

Guidelines for Forest Operations

For

**State Forest Authorizations- Timber Sales Agreements,
Wood Cutting License Holders, State Forest Exploratory
Permits (SFA-TSAs, WCLs, SFEPs).**



**Guyana Forestry Commission
2018**

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1 INTRODUCTION

“Its overall purpose is to promote harvesting practices that will improve standards of utilization, reduce 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 ” (FAO 1996).

1.1 Forests and their multiple functions

Forestry no longer focuses exclusively on the production of commercial timber. The importance of forests for biological diversity, non-timber products, cultural values and environmental services is now recognized worldwide, and as a result forestry has become a more complex, more demanding discipline. One consequence of this increased complexity is that it is now more difficult to plan and carry out forest harvesting operations, as these must be designed and implemented in ways that accommodate and, if possible, enhance the multi-resource character of the forest. To accomplish this, foresters, planners and logging operators require guidance on the practices that society is willing to accept and on the outcomes that are required in connection with forest harvesting operations.

Forests perform a number of functions that are important to our planet and to the survival of human communities and of many other organisms whose continued existence is in our interest. These functions are essentially ecological, socio-economic, and socio-cultural.

Ecological functions

The forest environment has multiple attributes by virtue of its biodiversity:

- living environment for humans and the complex of animal and plant species;
- reservoir of genetic information;
- producer of biomass, fuel and minerals;
- regulator and stabilizer of the biosphere.

The need to conserve biodiversity and its attributes means that forest harvesting should not significantly change the different ecosystems encountered. Measures

need to be taken to conserve and protect threatened species. Hunting and the extraction of forest products need to comply with legislation and international agreements.

Socio-economic functions

The continuity of a forest's socio-economic functions can be assured if it maintains its timber and non-timber production potential and, therefore, if the scale of utilization is strictly adapted to sustainable yield and regeneration capacity. Damage to the remaining stand and future crop trees must therefore be kept to a minimum. Another important key to success is involving local communities in the sustainable management process and in decision-making. They need to have a share in the revenue, to retain their land tenure rights and to see an improvement in their living conditions.

Socio-cultural functions

The socio-cultural functions of the forest need to be maintained, particularly those associated with the cultural identity of local populations (e.g. customary rights and traditional, non-commercial uses, sacred trees, forests or sites and sites of archaeological interest). The negative impacts of forest harvesting need to be limited and mitigated by applying reduced impact logging practices.

Reduced impact logging

Reduced-impact logging is integral to sustainable forest management. It is in fact a vital element as forest harvesting can have many negative impacts that partly affect forest regeneration and thus the potentially harvestable volume of subsequent cutting cycles. Furthermore, harvesting operations are activities, which can be controlled most directly and easily by logging companies striving for sustainable management.

1.2 National legislative framework

Guyana has made significant progress in terms of development of legislation for promoting effective environmental management and protection and the sustainable use of Guyana's natural resources. The more relevant national legislation include:

- Environment Protection Act, Cap. 20:05;
- Mining Act, Cap. 65:01;
- Guyana Forestry Commission Act, Cap. 67:02;
- Forest Act, Cap. 67:01;
- Protected Areas Act, Act No. 14 of 2011;
- State Lands Act, Cap. 62:01
- Hydroelectric Power Act, Cap. 56:03
- Public Lands (Private Roads) Act, Cap 62:03
- Wildlife Conservation and Management Act, Act No. 14 of 2016
- Roads Act, Cap. 51:01

In terms of assurance of the socio-economic and socio-cultural benefits of sustainable forest management, the following among the national legislation are relevant for the guidelines for Forest Operations:

- Labour Act, Cap. 98:01;
- Labour National (Minimum Wage) Order No. 15 of 2016
- Occupational Health and Safety Act, Cap. 99:06;
- Prevention of Discrimination Act, Cap. 99:08;
- Amerindian Act, Cap. 29:01;
- Employment of Young Persons and Children Act, Cap. 99:01;
- Equal Rights Act, Cap. 38:01;
- National Insurance and Social Security Act, Cap. 36:01;
- Combating of Trafficking in persons Act, Act No. 2 of 2005

Section 5 of the Guyana Forestry Commission Act, Cap. 67:02 stipulates the functions of the Commission which includes *“to prepare plans, Code of Practices and Guidelines for the conservation and management of the forest”*. This Guideline is therefore enforceable and legally binding and has direct linkage to the Code of Practice for Forest Operations (large concessions), which regulates any class or description of forest operations.

