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APPROACHES TO SUSTAINABLE FOREST MANAGEMENT

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Summary

Claims of sustainability are virtually impossible to prove but enough is known about tropical forest ecology and silviculture to protect ecosystem functions and maintain biodiversity while still deriving financial profits from logging. Rapid improvements in long-term forest production will derive from better planning of harvesting operations and stand improvement treatments. Lack of good management plans generally results in logging practices that destroy natural regeneration and increase forest susceptibility to soil loss, wildfires, and weed infestations. Participation of forest managers, timber importers, researchers, and environmentalists in the development of methods for assessing the social and ecological impacts of tropical forestry operations inspires hope for sustainability.

Introduction

Sustainable forest management is based on methods that jeopardize neither future harvests of forest products nor future benefits of environmental services. Although overall sustainability cannot be conclusively proven, application of good forest management practices unquestionably helps maintain the value of forests as sources of timber and other forest products , while simultaneously helping to maintain biodiversity and protecting watershed and other ecosystem function. Even good management may result in unforeseen losses of non-target species and subtle but consequential modifications of ecosystem processes. It seems extreme, however, to expect maintenance of pre-intervention conditions in forests dedicated to forest management.

Given the immense variety of forests in the world, and the often substantial differences between adjacent stands in the same forest, management guidelines must remain flexible. Nevertheless, there appears to be nearly global acceptance of at least the basic components of good forest management. This conclusion is supported by the profound similarities among the forest management regulations of tropical and temperate countries, representing a truly remarkable range of environmental, social, and economic conditions. In this paper I will outline some of these basic guidelines for good forest management with emphasis on timber harvesting, silvicultural practices, environmental protection, and social responsibilities.

Some Challenges for developing "GENERIC" Sustainable Forest Management Guidelines

Given the wood product industry's need for assurance of future supplies of raw materials and the interest of consumers in forest products harvested in sustainable ways, the diversity of forests represents a major challenge to development of criteria for evaluating forest management practices. Forests differ in the regeneration requirements of their most valuable species and in their sensitivities to different silvicultural treatments. Some forests are clearly owned by a single person, company, community, or indigenous group while others are the subject of overlapping and conflicting claims. Furthermore, forests can be important for watershed protection, for their recreational value, or as sacred ground. To this obviously incomplete list of differences between forests we must add the range of perceived values of the same forest: to a concessionaire a forest may

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represent a source of logs for the next 10 or 20 years; to a local forest dweller the same area may be the source of game, shelter and marketable non-timber forest products; a landless farmer might view the trees as impediments to growing food crops; and, to a relatively wealthy city person the same forest might represent recreational opportunities, wonder drugs waiting to be discovered, and a means to offset the global warming potential of the gases emitted from homes, factories, and automobiles. To this complex of forest uses and perspectives, we must add the undeniable conclusion that forestry is not an exact science. It would be ludicrous to try to stipulate exactly how forests are to be managed. In fact, "legislated silviculture" (i.e., the application of a single silvicultural technique over vast, generally politically defined areas) has been the anathema of good forest management. This is particularly the case in the rainforests where our attention is focused today. Where a hectare of forest may contain hundreds of plant species with regeneration requirements ranging from full sun to complete shade and where the adjacent hectare may share a relatively small portion of these species, forest management guidelines need to be flexible. When we add to the natural variation in rainforests the vast potential for differentiation due to human interventions, it is clear that forest management needs to be adaptive and stand-specific. (Note: A "stand" is an area that is more-or-less biologically homogeneous and likely to respond uniformly to silvicultural treatments). This need for flexibility may prove problematic when it comes to certifying that a forest is well managed, but not if both managers and certifiers understand and accept the goal of working towards sustainability.

Harvesting Practices Compatible with Sustainable Forestry

With proper planning and operational practices, logging need not greatly disrupt forest processes nor substantially diminish the future potential for a wide range of forest uses. Logging is damaging, however, no matter how well planned and carefully implemented. Ecologically acceptable or "good" forest management therefore begins with good logging and good logging begins years before the first chainsaw is cranked, with the development of forest management and harvest plans. The comprehensive forest management plan includes maps and descriptions of areas to be harvested, areas to be protected, contractual information, and other general policies. Somewhat more relevant here are the detailed harvest plans described below.

