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Biological Challenges for Certification of Tropical Timber[1]

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ABSTRACT

Ecological certification of forest products is a rapidly developing market-based incentive for better forest management. Improved forest management can be an important component of tropical conservation and development strategies. To provide a solid biophysical basis for certification programs, however, research is needed on the ecological and silvicultural consequences of different forest management practices. The current criteria for certification are generally based on sustainability of timber harvest volumes, protection of hydrological functions, maintenance of soil productivity and forest structure, and minimization of the deleterious impacts of forest management on non-commercial plants and animals. Some criteria and the field indicators used in their assessment apply equally well to most forests, whereas others are only appropriate for certain forest types, stands, or species. Tropical biologists can contribute to the processes of refining eco-certification criteria and selecting ecologically meaningful indicators of good forest management that can be readily assessed and monitored. Participation of tropical biologists in the design of ecological certification protocols will improve credibility of the process and promote better forest stewardship.

RESUMEN

La certificación ecológica de productos forestales es un incentivo de rápido desarrollo, basado en las fuerzas del mercado, para un mejor manejo forestal. El manejo forestal mejorado puede ser un componente importante de las estrategias de conservación y desarrollo tropical. Sin embargo, para proporcionar una base biofísica sólida para los programas de certificación, se necesita investigación sobre las consecuencias ecológicas y silviculturales de los distintos procedimientos de manejo forestal. Los criterios actuales para la certificación están generalmente basados en la sostenibilidad de los volúmenes de aprovechamiento de madera, protección de funciones hidrológicas, mantenimiento de la productividad del suelo y estructura del bosque y reducción de impactos nocivos del manejo forestal sobre plantas y animales nocomerciales. Ciertos criterios y los indicadores de campo utilizados en su evaluación, se aplican por igual a la mayoría de los bosques, mientras que otros son apropiados solamente para ciertos tipos de bosque, rodales o especies. Los biólogos tropicales pueden contribuir al proceso de perfeccionamiento de los criterios de ecocertificación y de selección de indicadores válidos para el buen manejo forestal, los cuales puedan ser rápidamente evaluados y monitoreados. La participación de los biólogos tropicales en la elaboración de protocolos de certificación mejorará la credibilidad del proceso y promoverá un mejor cuidado de los bosques.

Key words: *conservation; ecological certification; forestry; green markets; silviculture; sustainability.*

Public concern about deforestation and forest misuse, perceived and anticipated shortages of timber and other forest products, as well as threatened and realized boycotts of tropical timber have prompted proliferation of programs for certifying that forest management is carried out in socially and biologically acceptable manners. A number of assumptions underlie these certification programs among which the following figure prominently: Commercially-exploited forests are important components of local, regional, and global conservation and development strategies; Forest management can be more financially profitable, socially beneficial, and environmentally acceptable than competing land uses; Conversion of natural forest into pastures, plantations, and other non-forest land uses is less likely where the forest has commercial potential; and by reducing the demand for and thus the financial value of forest products, boycotts may increase the likelihood of forest destruction. A basic dilemma faced by some environmentalists is that because the goal of forest management for commercial production of timber and non-timber forest products is to concentrate growth in commercially valuable species, successful forest "domestication" unavoidably has deleterious environmental consequences. The effects of forest management on bio-

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TABLE 1. *Examples of biophysical principles for certification of timber established by the Forest Stewardship Council (FSC) and the International Tropical Timber Organization (ITTO).*

FSC Principle #5. Forest management operations shall encourage the efficient use of the forest's multiple products and services to ensure economic viability and a wide range of environmental and social benefits.

FSC Principle #6. Forest management shall conserve biological diversity and its associated values, water resources, soils, and unique and fragile ecosystems and landscapes, and, by so doing, maintain the ecological functions and integrity of the forest.

