Polycyclic Selection System for the Tropical Rainforests of Northern Australia[1]

Glen T. Dale **Grahame B. Applegate[2]**

Abstract: The polycyclic selection logging system developed and practiced for many years in the tropical rainforests of north Queensland has been successful in integrating timber production with the protection of conservation values. The system has been used by the Queensland Forest Service to manage north Queensland rainforests. The Queensland system has considerable potential as a model for developing appropriate management systems in other tropical countries in the Pacific region where maintenance of forest integrity is an important aspect in the integration of timber production with more traditional uses of the forest.

For many years, a system of polycyclic selection logging has been successfully employed within the tropical rainforests of north Queensland. This system is based on the philosophy of minimizing damage to the forest, and has the overriding objective of applying multiple use principles to achieve sustainable timber production within a balanced conservation program.

Many similarities exist between the management of tropical moist forests in north Queensland for timber production and conservation values, and the management of other tropical moist forests throughout the Pacific Islands region where timber production must be integrated with the harvesting of traditional forest products essential to the daily existence of the region's inhabitants. Both require that timber production does not affect the basic integrity of the forest such that its other values remain intact.

This paper describes the system and procedures developed by the Queensland Forest Service for managing north Queensland rainforests. It suggests many relevant aspects that could be incorporated in guidelines for managing other rainforests throughout the Pacific Islands countries.

The North Queensland System

Land Use Zoning

Land use zoning is the necessary first step to achieving a satisfactory balance between forest utilization, preservation and other land uses. It also ensures that land is allocated to its most appropriate use.

In north Queensland, a two-tiered zoning system has been applied. The first tier provides strategic zoning of all Crown Lands (State Forest, Timber Reserve, National Park, Leasehold). Undertaken at a scale of 1:500,000, this zoning level ensures coordinated management of Crown rainforest lands held under a variety of tenures.

Four zones are defined at the strategic zoning level: Principal Preservation Zone, Restricted Use Zone, Multiple Use Zone and Transition Zone.

Within the Crown tenures of State Forest and Timber Reserve, a tactical zoning tier known as Management Priority Area (MPA) zoning is employed. This is generally undertaken at a scale of between 1:25,000 and 1:50,000.

MPA zoning identifies a priority use for a given area and specifies compatible secondary land uses (Prineas 1987). It defines specific areas within which timber harvesting is permitted, and thus provides the basis from which gross productive area can be determined.

Area Estimation

Accurate estimates of loggable forest area are an essential component in yield prediction, since any errors in area estimates are directly proportional to errors in final yield estimates.

Loggable area is determined by deducting unloggable and unproductive fragments of forest from the area identified in zoning plans for logging. This process provides an estimate of the actual "on ground" area from which trees are harvested. The actual loggable area will vary between logging cycles as the volume of timber standing on any given area varies.

Yield Calculation

Within the area identified for sustained timber harvesting, it is necessary to obtain information on the forest stand, its species composition, size class distribution, rate of diameter increment, standing commercial timber volume, standing potential timber volume and rate of volume increment in order to be able to calculate the level of sustainable yield.

This calculation consists of six basic components:

1. Temporary inventory plots are established throughout the net productive rainforest area on a stratified random sampling basis to provide a detailed picture of the existing forest condition and the likely post-logging condition.
2. Permanent detailed yield plots maintained on a number of sites, some for up to 40 years, provide data forming the basis for development of the various increment functions used to simulate the future growth of different species and different forest types.
3. A computer-based growth model incorporating functions for diameter increment, mortality, and recruitment is applied to the temporary inventory plot data to predict the future condition of the forest. This model recognizes two site quality types and six soil parent material types. Because of the large number of species in the rainforest, the model "grows" trees not as individual species, but as

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[2]Resource Forester, Atherton; Officer in Charge, Research Center, Atherton, respectively, Queensland Forest Service, Australia.

groups with similar growth habits. Species within a growth group also display similar ecological characteristics (Preston and Vanclay 1988).

4. At selected intervals, a timber harvesting model simulates future logging operations within the forest stands projected forward in time by the growth simulation model. The harvesting model simulates logging under standard tree-marking rules and allows for the proportion of defects in logged stems and mortality arising from felling and snigging damage to the residual stand.
5. One-way volume equations are used to convert projected stem diameters to log volumes. This step is undertaken since it is unnecessarily complex and inaccurate to project information other than stem diameter (Preston and Vanclay 1988). Volume equations used recognized site and species group differences.
6. Yield calculations undertaken to date have used a modified version of the Cutting Cycle Analysis procedure (McGrath and Carron 1966, Preston and Vanclay 1988). The analysis simulates the growth and harvesting of each inventory plot through three cutting cycles. This procedure ensures continuity of future harvests and provides an estimate of the yield that can be sustained under a given management regime and set of economic conditions.

