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Reducing waste during logging and log processing: Forest conservation in eastern Amazonia

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This article describes the waste associated with logging and log processing in eastern Amazonia and suggests methods for reducing both waste and forest damage as a result of logging.

Over the past 20 years, eastern Amazonia has become Brazil's primary producing region for hardwood logs (Verissimo *et al*., 1992). Much of this increase in production has occurred in Pará State (Figure 1). In the eastern part of the state, near the township of Paragominas, the number of veneer and saw mills rose from two mills with a total production of 8600 m³ in 1970, to 238 mills with an output in excess of 1.2 million m³ in 1990 (Verissimo *et al.,* 1992). To date, the majority of this region's production has been absorbed by the demand for lumber within Brazil. However, as timber stocks are depleted in tropical Asia, eastern Amazonia, with its still extensive tracts of unexploited forests, is on the way to becoming a major supplier of tropical timber for international markets.

FIGURE 1 - Pará State encompasses the major part of the eastern Amazon region of Brazil

Forestry is among the important land-use options in eastern Amazonia, but a close look at the growth of the region's wood industry reveals a repeated pattern of the careless exploitation and degradation of forests near mill centres. A typical logging operation removes 30 to 50 m³ of wood volume per hectare of 30 to 60 species. In the process of extraction, 26 percent of all trees existing prior to harvest are killed or damaged and total forest canopy cover is reduced by 50 percent (Uhl and Vieira, 1989). Also, extensive canopy opening combined with the creation of many dead trees and piles of slash leave logged forest vulnerable to encroaching fires (Holdsworth and Uhl, in press). When nearby forests have been thoroughly exploited, loggers travel to increasingly distant forest tracts until high transportation costs drive mill owners to move their mills closer to unexploited forest. If this pattern of forest mining and subsequent abandonment continues, even the relatively vast tracts of intact forest in eastern Amazonia will be rapidly depleted and the importance of this region as a timber-producing centime will be short-lived. Breaking this destructive pattern requires shifting from forest mining to a system of forest management where working forests provide a reliable source of timber far into the future (Barreto, Uhl and Yared, 1993).

The need for sustainable forest management in eastern Amazonia is obvious, but practical models for forest management in the region are few and far between. In 1992, a group of researchers working as part of a small, non -profit-making research institute, Instituto do Homem a Meio Ambiente do Amazônia (IMAZON), set out to conduct a demonstration forest management project near Paragominas to determine the economic and ecological implications of forest management. The core of this management project was a side-by-side comparison of a 75 ha traditional timber operation with a 100 ha timber extraction effort that was planned to reduce waste timber volume, damage to the residual stand and excessive machine use. The components of the planned forest extraction included: stand inventorying and mapping; preharvest vine cutting, road and skid trail planning and marking; directional tree felling; and the use of a skidder with a winch instead of a bulldozer with no winch (Figures 2 and 3). Management of a timber resource does not, however, end in this forest. As a complement to the forest extraction project, the group also conducted an analysis of the conversion efficiencies and opportunities for waste reduction in the region's wood-processing industries.

FIGURE 2 - In the traditional logging model, a bulldozer with a fixed cable was used to skid logs from the forest to the log landings

FIGURE 3 - As part of the planned logging model, a rubber-tyred skidder equipped with a winch was used to skid logs from the forest to the log landings

The results of the investigations indicated that the methods of exploiting the region's timber resource, both in the forests and in the mills, are unnecessarily wasting large volumes of wood. In the forest, this waste took the form of logs that were felled but never skidded and young trees of commercial value that were needlessly destroyed. In the mills, wood waste took the form of logs that degraded during storage and excessive lumber thickness owing to inaccurately sawn lumber. A first step towards conservation and sustainable use of a resource is minimizing its needless waste. Minimizing timber waste translates into reducing the amount of forested land that needs to be exploited in order to produce a constant volume of timber. The following sections of this article describe some of the sources of waste incurred during timber exploitation and processing as it is currently practised in eastern Amazonia. The group concluded that, in many cases, waste could be greatly reduced by the adoption of straightforward management practices.