ITTO Principle 33. Monitoring and research should provide feedback about the compatibility of forest management operations with the objectives of sustainable timber production and other forest uses.

diversity and ecosystem processes, however, might more appropriately be compared with those of farming and cattle ranching rather than with intact forests because forestry generally competes with these non-forest land uses.

If forest product certification programs are to be successful, they must be based on the best available social, silvicultural, and ecological information. Although social and economic pressures have great influence on the fates of forests, this article concentrates on the ecological basis of certification protocols. Also, we restrict our comments to natural forest management, leaving plantation forestry and agroforestry for future discussions. We outline the rationale behind certification criteria and suggest research needed to further refine the field indicators used to determine compliance with these criteria. For background, a brief history of certification is provided and the certification process as it is currently being carried out is described. Our goal is to facilitate involvement of tropical biologists in the certification process.

A BRIEF HISTORY OF FOREST PRODUCT CERTIFICATION

Certification programs initially focussed on the tropical timber trade because of alarming rates of deforestation in the tropics (*e.g.*, FAO 1993), the fantastic biological richness of tropical forests (*e.g.*, Wilson 1985), the concern that few tropical forests are well managed (*e.g.*, Poore *et al.* 1989), and repeated threats and occurrences of boycotts of tropical forest products (see Willie 1991). Furthermore, in 1990 the International Tropical Timber Organization called for sustainable forest management in the tropics by the year 2000 for internationally traded timber and timber products (ITTO 1990). By mid-1994, at least 11 forest operations were certified and 19 were under evaluation by five certification organizations in 11 countries (Viana 1994). As participation in certification broadened to include more representatives of tropical countries and with agreement on Global Forest Principles at the United Nations Conference on Environment and Development (United Nations 1992), the geopolitical inequity of certifying only tropical timber became apparent. Organizations involved in certification of tropical forestry operations thus modified their programs to include temperate and boreal forests.

Rapid proliferation of certification programs and a multitude of unsubstantiated claims of sustainability motivated creation of the Forest Stewardship Council (FSC), an umbrella organization that coordinates certification efforts worldwide (Cabarle *et al.* 1995). FSC is an international non-governmental organization dedicated to promoting certification of forest products through voluntary third-party accreditation of certification organizations on the basis of generally recognized principles of good forest management (Table 1).

Although the certification process is still developing, an overall structure appears to be emerging. Globally applicable principles for good forest management have been proposed by the International Tropical Timber Organization (ITTO 1992), the Forest Stewardship Council (FSC 1994), the Ministerial Conference on the Protection of Forests in Europe (Loiskekoski *et al.* 1993), the United Nations Conference on Environment and Development (United Nations 1992), and as part of the Montreal Process (*i.e.*, the Santiago Declaration, Anonymous 1995). The principles vary in specificity, but are in general accord with one another and with principles

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promulgated by many foresters during the last two centuries (Table 1). At regional and stand levels, criteria for certification as well as verifiable indicators of compliance with these criteria are being developed more-or-less independently by many different organizations. In this paper we focus on potential contributions of tropical biologists to the development of certification criteria and to selection of indicators of acceptable forest management practices.

THE CERTIFICATION PROCESS

In general, a team of 3–5 people spends 5–15 days inspecting forest management practices, reviewing data on tree growth and yield, and conducting field interviews with forest workers, environmental groups, and local residents (Seymour *et al.* 1995). Inspection teams often consist of a forester, an ecologist, and a social scientist.

At present, the various certification organizations have their own criteria on which certification decisions are based (Hahn-Schilling *et al.* 1994). Although all organizations that participate in FSC or that want to be recognized by ITTO must follow their principles (Table 1), there is still flexibility in the explicit guidelines used. Field-based comparisons of the certification criteria and indicators used by a number of different organizations are currently being coordinated by the Center for International Forestry Research (CIFOR, Prabhu 1994). The goals of the tests include evaluation of the scientific validity, technical feasibility and cost-effectiveness of different sets of criteria.