The GFC may, at any time amend the Guidelines with appropriate justification. Such amendments will come into force as if it were a Guideline. No person shall carry out any forest operations in breach of this Guideline and the Code of Practice for Forest Operations (large concessions).

1.3 Objectives of the Guidelines

The Guidelines for Forest Operations (large concession) provides a range of standards and rules that will help concessionaires to adopt appropriate practices. Its aim is thus to function as:

- an effective instrument for the implementation of sustainable management of Guyana's forests;
- a compendium of guidelines that will facilitate forest activities compatible with international directives and principles, regional criteria and indicators, and the GTLAS and WTS;
- a series of guidelines that will help conserve biological diversity, forest regeneration and wildlife protection;
- a tool for promoting enhanced productivity, sustainability and economic viability of forest harvesting;
- a tool for promoting improved living conditions and safety of the workforce; and
- a tool for promoting improved relations between logging companies and local communities.

The Code of Practice for Forest Operations (large concessions) concentrates more on "what needs to be done" than on "how this needs to be done", and all of the principles will not be directly applicable to all situations, given their number and variety.

The Code nevertheless lays down important general principles for environmentally sound forest harvesting for all State Forest Authorisations (SFAs). This Guideline accompanies the Code by detailing the specific activities to be undertaken to achieve each principle.

1.4 Guyana Forestry Commission

The Guyana Forestry Commission (GFC) is a semi-autonomous organization entrusted with the mandate to ensure that Guyana's forest resources are sustainably managed and conserved. The GFC's main responsibility is policy implementation,

sustainable forest management, community forestry, and planning the effective utilization of Guyana State Forest Resources. With regards to private lands, the GFC works with the management structure of private lands to assist in areas of forest activities. The GFC oversees the activities of the REDD Secretariat which is responsible for the implementation of REDD + activities.

The GFC also has a development mandate to ensure that there is a balance among the pillars of social, economic, and environmental development.

The Forest Act 2009 outlines these pillars and outlines key legislative requirements for the Commission work. The GFC has, over the past decades, undergone rapid development in the implementation of sustainable forest management, legality, and environmental standards.

Community Forestry has been an important part of the GFC's work programme over the past 15 years. Many communities have come to depend on the forest for their main source of livelihood and for income generation. The GFC's efforts in community forestry have focused on formalizing the establishment of community groups into legally constituted Associations, assisting them in providing relevant training needs, overall support to their practices of sustainable forest management, and fostering sustainable development of the community forest resources as a whole. Some of the main areas of community development have been directed towards governance and decision-making, financial management, movement of community forest operations along the value chain, marketing and trade, capacity building and training in key areas, and sustainable utilization of forest resources.

Forest Monitoring

Guyana has maintained a robust and continuously improving system of forest monitoring and regulation in the forest sector, resulting in maintained low rates of illegality, an environment where there is an inherent deterrent to illegal activities, systems of reporting and monitoring that lend to the fulfilment of most, if not all elements, of an effective chain of custody management system of forest product from the point of harvest to export, and a system that allows for verification of legal origin of forest produce. These have been enabled over the years by the strengthening of the institutional framework, whilst also supporting the sector. Key monitoring tools are in place including several guidelines, the log tracking system, concession level, and environmental monitoring. GFC has several forest monitoring stations located at

strategic control points throughout the Country and many additional mobile monitoring units. Guyana is also using its existing robust management and monitoring system to finalize a Guyana Timber Legality Assurance System (GTLAS). This system will be the basis of engaging with relevant international and regional partners as the country advances efforts to promote legality of timber products.