Reducing timber waste during logging

The traditional timber extraction model, as it is currently practised in eastern Amazonia, can be thought of as unplanned forest mining that both wastes usable timber and damages the future productive capacity of the forest. Tree-felling decisions are made by chain sawyers (contract workers) as they walk the forest in search of potential timber trees. The chain sawyers have little formal training in tree felling and no training in forest management or silviculture and they are paid according to the volume of timber they fell per day. Thus, rapid sawing is better rewarded than careful sawing. Log skidding by bulldozer occurs several days after tree felling. Although chain sawyers and bulldozer drivers live in the same camp, there seems to be little communication among them regarding the locations of the felled trees. To find felled trees, bulldozer operators drive their tractors towards openings in the forest canopy. When a log is found, it is skidded back to the log landing, but not necessarily by retracing the path used to arrive at the log. The result of this unplanned searching and skidding is a criss-crossing network of skid trails, some of which lead to natural forest gaps in which no timber tree was felled.

It is noteworthy that the underlying reason for this type of utilization is that, until recently, in order to validate their claims to the land, owners have been required to "develop" the forest area. This has involved subcontracting to a logging crew to clear 50 percent of the land (the maximum allowed by law) for cattle ranching. Under these circumstances, it is not surprising that loggers (and their subcontractors) have not been concerned about forest degradation.

There are two major sources of timber waste in forest extraction operations that can be eliminated or reduced through planning and training. The first source of unnecessary waste is trees that are felled but never found by the bulldozer drivers. The group covered a total of 15 km of transects in three previously logged areas and found an average of 6.6 m^3 per hectare of usable timber that had been felled but never skidded. This represents about one tree per hectare and as much as 20 percent of the 30 m^3 of timber volume that is extracted from a typical hectare. The majority of the felled trees that were not found were either buried under the crowns of other felled trees or isolated from other timber trees. This type of waste did not occur in the planned extraction effort. Stand mapping of potential timber trees coupled with skid trail marking resulted in all the trees that were felled being skidded.

In addition to felled trees that are never found, there is unnecessary waste in traditional logging as a result of poor felling and bucking techniques. Several errors can lead to this type of waste: for trees without buttresses, sawing too high on the bole (i.e. more than 20 cm from the ground) and leaving usable wood in the stump; for trees with buttresses, sawing trees above the buttresses instead of removing the buttresses and sawing lower on the tree; improperly sawing at the base of the tree so that the bole splits upwards from the base as it falls; and bucking the tree too far from the top and leaving the usable bole with the crown. The group assessed 854 felled trees in traditional logging sites and found that these four errors, combined, resulted in an average waste of 0.41 m^3 per tree felled. This waste represents 7 percent of the harvestable volume of a typical tree and amounts to 2.3 m^3 per hectare. To reduce this type of waste in the planned extraction, a chain sawyer who had been specifically trained in both directional felling and sawing to minimize the types of error described above was employed. A sample of 164 trees felled by the trained chain sawyer showed 0.11 m^3 of waste per tree felled in felling and bucking operations. The difference in waste between trained and untrained chain sawyers was 0.30 m^3 per tree felled or 1.7 m^3 per hectare. Combining this difference with the elimination of waste owing to trees that are felled but never found (6.6 m^3 per hectare) produces a total yield increase of 8.3 m^3 per hectare which resulted from planning timber extraction and training the chain sawyer. This increase in per hectare yield can be directly translated into fewer hectares of forest subjected to extraction to meet a given timber demand.

Reducing forest damage during logging

Logging in eastern Amazonia is most often conducted with little prior knowledge of the stand and virtually no planning (this is not the case in the Permanent Forest Estate). The result is much unnecessary damage to the small-to medium-sized trees that could make up future harvests. Although these operations are selectively logging the forest (cutting only five to six commercial trees per hectare), an additional 200 trees per hectare with more than 10 cm dbh are incidentally damaged.

Several factors contribute to this damage. Vines are common in the region, connecting each tree canopy to an average of six others. When a tree is felled for harvest or road building, neighbouring trees are damaged when the interconnecting vines pull apart their canopies. In addition, during tree felling, with no training in the art of directional felling, the sawyer attempts to fell the tree along its natural inclination; however, vines that still connect the crown of the cut tree to adjacent crowns often foil such efforts. This greatly reduces the possibility of sparing a specific tree that is not yet large enough to cut for the next harvest. In addition, this lack of controlled felling frequently results in piling one tree on top of another. Such tree "tangles" make it exceedingly difficult to extract the boles during skidding. With no grapple on the bulldozer, the operator must push the boles apart with the blade. In exceptionally difficult tangles, the operator is reduced to driving in circles around the felled trees in an effort to free or lift the boles. Clearly, such movement causes an inordinate amount of damage to nearby trees and results in large areas of disturbance both to the forest canopy and to the forest floor (Figure 4). Skidding is further complicated because boles are usually bucked only once near the crown of the tree. Therefore the bulldozer operator skids long boles back over the twisting trails that were made in search of the felled trees. Skidding back through the forest, the bole cannot bend and the trunks of trees standing near the edge of the trail along the curves are damaged by the passing log.