A difficult question that has emerged during discussions of the principles of certification is whether forest management operations should be certified solely on the basis of overall sustainability, or whether they should also recognize the application of "good" but perhaps not yet proven sustainable forest management practices. The concept of "sustainability" is extremely complex, with nearly as many definitions as there are people discussing the topic (*e.g.*, Gale & Cordray 1991, Johnson & Cabarle 1993, Dovers & Handmer 1993); just deciding on the spatial and temporal scales over which sustainability should be evaluated can be contentious. In recognition of the problems associated with declaring a forest management operation "sustainable", some certification organizations have opted for multi-leveled certification to promote better forest stewardship. The Smartwood Program of the Rainforest Alliance, for example, might certify a forestry operation as "well managed" but not necessarily "sustainable." Scientific Certification Systems, in comparison, assigns numeric scores (0–100%) for each of the categories of "sustainable harvest," "ecosystem health," and "community benefits" (Seymour *et al.* 1995). Annual audits of certified forest management areas allow verification of continued compliance with guidelines, including required improvements in management practices.

VOLUMETRIC SUSTAINABILITY OF TIMBER YIELDS

A basic tenet of sustainable forest management and one of the major criteria for certification is that the rate of timber harvesting (*e.g.*, m^3/ha/yr) should not exceed the rate at which timber volume accumulates. In other words, only the "interest" on the forest "capital" is harvested. Field application of this ostensibly simple concept is fraught with difficulty; one common problem is that few forests are composed of balanced mixtures of stand ages (*e.g.*, Smith 1986). Furthermore, where old-growth forest abounds there is a strong financial incentive to "liquidate" quickly as much of the forest capital as possible (*e.g.*, Vincent 1992).

Claims of sustained timber yields should be based on data from repeatedly measured growth and yield plots representing the full range of stand ages and stand conditions. Many forest owners and concessionaires interested in pursuing certification lack growth and yield data or lack personnel trained in analysis of the data that are available. Given the costs of establishing and monitoring growth and yield plots, research is warranted on the efficiencies of different plot designs for capturing the data necessary for assessment of volumetric sustainability. Researchers could also help to develop protocols for estimating sustainable harvesting rates when long-term site-specific data are not available.

To be worthy of certification, it seems reasonable to expect that a timber management program approaches volumetric sustainability, but we must ask ourselves what time periods and degrees of temporal and spatial variation are reasonable? For example, should forest managers be required to demonstrate that the nutrients removed in the harvested products are replaced by rainfall inputs or released from bedrock? Do they need to account for minor environmental damages that might accumulate over a number of rotations? Should possible increases in the severity of weed infestations after several cutting cycles be considered? Finally, can enhanced timber production through intensive forest management (*e.g.*, enrichment planting) in some parts of a forest compensate for forest liquidation elsewhere?

Growth and yield studies are particularly challenging in the tropics where trees lack annual rings, the marketability of different species fluctuates wildly, and rapid developments in the wood processing industry induce changes in the acceptability of different sized logs. In anticipation of changes in marketability, should growth and yield analyses consider all species and size classes, or only those for which there are current demands? Also, should volume increments of damaged, hollow, or otherwise malformed trees be included in the calculations, or only those likely to produce high quality logs? Forest owners might justifiably claim that restriction to currently marketed tree species is unfair, but how many species should be included?

PROTECTION OF HYDROLOGICAL FUNCTIONS AND MAINTENANCE OF SOIL PRODUCTIVITY

In recognition of the potentially deleterious effects forestry operations can have on water quality and flow regimes, forest certification programs generally include criteria pertaining to hydrology. Concerns about water pollution and other hydrological changes apply to most forests of the world and hydrological certification criteria are among the most easily generalized. As with other criteria, however, logging practices thought to minimize deleterious hydrological impacts are generally audited, not the hydrological changes themselves. For example, stream sediment loads in logging areas are generally minimized if streamsides are protected, culverts are right-sized, and bridge abutments are properly constructed. Due to lack of time, certification auditors determine whether or not these good forest management practices were implemented, not whether implementation of these practices resulted in the desired hydrological effects. Management practices are therefore used as surrogates for the more difficult to audit hydrological processes.