Forest Resources Management

The GFC is responsible for the administration and management of all State Forest land. The work of the Commission is guided by a National Forest Plan (2018) that has been developed to address the 2018 forest policy. The Commission develops and monitors standards for forest sector operations, develops and implements forest protection and conservation strategies, oversees forest research and provides support and guidance to forest education and training and to promote sustainable forest management (SFM).

The SFM practices implemented by the GFC are as follows:

1. Submission of Forest Management Plans (FMP) and Annual Operational Plans (AOP).
2. Development of Guidelines to assist in the preparation of the FMP and AOPs.
3. Control of harvesting through the implementation of Annual Allowable Cuts and Annual Allowable Area and compliance to the Code of Practice for Forest Operations (large concessions)
4. Post-harvest assessments.

The main forest enforcement guidelines and activities implemented by the GFC are as follows:

1. National Log Tracking System
2. Legality Monitoring and Assessment
3. Concession level and Environmental Monitoring
4. Removal control documentation system

1.5 Development of the Guidelines

This Guideline for Forest Operations (large concessions) contains the specific activities which Forest Sector Operators (FSOs) of large concessions must undertake in order to comply with the principle of the Code of Practice for Forest Operations (large

concessions). These specific activities or requirements were developed based on the 2018 edition of the Code of Practice for Forest Operations (large concessions), which takes into consideration over 20 years of research knowledge and practical experience both locally and abroad. It is also based on extensive stakeholder engagements of the code over the last 4 years.

1.6 Scope

These guidelines for Forest Operations apply to large concessions such as State Forest Authorisations (SFAs) - Timber Sales Agreement (TSAs), Wood Cutting License holders (WCLs) and State Forest Exploratory Permits (SFEPs).

1.7 Verbal forms for the expression of provisions

[Adapted from ISO/IEC Directives Part 2: Rules for the structure and drafting of International Standards]

“shall”: indicates requirements strictly to be followed in order to conform to the standard.

“should”: indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required.

“may”: indicates a course of action permissible within the limits of the document.

“can”: is used for statements of possibility and capability, whether material, physical or causal.

2 SUSTAINABLE MANAGEMENT OF PRODUCTION FORESTS

2.1 Forest Management Plan

All concession holders of Timber Sales Agreements and Wood Cutting Leases shall submit a Forest Management Plan (FMP) to the GFC, which shall be updated every 3-5 years or as deemed necessary by GFC/Concessionaire with appropriate justification. The Forest Management Plan should be based on a detailed social, economic and environmental appraisal, setting out the order and extent of all activities to be carried out in a concession.

The Forest Management Plan Guidelines outline the information that is required to prepare the plan. Nonetheless, the FMP should commence with a description of the forest area and an outline of the logging company and its human and technical resources. It then covers the following main stages:

2.2.1 Examination of the forest and its socio-economic environment

The first section deals with the location and legal status (type of concession), geographic location, description of boundaries, villages and communities within or neighboring the concession. This is followed by the natural setting, including topography and hydrology, geology and soils, climate, vegetation and forest types, which are examined using existing maps and documents. Analysis of the socio-economic environment is central to the management plan, as it will identify opportunities and constraints for company integration into the existing socio-economic context. The analysis should also look at employment opportunities for villagers and young qualified workers and enhance their skills through further training.

Furthermore, the present state of the forest is described and previous interventions that might have modified the forest environment or in some way affected its evolution or otherwise have influenced or will influence the working of the concession; such as the area management history, existing physical infrastructure, existing and proposed roads and bridges.