Many of the reductions in logging damage characteristic of well managed forests are the results of careful harvest planning (e.g. Dykstra and Heinrich 1992). To the apparent surprise of some loggers, these environmental benefits are generally not expensive; harvest planning often reduces the costs of transporting logs from the forest to the log pond, mill, or port (see for example, Hendrison 1990, Jonkers and Mattsson-Marn 1986). These short-term financial benefits derive from the increased efficiency of planned harvesting operations. For the forest owner, be it the state, a community, or a private individual, long-term economic benefits also accrue as the less-severely damaged forest recovers more quickly after harvesting. The components of most harvest plans include the following:

1. Large-scale (e.g., 1:5000) topographic maps on which stream buffer zones, wetlands, steep slopes, local human use zones, and other protected areas are demarcated.
2. Maps of proposed haul roads and log landings (if necessary) with construction guidelines specified.
3. In selectively-logged forests the trees to be harvested are marked both in the field and on the topographic map. Felling directions can be included on the harvest plan or just indicated on the trees themselves. In many cases marking and mapping of the trees to form the next crop ("potential crop trees") are also warranted.
4. Field marked and mapped skid trails with construction and use practices specified.
5. The relationships between forest managers (e.g., loggers) and the people potentially affected by management activities (e.g., local residents) are described.

In addition to developing the harvest plan, pre-felling vine cutting is often prescribed where vines bind tree crowns together and thereby increase felling damage (e.g., Appanah and Putz 1984). To ensure that the vine stems have weakened sufficiently, it is recommended that they be cut about one year prior to logging. An

additional silvicultural benefit of vine cutting is reduced post-logging vine infestations because if not cut, fallen vines proliferate vegetatively. In forests in which canopy vines contribute as much as 25% or 30% of the total forest leaf area (Putz and Mooney 1992), cutting vines one year prior to logging may also result in increased physiological vigour of understorey tree seedlings.

In tropical rainforests selectively logged using bulldozers, generally about half the damage to residual trees is inflicted during felling, the remainder occurs during log yarding (e.g., Nicholson 1958, Redhead 1960). Felling damage is substantially reduced, however, when chainsaw operators direct the fall of the trees so as to avoid destroying potential crop trees and to facilitate skidding. Not all trees can be set down in any direction chosen, but training increases the are over which fellers can safely direct trees and thereby decrease damage. In dipterocarp forest in Sabah, Malaysia, we have evidence that the difference in directional felling ability of trained and untrained chainsaw operators may be as great as 100 degrees, a difference that can correspond with substantial potential reductions in felling damage (Pinard *et al.* in review).

Due to damage to residual trees and the often more severe and long-lasting damage to soils, improper yarding is generally at fault when forest management is obviously unsustainable. Yarding deserves a great deal of attention from engineers and environmentalists alike. Although there is a variety of options for extracting logs from forest (e.g., oxen, elephants, farm tractors, articulated skidders, crawler tractors, high-lead and skyline cable systems, helicopters, and balloons), the most common yarding tool, the bulldozer, was designed for road building, not for log skidding. Bulldozer-caused damage can be reduced by restricting machine movements to designated skid trails and by maximizing log winching distances. Where these controls are not implemented, 30 or even 40% of areas from which only l0-12 trees/ha are extracted can suffer the direct impacts of bulldozers (e.g. Sabah Forest Department 1989). Because these machines are so heavy and powerful, their passage results in seriously compacted soils into which water infiltrates very slowly and plant regeneration is impeded, often for decades. To avoid soil damage, the use of yarding systems that move logs suspended in the air (e.g., skylines, helicopters, and balloons) should be encouraged. Whatever the yarding system chosen, implementation must be controlled and monitored in the forest.

The likelihood of sustainability is enhanced when haul roads are properly located, constructed, and utilized. The main goal in designing logging road networks is to minimize the total area disturbed by roads and road-related activities. Well-located roads can also contribute to reducing yarding damages by facilitating uphill skidding. Given the extremely high cost of road construction, it behooves forest managers to plan and construct logging roads carefully. When managers have little long-term interest in the forest and thus little reason to utilize engineering principles that make roads permanent, the forest owner should demand good roads. When this control is not forthcoming, market incentives, like those associated with eco-labelling, could serve the same purpose. Determination of compliance with the widely accepted guidelines for proper road construction (e.g., drainage structures, bridge construction, and spoil disposal) is one of the more straightforward steps in the eco-certification process.