The degree to which the audited forestry practices (*i.e.*, the indicators of compliance with the criteria) will result in the desired hydrological effects will be improved through research. Forests differ hydrologically and so must the criteria used to evaluate the environmental acceptability of forestry operations. For example, managers of forests on flat terrain with well drained soil may object to prohibitions of clearcutting within 20 or 30 m of streams on the grounds that in their forests this practice does not result in increased sediment loads. Clearcutting stream banks might justifiably be prohibited on other grounds (*e.g.*, water temperature changes or wildlife corridor protection), but erosion is not a universal problem.

Where streamside buffer zones are known to be beneficial (*e.g.*, Moore & Moore 1994), it still remains to be determined how wide they should be, the minimum size of streams requiring buffer zones, and what forestry activities should be permitted within buffer zones. There is even some question as to whether protection of headwaters or streamsides is more effective in reducing sediment loads (A. Greer, pers. comm.). The answers to these questions and most others related to forest management will vary from forest to forest and the explicit certification criteria used should be based on sound local scientific research.

Appropriate methods for mitigating hydrological damage due to forestry operations vary among and even within forests. For example, many certification guidelines call for installation of cross drains on skid trails at intervals determined by slope, soil type, and rainfall intensity. Cross drains direct water off compacted and otherwise damaged soils of skid trails and thus reduce rates of erosion. Where the surface soil layers have been somewhat protected by prohibitions on wet weather logging and restrictions on use of soil-moving blades on extraction equipment, infiltration rates on skid trails can remain fairly high and digging cross drains may result in unnecessary environmental damage (Pinard *et al.* 1995). Other forestry practices with hydrological consequences that warrant research include culvert design and installation, bridge construction, and slope stabilization.

Uncontrolled and unplanned forest operations can result in considerable damage to soil not directly related to erosion. In particular, soil compaction can greatly reduce plant growth rates (*e.g.*, Greacen & Sands 1980). To some extent, soil compaction is an unavoidable consequence of ground-based log extraction. Efforts to improve and implement aerial logging systems should be continued, but research is also needed on improving plant regeneration and growth on compacted soils. Where heavy equipment is used, research is needed on methods for reducing soil damage through, for example, planning skid trail locations (*e.g.*, Gullison & Hardner 1993) and directional felling to reduce skidding distances (*e.g.*, Hendrison 1989). Researchers could also help develop guidelines for operators to follow in deciding how wet is too wet for logging.

MAINTENANCE OF FOREST STRUCTURE AND BIODIVERSITY

In developing ecological certification criteria for forest products, the accumulating evidence that many forests suffered severe disturbance in the not-so-distant past should be considered. The presence of charcoal in the soil of many tropical forests formerly considered "pristine" (*e.g.*, Sanford *et al.* 1985, Saldarriaga & West 1986, Goldammer & Siebert 1989) along with evidence of widespread human occupation and forest use (*e.g.*, Gómez-Pompa & Kaus 1990) may suggest the conditions under which current canopy dominants regenerated. For example, the scarcity of regeneration of important neotropical timber trees even in the vicinity of mature trees (*e.g.*, *Swietenia macrophylla*) suggests a relation with major disruptions of what are now fairly continuous forest canopies (*e.g.*, Lamb 1966). Forests on the Darien Peninsula, Panama, are evidently still influenced by land-use practices that ended centuries ago (*e.g.*, Bush & Colinvaux 1994). On the basis of these and other similar observations by ecologists, the issue of maintaining forest structure in a pre-intervention state becomes complicated by the necessity to determine the appropriate time frame (*i.e.*, how long "pre-intervention" can the target be?).