The group found that the adoption of a series of planning measures and techniques can lead to a significant reduction in damage during logging. One such measure is vine cutting two years prior to logging. When a tree was felled during traditional logging, vines often tore branches from neighbouring trees behind the stump, uprooted trees along the bole and topped trees in the vicinity of the fallen crown. In the planned area, cut trees fell swiftly to the ground, causing little damage behind the stump or along the bole and only minor damage around the crown. The cost implications of this preharvesting treatment would need to be factored into any economic analysis.

A second measure that is associated with reduced damage during logging is directional felling. With directional felling, trees were felled to reduce damage to trees targeted for future harvests, to avoid piling trees one on top of another, and to facilitate choker hookups in preparation for skidding. Utilization of these techniques allowed trees occurring in groups to be harvested without creating unnecessarily large forest disturbances (Figure 4).

The planning of skid trail layout is a third factor that can reduce damage. In the planned effort, trails were laid out to approximate a herring-bone pattern, with a central primary skid trail and secondary trails that formed obtuse angles with the primary trail. This design both minimized the total area in skid trails and avoided sharp corners that result in damage to neighbouring trees as logs are skidded past.

FAO Model Code of Forest Harvesting Practice

Considerable progress has been made in recent years in the introduction of efficient, environmentally sound forest harvesting practices in many parts of the world. Nonetheless, much remains to be done. There is a continuing need to refine harvesting systems and techniques so that they become fully compatible with the objectives of sustainable forest management, allowing them to contribute in an important way to the economic and social aims of sustainable development. The newly published FAO *Model Code of Forest Harvesting Practice* is one response to this need.

This document is intended primarily to serve as a reference for countries considering the adoption or revision of their own codes of forest practice. Its overall purpose is to promote harvesting practices which will improve standards of utilization, reduce negative environmental impacts, help ensure that forests are sustained for future generations and improve the economic and social contributions of forestry as a component of sustainable development.

Forestry does not focus exclusively on the production of commercial timber. The importance of forests for biological diversity, non-timber products, cultural values, wildlife, scenic beauty, recreational opportunities and environmental services is now recognized worldwide. As a result, forestry has become a more complex, more demanding discipline. One consequence of this increased complexity is that it is more difficult to plan and implement forest harvesting operations. These operations must be designed and carried out in ways that accommodate and, if possible, enhance the multiresource character of the forest. Foresters, planners and harvesting operators require up-to-date information and guidance on the practices that society is willing to accept and the outcomes that are required in connection with forest harvesting operations. Whether they are mandatory or voluntary, codes of forest practice which fail to recognize and provide for the full complexity of modern, multiresource forestry will not be acceptable to society and are thus doomed to failure. This model code takes a comprehensive look at harvesting practices while intentionally not including other forest practices such as silviculture. However, many of the concepts expressed could be applicable in developing codes of practice for other forestry operations.

The model code takes the approach that there are four essential ingredients in relation to forest harvesting operations if forests are to be managed on a sustainable basis. These are:

- comprehensive harvest planning;

- effective implementation and control of harvesting operations;

- thorough postharvest assessment and communication of results to the planning team and to the harvesting personnel;

- development of a competent and properly motivated workforce.

Harvesting operations are further categorized by road engineering, felling, extraction, landing operations and transport operations. Each of the resulting eight items is treated in a separate chapter in the model code.

Each chapter follows a common outline. The section on recommended practices is preceded by discussions of objectives, guiding principles and a definition of the operation under consideration. The potential consequences of improperly implementing each harvest practice are discussed.

The code presents a comprehensive look at forest harvest practices that should provide valuable ideas for anyone dealing with forest practices. This is true from any point of view, public or private, small or large landholder, consumer or producer. Even holders of well-established, comprehensive codes of forest practice will find new ideas and a refreshing viewpoint presented to them.

FAO Model Code of Forest Harvesting Practice. 1996. Forest Harvesting, Trade and Marketing Branch, Forestry Department. Rome, FAO.