A more sophisticated system, however, has been developed. This system, known as Yield Scheduling, simulates the growth of defined units of forest. When the total available yield from a given unit exceeds a specified minimum, that particular unit is highlighted as being available for logging (Vanclay and Preston 1989).

Scheduling of Logging Operations

Cutting Cycle Analysis provides an estimate of the overall quantity of timber that may be harvested each year. However, it does not provide an indication from where this timber may be obtained (yield scheduling does indicate a time sequence of areas available for logging).

A series of detailed logging history maps are maintained for scheduling logging operations. These maps illustrate the time (in 5-year periods) that each section of the area zoned for logging was last logged. They also indicate unlogged areas intended for future harvesting. Areas so identified from map records are then subjected to intensive field inventory to determine, first, if a viable yield could be obtained, and, second, what the likely long-term effect of logging under an assumed set of conditions will be. This procedure helps ensure that the logging practices employed on any specific area do not lead to a long-term downgrading of the stand structure and integrity.

Pre-operational Logging Planning

The preparation of detailed pre-operational logging plans are an integral and important component of timber harvesting practices in north Queensland.

Guidelines for the preparation of logging plans have been formalized in the Queensland Forest Service's "Environmental Guidelines for the Selective Logging of North Queensland Rainforests" (Queensland Forest Service 1982).

The primary task involves deliniating a suitable harvesting unit or "sale area." During this process, Special Management Areas are taken into consideration. These include areas of scientific, recreational or landscape significance, erosion prone sites, or particularly steep sites that are either required to be excluded from logging, or logged under special restrictions or conditions.

The actual preparation of a logging plan is undertaken as a joint task between the Forest Service and the proposed timber purchaser. The initial step involves both parties gaining a field knowledge of the terrain, including the location and relative concentration of available log resources.

The major infrastructure components required for harvesting of the sale unit are then physically marked out in the field by a combination of brushing undergrowth and paint marking trees. These components include haulage roads, ramp sites, and stream crossings.

The sale area boundary and the boundary of selected special management areas are also identified on the ground. These features are then transferred from the field onto a logging plan map which becomes an integral and binding part of the sale agreement between the purchaser and the Queensland Forest Service.

The basic philosophy inherent in the specifications and requirements of logging plans is to minimize damage to the rainforest canopy and the potential for soil erosion. The obvious benefits are more rapid recovery of the forest canopy, faster stabilization of the soil, and reduced harvesting costs through minimization of earthworks. Considerations in this regard include:

- Retention of buffer strips along streams within which logging or machine disturbance is not permitted *(fig. 1)*
- Identification of suitable stream crossing sites where necessary and construction of appropriate crossings to minimize soil erosion
- Restriction of lorry roads and snig tracks to within maximum permissible widths and grades
- Restriction of ramp sizes to less than a maximum area and ramp locations to sites below a maximum slope
- Location of lorry roads, snig tracks, and ramp sites on ridge tops or moderate side slopes for ease of drainage and minimization of earthworks
- Design of uphill logging systems feeding onto ridgetop ramps to disperse rather than concentrate runoff
- Provision of adequate drainage structures on roads and snig tracks, both during use and following completion of logging *(fig. 2)*

Treemarking

The Queensland Forest Service's "Treemarking Guidelines for North Queensland Rainforests" (Queensland Forest Service

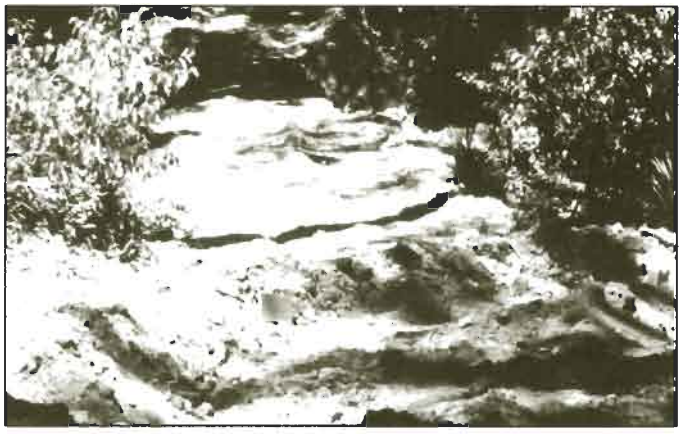

Figure 1—After logging, cross drains are provided on snig tracks to control runoff and prevent erosion on exposed soil surfaces.