How much disruption of forest structure and loss of biodiversity in the course of forest management will be allowed under certification guidelines? The answer to this question is basically political, but researchers need to provide guidance for policy-makers. For example, what floral, faunal, structural, and hydrological changes result from liana cutting to reduce felling damage and promote tree growth? Given that logging and silvicultural treatments unavoidably alter forest structure and composition, are there particular life forms (*e.g.*, hemiepiphytes) or species (*e.g.*, pollinators) that should be given special protection? Where should logging operations be designed to mimic large-scale, stand-regenerating natural disturbances such as hurricanes and wildfires? Where should forest managers mimic gap-phase succession using carefully controlled single-tree selection (*e.g.*, Baur 1964)? Research obviously is needed on the effects of different landscape-level patterns of forest management activities (*e.g.*, stand size, shape, internal heterogeneity, and spatial distribution) on biodiversity conservation, fire susceptibility, and other ecosystem properties.

Another issue that scientists should consider is whether drastic manipulation of forest structure to maximize timber yields in some portions of the landscape can be compensated for by protecting or gently treating more environmentally-sensitive areas elsewhere. Perhaps different management practices and certification criteria should be used in potentially productive areas capable of withstanding or recovering from heavy logging or drastic silvicultural treatments (*e.g.*, level terrain with well drained soil) than in ecologically-sensitive areas (*e.g.*, steep slopes with erosion-prone soil or areas that are particularly rich in rare and endemic species).

Because certification is based on a fairly broad interpretation of "sustainability," forest operations are judged on the basis of criteria that may have little direct silvicultural importance. A major goal of certification, for example, is to minimize the deleterious impacts of forest management on species and genetic diversity and composition. Impacts on non-target species are generally estimated indirectly by evaluating forest management practices. Only in regards to large animals is there likely to be any fairly easy way of determining impacts (*e.g.*, evidence of hunting, presence of captive animals, scarcity of easily detected birds and mammals). There is the possibility, however, that some easily monitored species might provide indications of the overall similarity of the flora and fauna to pre-management conditions.

So-called "indicator species" are receiving a great deal of attention from researchers and policy-makers. Apparently, an analogue of the "mine canary" is being sought for forestry operations. Large and so-called "charismatic" vertebrates are often suggested as indicator species and continue to receive the bulk of funding for research on the environmental impacts of tropical forestry (*e.g.*, Frumhoff 1995). The multitude of studies on the effects of logging on birds and mammals (*e.g.*, Johns 1988, Lambert 1992, Thiollay 1992, Mason 1996, Laurance & Laurance 1996) is testimony to this tendency. Research on the consequences of logging and other forest management activities for plants, insects, and other taxa is less common, but the conclusions are generally similar and often equally obvious; species characteristic of forest interiors suffer when the canopy is disturbed while species characteristic of more open conditions thrive. These conclusions are neither surprising nor particularly informative; certifiers clearly need more sensitive indicators of change and more ecological support for any predetermined limits on the degree of change allowable. Suggestions of appropriate surrogate species for biodiversity monitoring are likely to emerge from research under way in Brazil, Costa Rica, Malaysia, and elsewhere in the tropics.

An indirect way of assessing impacts of forestry operations on non-target species might be based on determining the status of "keystone species" (*e.g.*, Mills *et al.* 1993), *i.e.*, species upon which many other species depend. Among the most commonly suggested keystone species in the tropics are figs (*Ficus* spp.) because they sometimes fruit when other foods are scarce (*e.g.*, Windsor *et al.* 1989). While much remains to be learned about figs as keystone species (*e.g.*, Susilo 1993), protecting them in forest management areas seems reasonable. Before keystone species should figure prominently in forest certification guidelines, however, the concept deserves close scrutiny from researchers. Given the prohibitively high cost of general biodiversity monitoring, research on this topic is clearly warranted.