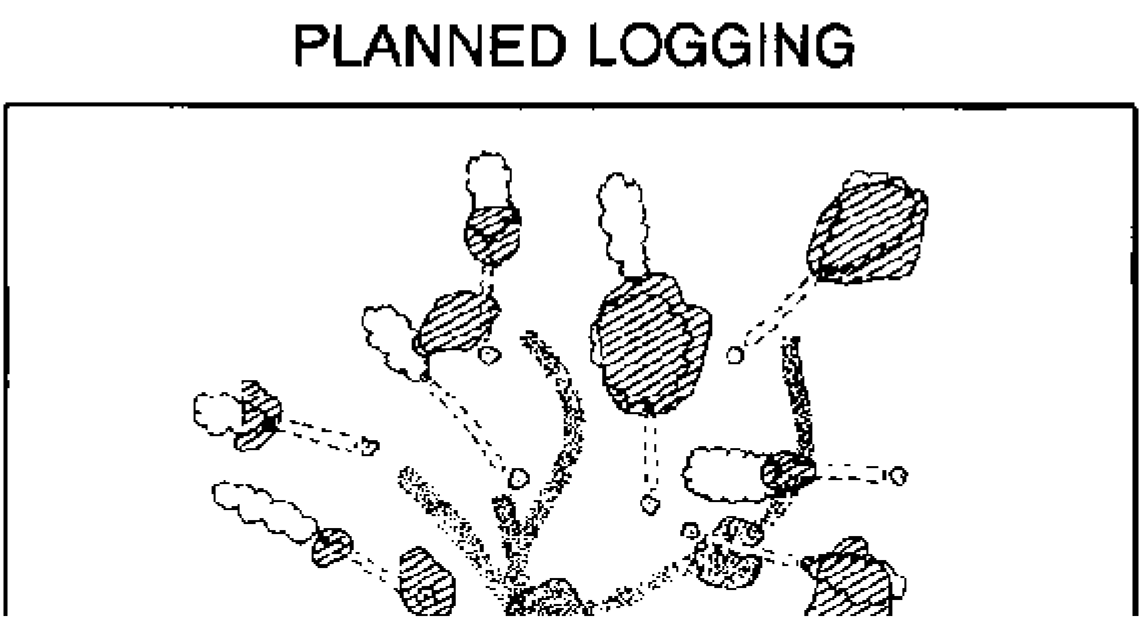
FAO Model Code of Forest Harvesting Practice

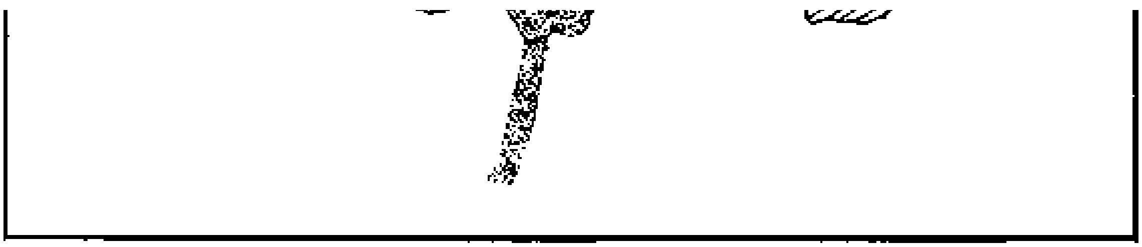
Utilization of these planning methods and careful logging techniques resulted in a reduction of the number of trees inadvertently damaged during each phase of logging. For instance, in traditional logging, 28.7 trees of more than 10 cm dbh were damaged per tree felled, compared with 20.5 trees per tree felled in the planned operation. Thus, during felling alone, 46 trees of more than 10 cm dbh per hectare were spared from unnecessary damage. Similarly, for each tree skidded to a log landing, 7.1 trees were damaged in the traditional operation, whereas only 4.4 were damaged in the planned operation. In total, 16.2 fewer trees were damaged per tree logged, resulting in 91 fewer damaged trees per hectare in the planned than in the traditional operation. Of these 91 trees, 57 were severely damaged (i.e. topped or smashed) and of these, 11 trees (totalling 2.7 m^3 per hectare) were of species with current commercial value.