Figure 2—Before logging in a North Queensland rainforest, stream bank buffer zones are marked within which no logging is allowed.

1986) provide the silvicultural control on which the polycyclic selection system is based.

Consistent and accurate implementation of these guidelines is paramount to achieving sustainable timber production.

The treemarking guidelines provide for the removal of mature and defective trees, and the retention of advanced growth, vigorous mature trees and seed trees. These retained trees provide for regeneration, and are critical to ensure the availability and continuity of timber yields throughout future cutting cycles. Hence it is a necessary objective of treemarking for a polycyclic selection system to retain a scattering of trees after logging throughout the full range of commercial size classes to provide for future timber yields.

The treemarking guidelines used in north Queensland grouped the commercial species into five categories, each of which reflects both the relative timber desirability and the mature tree size attained. These groups are assigned an upper and lower cutting diameter. The lower diameter defines the minimum size a healthy tree may be cut under normal circumstances, and the upper limit defines the maximum size to which a tree carrying a commercial log may be retained. For example, group A species have a lower cutting limit of 80 cm d.b.h. and an upper limit of 100 cm d.b.h.

Defective trees below their normal minimum cutting diameter and above the absolute minimum cutting limit of 40 cm d.b.h. may be removed if they are defective or damaged in such manner that their likelihood of contributing to the yield of future cutting cycles is low, and if such trees may produce a log of at least minimum standard in the present cutting cycle.

Other considerations taken into account by the treemarker in addition to cutting limits include seed trees, outstanding trees, defective trees, canopy maintenance, and species preferences.

Notwithstanding guidelines for retention of seed and outstanding trees, the maximum canopy removal permitted by any harvesting operation is limited to a maximum of 50 percent. In practice, this level of removal is never reached. Typical logging operations remove around 8 to 12 stems per ha, generally comprising 20 percent of canopy, and approximately 9 percent of the ground area is cleared for snig tracks, lorry roads, and landing ramps. Therefore, the average overall mechanical ground disturbance in a normal harvesting operation is in the order of 24 percent, and the average removal of foliage cover is 20 percent.

In the treemarking operation, Forest Officers paint-mark trees for harvesting with a cross on the bole at eye height. They also mark direction of fall to ensure minimization of damage to retained growing stock. The falling direction is indicated by an axe bench in the tree butt, and may be highlighted with a vertical paint stripe. Each tree is assigned a number, which is written onto the axe bench or the base of the tree.

The axe bench is then embossed with the treemarker's own identifying brand. Species, estimated d.b.h. and treemarking number are recorded into a field notebook, as well as any specific reasons for removal of the tree (fungal rot, crown dieback, etc.).

This allows the Forest Officer to check trees marked against those cut, hence ensuring that all trees marked are cut and that unmarked trees are not cut. In addition to trees marked for removal, advanced growth of commercial species that is to be retained for its potential to contribute to timber yield in future cutting cycles is also paint marked by a ring around the circumference of the tree. The intention of marking such trees is to draw them to the attention of the logging contractors in order to avoid any damage to this valuable component of the retained stand.

Operational Control of Timber Harvesting Operations

Tracking Requirements

Prior to removing any logs from stump, it is necessary, in addition to roads and landings shown on the logging plan, for the minor extraction system to be planned. This system serves the purpose of "feeding" logs from stump, along winch lines, minor snig tracks, and major snig tracks, onto loading ramps.

The timber cutter can best identify the most efficient extraction route for logs from stump to ramp. The cutter is responsible for locating and marking the extraction route for each log to minimize disturbance to the forest. The cutter should also

identify the end of snig tracks where machines are to stop and turn around, and from this point on, must also mark winch line paths to logs.

This practice eliminates the necessity for the extraction machine to drive right up to every log, thereby reducing overall clearing and damage to the stand. For this purpose, all snigging machines are required to carry a winch with not less than 30 m of wire rope.