Sustainable harvest management does not end when the last log is carefully extracted from the forest. Closure of logging areas should include removal of any stream crossings that impede water flow and may require treatments to promote revegetation of denuded areas. Replanting and fertilization of severely compacted soils can reduce soil erosion, but avoidance of damage should be the primary objective of management. After logging is completed, drainage structures on skid trails and spur roads need to be installed or repaired so as to ensure that when the forest is next logged, these same extraction paths can be used without expensive "cut and fill" work. Most logging guidelines specify the minimum distance between drainage structures as a function of slope and soil erodability (e.g., cross drains should be spaced less than 25 m apart on skid trails sloping 10-15 degrees).

Although management guidelines are very useful during forest assessment, they need to be treated as guides, not immutable rules. There are situations where installation of cross drains causes unnecessary damage; for example, in Ulu Segama Forest Reserve in Sabah, where skid trails are located on ridges and where the soil surface has not been too badly disturbed, there is little gullying and cross drains can safely be more widely spaced (Pinard *et al.* in review).

Difficulties in specifying what is meant by "too badly disturbed" reminds us again that forestry is an inexact science. Forest assessors need to keep the goals of the reduced-impact logging guidelines in mind and not become slaves to a set of rules.

Silvicultural Practices Compatible with Sustainability

If timber yields are to be sustainable, the volume of timber harvested each year must not exceed the volume of the increment. (The financial analogy of investing the interest without endangering the capital is apt. It is obvious that only by knowing the annual increments of all stands in a management unit can the annual allowable cut be reasonably estimated. Data on tree growth rates and regeneration requirements are derived from monitoring post-logging changes in permanent growth and yield plots or by using other methods of continuous forest inventory. Whatever the method, growth must be monitored over many years because increments often diminish after an initial post-logging spurt. Furthermore, weed infestations and heartrots arising from damage associated with logging often take a few years to develop. The requirement of verifiable data on annual volume increments remains one of the main stumbling blocks to be faced by forest managers who want their operations eco-certified. The requisite data are neither difftcult to collect nor complicated to analyze, but are extremely rare in the tropics. The alternative to real and readily available growth and yield data in Southeast Asia is the questionable assumption that trees in logged but not silviculturally treated dipterocarp forests have mean annual increments of 1.0 cm per annum and that these unmanaged forests accumulate harvestable timber at an annual rate of 1.0 cubic meter. With proper management, these increments and perhaps better are achievable. The problem is that based on these assumptions in lieu of data, cutting rates that far exceed sustainable levels are seemingly justified.

Controlled harvesting can be thought of as a first step towards good management of areas dedicated to timber production, but post-logging silvicultural treatments are also important. Thinning, enrichment planting, pruning, etc. are all familiar techniques to foresters, but deserve re-examination in light of concerns about the effects of forest management practices on biodiversity. Given that managed forests are outside the inviolate preserves that generally serve as the core of biodiversity preservation programs, is it reasonable to condemn silvicultural practices that favor certain species at the unavoidable expense of others? A weed, for example, is defined as a plant growing where a human does not want it to grow. But weeds constitute a considerable component of overall biodiversity. Policy makers need to evaluate the acceptability of changes in forest structure and composition associated with forest domestication. For the forest manager striving towards sustainability, every effort should be made to avoid unnecessary silvicultural treatments, to preserve sufficient areas in an unlogged and unmanipulated state (e.g., at least 20% of each annual coupe not including buffer zones), to maximize economic gains while minimizing ecological effects, and generally to treat forests "gently". Can these vague suggestions be quantitatively assessed for compatibility with sustainability? My answer is a guarded "yes", but again, rather than expecting managers always to follow a rigid set of guidelines, assessment should be based on the degree to which the deleterious ecological, siivicultural, and social effects of forest management have been reduced.

Environmental Protection Practices Compatible with Sustainable Forest Management

Where ground-based yarding is practiced, logging can have long-lasting, deleterious impacts on soil. Right-sizing yarding equipment, installing 'low load-bearing ratio tracks on bulldozers or switching to balloon-tyred articulated skidders, and, most importantly, limiting the widespread practice of blading off skid trails at every pass will all reduce damage. Proper skid trail planning and appropriate training and guidance of tractor operators remain the bases for good forest management.

Protection of hydrological functions in managed forests is a top priority but one that can be accomplished fairly easily. Restricting logging during wet weather and keeping ground-based yarding equipment off steep slopes and away from streamside buffer zones are also important and easily audited guidelines that will contribute to reducing sediment loads in streams.

Additionally, strict rules about use and disposal of herbicides, pesticides, and waste oil need to be developed and followed. Soil erosion can be reduced by proper planning, construction, and use of skid trails and haul roads, as discussed above.