Reducing waste during log processing

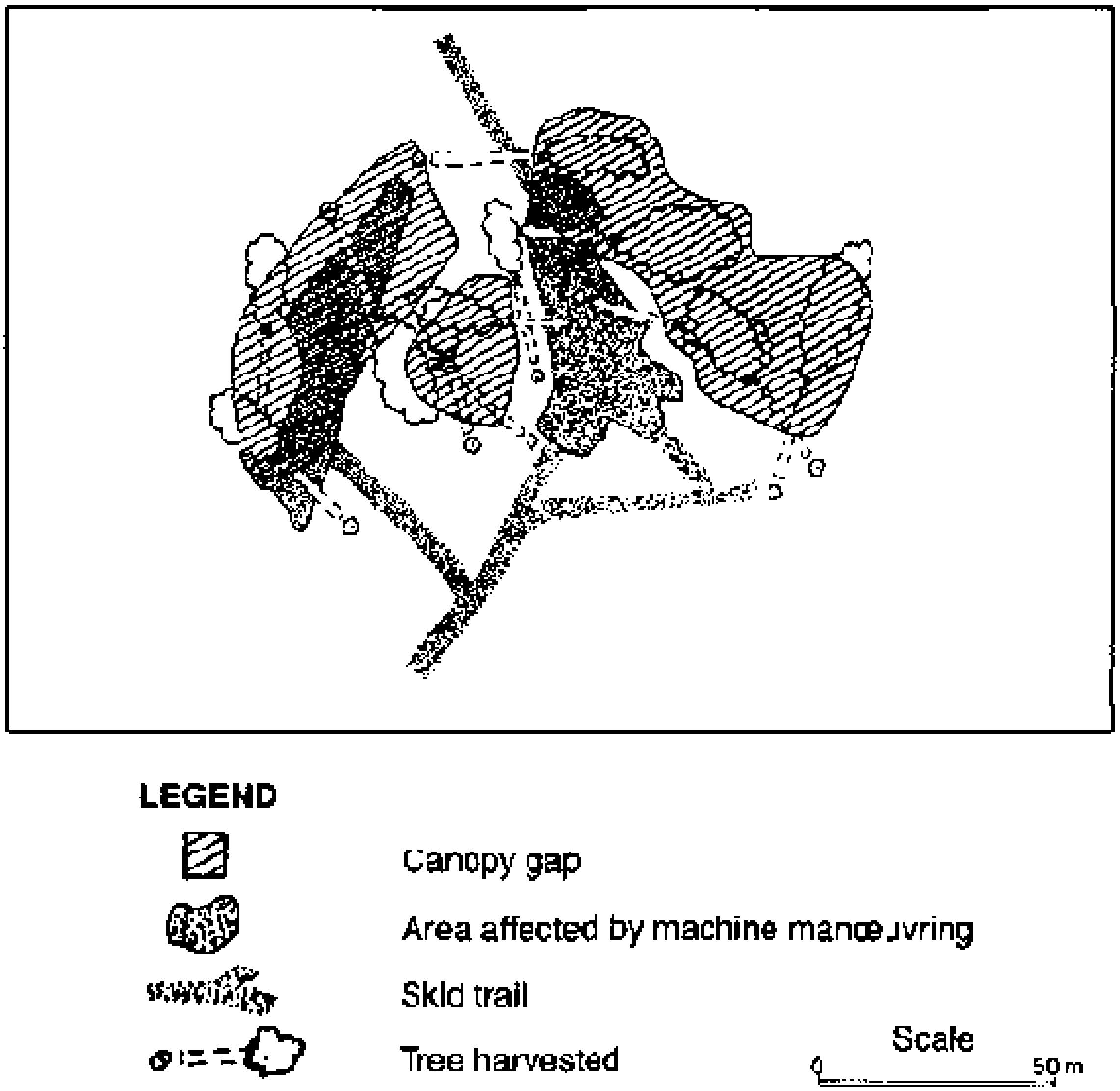
The efficiency with which logs are converted into finished products can significantly affect the area of forest needed to satisfy demand. The group studied the factors governing log conversion efficiencies in ten sawmills and two veneer peeling mills in the wood-processing centre of Paragominas. In general, processing efficiency was low (Figure 5). Of the total volume of solid wood in a typical saw log, less than 35 percent was converted into sawn timber.