CARBON BALANCE: A GLOBAL ECOLOGICAL CONSIDERATION

Improved natural forest management and reforestation both reduce atmospheric accumulation of carbon dioxide and other heat-trapping gasses (*e.g.*, Trexler 1991, Houghton *et al.* 1992, Trexler & Haugen 1995). Many forest stewardship practices required for certification result in larger carbon storages and increased rates of carbon sequestration (*e.g.*, Putz & Pinard 1993, Pinard & Putz 1996), but should carbon balance be explicitly considered as a certification criterion? If so, what standards of carbon offset data reporting should be required and how should carbon balance be weighed against, for example, biodiversity maintenance? Certainly it is easy to envision silvicultural stand "improvement" treatments that increase rates of carbon sequestration at the expense of species diversity (*e.g.*, culling of trees of non-crop species). Furthermore, where cataclysmic disturbances characterize a forest's dynamics, reduced-impact logging and gentle stand improvement treatments to retain carbon in living trees may be silviculturally inappropriate.

POLICY ISSUES

Researchers need to work with policy-makers to decide just how much change in forest structure and composition will be permissible in certified forests. Some modifications in species composition and genetic composition will unavoidably result from forest management activities (Robinson 1993); such changes are to some extent the goal of commercial forest management. If conservation-minded consumers are willing to accept "organically certified" exotic vegetables grown in fields that formerly were forests or savannas, it would be unreasonable for them to expect managed forests to be identical to protected areas in composition and structure. Perhaps, as we suggested above, conservationists should compare the effects of certified forest management activities with the consequences of "liquidation logging" and forest conversion to other land uses.

In many certification programs the introduction of exotic organisms is prohibited under all but the most pressing circumstances. This anti-exotic bias is presumably based on fears of invasive expansion of the introduced species ("harbingers of the Homogocene") as well as the apparent incompatibility of exotics with native organisms (but see Lugo 1992). Researchers will need to help elucidate the conditions under which exotics, particularly fast-growing or high-value trees, can play a role in conservation efforts (*e.g.*, Parotta 1992). For example, most people would agree that in deforested areas subjected to intense erosion, any trees are better than no trees. Also, tests are needed of the assumption that wood fiber production from intensively managed plantations reduces the likelihood of natural forest destruction.

CONCLUSIONS AND RECOMMENDATIONS

Although environmentalists and foresters are primarily responsible for development of the certification process to date, biological scientists can contribute to the refinement of ecologically-sound forest management practices and help to develop the guidelines on which these practices will be evaluated. Conservation biologists interested in contributing to the forest certification process, however, may have to reconcile their preservationist principles with the unavoidable impacts of forest management. Whereas there is no inherent conflict between strict preservation and management, saving every species everywhere is not an option and neither is maintaining "pre-intervention" forest structure in forests managed for timber. The challenge for biologists who accept these awful conclusions is to develop scientifically valid,
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develop scientifically valid, technically feasible, and cost-effective methods for mitigating and monitoring the effects of forest management. Forest certification, if properly conceived and executed, can provide important fiscal incentives for promoting better forest stewardship.

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Changes in Leaf
Along a Success
Upper Montane

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ABSTRACT

Morphology and mineral
dominated upper montane
undisturbed Primary Fores
simple, elliptic, entire, an
During secondary successi
average leaf area of prima
than secondary species. As
among primary species. Du
In leaves of species in ESF n
recorded in Costa Rican m
forests.

RESUMEN

Se estudiaron la morfologí
(22) en un robledal secun
un robledal primario no al
es simple, elíptica, entera
secundaria el tamaño pron
mientras que el tamaño p
foliar seco por unidad de
de agua foliar específico de
las especies primarias. Du
significativamente. En hoj
valores de características fo
de los alcanzes conocidos

Key words: Costa Rica;
secondary succession.

♦

LEAF CHARACTERISTICS in
to vary along environm
leaf morphology and m
latitudinal and altitudin
moisture and soil gradi
detail (Webb 1968, G
Grubb 1977, Werger
& Dilcher 1980, Givn
Sugden 1985, Bongers
al. 1994). For instanc
mented that leaves of tro

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