture or cattle ranching prevail vis-à-vis MFM approaches. At some point, however, countries tend to undergo a forest transition where forests are revalued for

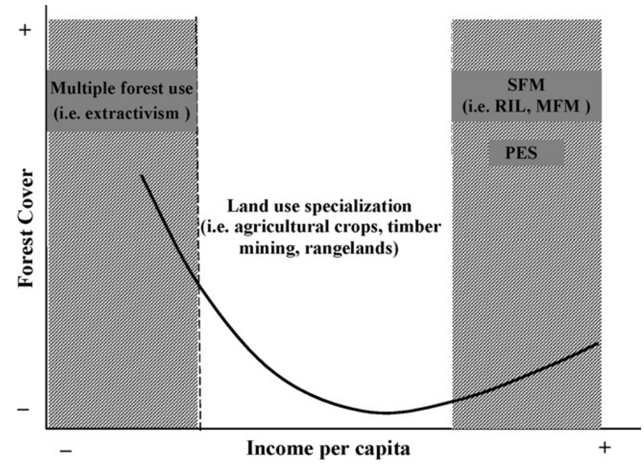

Fig. 2. Country development relationship to forest transitions. Shade areas represent stages with favorable conditions to implement forest management regimes and other conservation schemes that make use of the wide array of goods and services provided by forests.

multiple goods and services. First, richer societies consume more wood-based products, creating incentives for new forest plantations. At the same time, growing demand for recreation areas, clean water, etc. lead societies to value forest ecosystem services. Perhaps most importantly, higher wages and new technologies focus agricultural production on prime croplands, leading marginal lands to be abandoned and grow back into secondary forests. These factors combined lead forest areas to expand (Sayer et al., 1997). The mixed character of these societal demands on forests also favors MFM. However, often MFM re-expands at the landscape, not the stand level: specialization of forest stands remains the most profitable management option, but different stands within the landscape accommodate the different foci of demand. Hence, forests transitions could help to explain why forest management in industrialized countries has progressed more towards MFM than most developing countries. In some middle-income countries where a forest transition has recently occurred (e.g. Costa Rica, Sri Lanka, China or India), it is also possible to recognize some of the above tendencies.

The 'turning point' where forests stop shrinking and MFM models rebound, as well as the conditions that determine this transition, vary greatly across countries. But we can identify some of the elements involved in the 'turning point' to enable MFM conditions. It is clear that in scenarios with high discount rates, emerging competitive land-use alternatives, undeveloped environmental services incentives, and precarious governance, MFM will not be the financially most attractive proposition. A higher economic development stage and demographic transition will thus be key factors in re-enabling conditions for MFM. Other determining factors – whether correlated with the development stage or not – may include consolidated markets for timber and non-timber, well-defined and secure tenure rights, clear extractive regulations, good governance, and institutional incentives. However, as we have seen above, the evidence for some of these effects is not unambiguous, i.e. secure tenure or improved market access can sometimes act as deforestation drivers. In any case, local communities' involvement seems to be co-determinant at the micro scale, since the multiple-use strategy explicitly copes with risks through income diversification.

Probably it is most strategic to discuss MFM scenarios at the landscape versus the management unit level. Factors favoring specialization over integration to be highlighted are the intrinsic differences between forest products, specific market constrains for each set of products, and production trade-offs. In general, management of timber and non-timber forest outputs require different sets of knowledge, skills and capacities, which are segregated among forest actors (Guariguata and Mulongoy, 2004). Furthermore, the market chain from the forest to the end consumers is in most cases different for the various outputs. Generally, diverging markets for timber, NTFPs and ES tend to require specialization and market knowledge that is not level among all actors, which does not favor multiple-use forestry—at least, not implemented by the same actors (Belcher, 1998). Finally, the extraction of one forest output can often negatively affect the maintenance of another. This is the case of some valuable timber species that also provide widely used NTFPs – thus selecting one use over the other will be mutually exclusive (Shanley and Luz, 2003; García-Fernández and Shanley, 2004) – or the negative impact of repetitive harvesting of NTFPs and timber species on the genetic and community components of biodiversity of wild populations (Putz et al., 2001).

In sum, some tropical forests will be inevitably lost due to aggressive expansion of very profitable agriculture and cattle ranching areas, making conservation opportunity costs too high to bear (Wunder, 2005). Some tropical forestlands will have high conservation value – regions with little forest left or with presence of species of special conservation value – and be critical to maintain biodiversity; in these areas conservation strategies should focus on the establishment of protected areas. For the remaining forest areas – and depending on the country's development stage, the politically determined economic incentives, and other factors – MFM at the landscape level could prove a viable management strategy. We need to analyze for each particular case the economic, social, and technical trade-offs between timber and non-timber values to identify which management strategy is preferable (Boscolo, 2000), establishing a functional forest landscape with land units allocated for either integrated or specialized priority use.

5. Concluding remarks

MFM is being promoted in the tropics as one of the potential conservation and development alternatives to simultaneously satisfy multiple forest stakeholders, raise local incomes and curb environmental degradation (Panayotou and Ashton, 1992). MFM has thus become a prime objective under the SFM concept, and its adoption was envisioned as a tool to counterbalance the economic and social shortcomings of timber-dominant management models. But its implementation in tropical countries has been limited—and as we argue in this article, this is for good reasons. Special scenarios with favorable preconditions are required for MFM to work, including a new mindset and incentives to successfully compete with more specialized land-use options.

Our examples show that integrated timber and non-timber management at the stand level is more common in areas managed and controlled *de jure* or *de facto* by local communities or indigenous groups. Many communities have a long tradition of managing their forests to meet diverse demands, but may face significant difficulties when obliged to adjust these practices to official forestry regulations. They are often constrained in their access to capital, technologies, and markets, implying that they may not be able to fully switch to more profitable specialization strategies. Real-world success stories indicate that multiple-use either at the stand or at the landscape level has focused almost exclusively on use values (Fig. 1), i.e. extractive and to lesser extent non-extractive uses—especially the integration of timber and high-value NTFPs. Full integration across the spectrum of uses is usually not found, except possibly at the earliest, autarchic economic development stages. Qualitative factors such as devolution policies, institutional incentives, and adoption of multi-agent management models can also clear play out to the favor of MFM.

The evolution of MFM strategies will be the combined response to the segregation and integration factors we have described. Society-wide factors (such as the corresponding forest-transition stage) set the stage, but local conditions (e.g. tenure and institutions) will often modify local outcomes, thus offering a diverse set of scenarios. This would require forestland managers to carefully assess which management alternatives are feasible in their particular setting (Sayer et al., 1997). However, multiple-use forest management within the same tropical forest-stand unit may only be implementable under exceptional circumstances. The key factors MFM is up against range from intricate technical trade-offs at the species level to the economies of scale in forestry planning, production and marketing, and further on to the structural conditions in capitalist societies favoring commodity specialization models. Yet MFM remains a valid management alternative under specifically favorable local context conditions, especially when practiced at the landscape scale.

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