FIGURE 4 - Canopy opening and ground area damage associated with the harvest of groups of frees in planned (9 trees) and unplanned (12 trees) logging operations near Paragominas in Pará State, Brazil





UNPLANNED LOGGING



The low product yields of logs processed in the region are the result of wood waste at various steps during log processing. Inadequate log storage in mill yards resulted in volume and quality losses (e.g. insect damage and log splitting). Over typical storage times of several weeks to a month, an average of 15 percent of log volume was found to be affected by insect damage. In logs of the most commonly sawn species in the region, *Manilkara huberi,* log splitting affected 13 percent of the total sawable log volume.

The use of inadequate or outdated equipment in regional mills also reduces the conversion efficiency of logs to timber. Of 47 sawmills surveyed, the mean age of sawing equipment in the region was ten years. The relative lack of investment in new sawing equipment has led to poor sawing accuracy. In the 11 mills studied, the mean variation in sawn board thickness was 4.3 min. Thus, on average, 4.3 mm of thickness is added to each board produced to ensure that its minimum thickness is within the purchasers' specifications. Although several millimetres per board may seem a trivial amount, it can amount to the waste of several potential boards per log, or about 5 percent of total log volume (Williston, 1981).

Substantial gains in the conversion efficiency of logs to timber could come with the implementation of some relatively simple techniques and technologies. Primary among these is improved log storage. Techniques such as painting log ends with wax to seal in moisture and minimize splitting and using log yard sprinklers to wash off insects could reduce log degradation during storage and increase conversion efficiency by 5 to 8 percent. Moreover, upgrading sawing equipment Could improve sawing accuracy and increase conversion efficiencies by 3 to 5 percent. Finally, the development of new product lines to make use of small pieces of wood (e.g. broom handles, parquet flooring and door pieces) Could improve efficiency by another 5 percent. In all, implementation of these improvements could raise total conversion efficiencies from 39 percent to approximately 60 percent for veneer mills and from 35 percent to 50 percent for sawmills.

Reducing forest resources waste as part of forest conservation

The first step in conserving a resource is gaining recognition of its value. Not long ago, it was common for landowners in eastern Amazonia to afford a greater value to a hectare of degraded. pasture than to a hectare of intact forest, Trees were simply an obstacle standing in the way of ranching, which was viewed as the appropriate land use for the region (and was supported by government incentives). Following the valuation of the forest resource, the next logical step in its conservation is using the resource in a manner that minimizes unnecessary waste. The benefits of such careful use of forest resources are at least twofold: with less waste of forest products, less forest area needs to be harvested to meet a given demand for timber; and carefully harvested forests have greater conservation value than those that are carelessly harvested.

FIGURE 5 - Piles of discarded wood scraps are common in the yards of sawmills in eastern Amazonia

FIGURE 6 - The amount of avoidable waste of commercial timber associated with typical logging and log-processing activities In the Paragominas region of Pará State, Brazil

By eliminating timber losses to trees that are felled and never found and losses caused by poor cutting and bucking practices, the amount of timber harvested from each hectare logged can be increased by an average of 8.3 m³ (Figure 6). However, this presupposes the processing and utilization of species that are not currently marketed. The adoption of simple strategies could improve timber-processing conversion efficiencies by 15 percent. If 38 m³ could be harvested from a typical hectare, this improvement in conversion efficiency would result in an increase in lumber production of 5.7 m³ for each hectare logged (Figure 6). Further reductions in timber waste could come in the form of future crop trees that are spared serious damage (i.e. topping or crushing). Spared trees would amount to 2.7 m³ per hectare of commercial timber that would be available for future cuts. In all, waste amounting to 16.7 m³ per hectare of commercial timber could be prevented through planned logging and improved log processing.

In addition to sparing potential crop trees from unnecessary damage, a carefully managed logging operation is also less damaging to other aspects of forest structure. For example, in the planned logging operation, the ground area affected by tree felling and machine movement was reduced by a total of 773 m² per hectare over traditional logging. Major reductions were also achieved in the amount of damage done to the forest canopy. In the planned extraction, the mean size of the canopy gaps formed was 189 m² less than in the traditional extraction. This was partially the result of fewer trees being felled into each gap. In the planned operation no more than four trees were arranged in a single gap whereas in the traditional operation as many as nine trees were felled together. Maintaining forest canopy cover and reducing the number of large canopy gaps is an important step towards maintaining the fire resistance of intact forests (Holdsworth and Uhl, in press). The accidental burning of traditionally logged forests is increasing in the region. Thus, careful, planned logging may be a way to break the cycle of regional forest degradation that includes both direct logging damage and subsequent fire.

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