Research is needed on the biodiversity-related consequences of forest management. Treating forests gently (advice promulgated by the late H.C. Dawkins among others), is a good start. Even where the environmental impacts of harvesting and silvicultural treatments are minimized, some species are likely to flourish and others suffer. Given the vast number of animal species in tropical forests and the diversity of their habitat requirements, the range of apparent responses of bird and mammal populations to logging (e.g., Johns 1985, Thiollay 1992) is understandable. Also, although many extirpations of large animals in logging areas are due to hunting, rather than to any direct effects of logging, the forest managers are still responsible insofar as their activities make forests more accessible, thereby jeopardizing wildlife populations.

Social Responsibilities of Sustainable Forest Managers

Experience shows that sustainable forest management programs must be carried out in ways that reflect local, regional, and national priorities. Disregard of local claims on and needs for forest land has resulted in the failure of many otherwise well intentioned forestry projects. Where usufructory rights are respected and where local people are involved in forest management decisions and benefit from forestry operations, the likelihood of successful management is enhanced. Discussing logging systems and annual coupes with local farmers is not a traditional approach to forest management in many of the world's rainforests, but forests have vanished where their needs and desires have not been considered. Ensuring that the people who determine the fates of forests are beneficiaries of forestry operations is both logical and a basic tenet of most existing eco-certification guidelines (e.g., Forest Stewardship Council Principles 2-4; ITT0 Principles 35-36).

Assessment of Forest Management Practices

Once good forest management guidelines are developed and accepted, the next challenge is assessment of compliance. Although a modest number of forest management operations have already been certified as "well managed" by organizations like the Smartwood Program of the Rainforest Alliance and Scientific Certification Systems, the process of forest assessment is still in its development phase. A fundamental issue is whether to assess forest management practices or to base certification on measurements of the environmental and social impacts of forestry operations. For example, should skid trails be assessed on the basis of compliance with specified distances between drains, or on hydrological data? Given the time and money necessary to monitor water flow regimes and sediment loads, or to determine the effects of different forest management practices on biodiversity, it seems clear that assessment will be based necessarily on management practices rather than on environmental consequences.

Given that the criteria for determining whether or not a forest is well managed are almost invariably based on research conducted in forests very different in species composition, structure, and sensitivity to forest management practices, considerable modesty is appropriate during forest assessment. For example, is it safe to assume that all figs are "keystone species" to be protected at all costs in all forests in order to avoid crashes in frugivore populations? Until the necessary data are available, assessors must assume that the values of different environmental protection practices are generalizable. Unfortunately, although research on forest management is critical, investment in rainforest research falls far short of the need. Why is it that investment in forestry research, as a proportion of the value of forest products, falls far short of investment in agricultural research (D'Silva and Appanah).

The people responsible for assessing forest management areas on the basis of ecological, social, and silvicultural practices should work closely with the people actually responsible for day-to-day activities in the forest. The field staff can often identify simple and cost-effective ways

of reducing damage associated with logging and other forest product extraction activities. Training needs can also be determined only in the forest, and incentive programs are more likely to succeed if the potential participants are consulted during the design process. Often the immediate challenge is to replace volume-based salaries with remuneration systems that provide incentives for good practices.

Conclusions

Synergistic interactions between responsible forest managers, enlightened timber merchants, and environmentally-conscious consumers help stimulate rapid changes in popular perceptions of tropical forests and, at least to some extent, in the ways forests are managed. We have emerged from a dark period during which forest preservationists were pitted against loggers in a battle from which neither could emerge victorious. While the importance of parks and other inviolate preserves is undiminished, fewer people question the role of managed forests in an overall conservation strategy. Now the issue in question is whether or not a forest is well managed. There is a great need for widely accepted and easily verified methods to help answer this question. Although additional research on issues pertaining to ultimate sustainability is needed and methods for evaluating forest management practices await further development, enough is known to proceed with eco-certification programs of the kind being coordinated by the Forest Stewardship Council. A major step towards eco-certification that can easily be made by forest managers is to develop and adhere to detailed forest management plans. As eco-certification programs expand, so will needs for training of forest certifiers and for disseminating information to consumers. Researchers associated with the newly created Center for International Forestry Research (CIFOR) are collaborating with environmentalist, land owners, concession holders, government agencies, and other forest stakeholders to design these training programs, to disseminate information about forest-use issues, and to help provide a firm scientific basis for sustainable forest management.

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