Snigging machine operators are encouraged wherever possible not to blade off soil and vegetation from snig tracks, but to "walk" their machinery over the vegetation. This precaution retains the binding mat of surface roots and organic matter, and, therefore, considerably reduces the possibility of erosion, hastens the recovery of the forest, and reduces the visual impact of the operation. The logging operator is not required to carry out drainage works where an adequate mat of surface roots remains intact.

Harvesting Equipment

The type of equipment to be used in each logging operation is specified in the logging plan. General specifications applicable to all areas require the blade of any snigging equipment not to exceed 4 m (consistent with maximum snig track width), and all snigging machines to carry a winch with not less than 30 m of wire rope (consistent with extraction requirements).

Equipment capable of raising the front end of logs during snigging is favored. The benefits of such equipment, however, include reduced horse power requirement and reduced soil disturbance caused by the ploughing effect of the front of logs during snigging. This can often be achieved by winding the wire on to the winch such that the leading end comes from the top of the winch and not from the base.

Fork lift type loaders are the preferred equipment for the loading operation as they enable landing sizes to be minimized.

Drainage Requirements

After the felling operations and final extraction of logs are completed, the purchaser is required to "put the area to bed." This involves constructing diversion drains across all snig tracks and sections of haulage roads. Construction of diversion drains is carried out according to the specifications in the logging plan for the particular soil type and track grade involved.

Landing sites must also be drained to ensure surface runoff is dispersed into undisturbed vegetation or silt traps, and ponding does not occur.

Each year, the same drainage requirements as above must be carried out throughout each current sale area prior to the start of the wet season, and must remain in place throughout this period. All trees cut are also required to be removed from the sale area before the wet season.

Post Operational Control and Review

After the harvesting operations are completed and the satisfactory drainage within the area serviced by each landing ramp in the sale area is fulfilled, the Forest Officer must inspect and assess the purchaser's compliance with the logging plan.

All trees over 20 cm d.b.h. that have been unnecessarily damaged incur a fine which is charged to the purchaser. To avoid possible disputes, the damage is clearly defined as bark removal in excess of an area 10 cm × 20 cm, torn wood fibre on either the bole, roots, or complete removal of the tree.

Recording of Logging History

After the timber sale is completed, it is necessary to record the actual area that was logged over, the time period during which it was logged, and the reason particular areas may have been bypassed in logging (inaccessible, unproductive, etc.).

The compilation and maintenance of such information over the entire area zoned for logging is indispensable for effective management of the north Queensland rainforest for many reasons, including:

- Maintaining continuity of the current logging face
- Scheduling of logging operations, particularly in previously logged areas
- Accurately identifying the productive rainforest area for resource calculations
- Developing resource stratification for yield calculation purposes
- Referencing specific details for any particular area
- Readily identifying special management areas, and
- Passing on information concerning the specific details of forest management from one generation of managers to the next

The time period and extent of past logging is recorded on two sets of maps, known as Logging History and Logging Management maps. Logging History maps record information from the first cutting cycle, and Logging Management maps record information in the current cutting cycle. The Logging History maps are essentially an archive for information on logging, while the Logging Management maps provide a means for coordinating and scheduling logging operations throughout the current cutting cycle.

A completion report is prepared, and includes a map showing actual areas logged within the sale, the 5-year time period within which each section of the sale was logged is specified by a colour code. Inaccessible areas too steep to log, unproductive areas too poor to log, other areas not logged for special management reasons, and the location of lorry roads and loading ramps within the sale area are also included on the map. The data contained in the completion report is transferred onto the master Logging Management map.

Conclusions

The north Queensland polycyclic selection logging system is the result of a gradual evolution in techniques and practices over a period of around 40 years. Its success lies in the considerable amount of background data and research effort on which it is based, the rigorous application of the guidelines embodied in this system by dedicated Forest Service staff, and the acceptance and adherance to these guidelines by logging contractors.

The result of this system is the commercial harvesting of timber without damaging the basic integrity of the forest environment and thus the opportunity for harvesting of non tangible products. Under this system of forest utilization, the economic and social value of tropical forest is increased and the argument for retention of land under forest cover as opposed to conversion to alternative land use is strengthened.

While the specific data behind the north Queensland system may not be directly transferable to other tropical countries, the methodology behind the development of this system and its basic principles and philosophies provide a universally valuable model that may help solve at least the technical aspects of managing these forests. This is the first major obstacle which must be hurdled if the social problems inherent in tropical forest management are ever to be adequately addressed.

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