2.2.2 Identifying the resource

The second section deals with mapping and forest stratification. Mapping is generally conducted on two levels:

- An overall view of the concession and its general characteristics, where a scale of 1:50,000 or 1:100,000 is usually required. This work draws on existing documents, base maps at this scale, satellite imagery and radar images;
- A vegetation and topographical stratification of the area using aerial photographs, base maps and thematic maps, with a working scale of 1:50 000 or 1:100,000;

Mapping prior to the management level inventory is based on remote sensing in the form of aerial photographs and satellite and radar images or existing base maps and thematic maps, which are available from GFC, which make it possible to:

- Accurately delimit the forest area to be surveyed;
- Stratify the forest area by major type of stand and natural formation. The description of strata is based on straightforward criteria used to identify and delimit main types of terrain (firm soil, swamp, marshland, savannahs, or steep slopes) and forest cover.

The stratification or forest organisation process will also detect and map topographical conditions relevant to the planning of infrastructure, especially roads:

- Unharvestable or non-productive areas:
 - areas of non-forest or non-commercial forest (savannahs, wetlands and flood-prone areas);
 - areas that are inaccessible for harvesting (limits shall be set beforehand regarding slope, frequency of rock, type of soil, above which an area becomes unharvestable);
 - areas set aside for biodiversity reserves, research and protected areas, buffer strips and areas of special cultural, religious or historical significance;
 - obligatory or impossible points of passage (e.g. ridges, deep valley lines).
- Identification of productive area and division into compartments:
 - Compartments are the unit of management. It is advisable that boundaries follow topographic features.
 - The maximum compartment size will be based topographic features, productivity estimates and which can be harvested in five years.
 - Compartments shall be permanent and numbered. Estimates should be made of gross and net areas (excluding, for example riparian reserves) and (if possible) area of each forest type within the compartment.

- The order in which compartments are to be harvested (and the planned harvest year) should be indicated.

2.2.3 Management level inventory

The general inventory of the forest area – the management level inventory – is the central management tool as it provides basic data to determine the general framework for the management of a concession, indicating immediately harvestable timber potential and medium-term crop tree potential.

The management level inventory, focusing on harvestable areas only (i.e. within production zones), will be a statistical survey based on (stratified) systematic or clustered sampling. For estimating the number and volume of harvestable and potential crop trees of the species currently identified as merchantable with sufficient statistical reliability, this sampling method normally requires a relative error of not more than 15 percent. The intensity of the inventory to be done should be in the range of 0.01 - 1 %, and will be determined in consultation with the GFC. Factors, which will be used to inform this sampling intensity, include homo/heterogeneity of the forest based on data available, accessibility, topography; and the nature of the forests whilst doing the actual inventory.

As a minimum, the inventory shall describe, for each forest type, the stocking of the major commercial species by diameter classes including an estimate of standing volume. For each forest type, a sampling error should be given for the total number of commercial trees per hectare.

The inventory concludes the fieldwork needed to formulate decisions on resource utilization and proposed management strategy.

2.2.4 Calculation of Cutting Cycles & Allowable Cuts

The Annual Allowable Cut (AAC) is calculated from the best information available on the resource available for production in that area, the average volume available per productive hectare, and the cutting cycle. The cutting cycle is the number of years between one harvesting operation and the next. The maximum harvesting intensity is set at 20 m³ per hectare per cutting cycle of 60 years, pending studies into the economic implications of this volume. The choice of 20 m³ per hectare is a deliberate attempt to ensure that merchantable trees remain in the stand after harvesting operations, and that the rate of harvesting does not exceed the growth rate of commercial species. Inversely, to sustain a 40, 30 or 25-year cutting cycle, a maximum cut of 13.33, 10, or 8.33 m³/ha is suggested for each cut respectively.

- (1) The maximum cutting intensity = 20 m³/ha per cutting cycle of 60 years,
= 13.33 m³/ha per cutting cycle of 40 years,
= 10 m³/ha per cutting cycle of 30 years,
= 8.33 m³/ha per cutting cycle of 25 years

The AAC is constrained by the quantity that can be removed per hectare in response to productive capacity of the resource (specifically the rate of volume increment of the commercial species). The AAC is also constrained by the number of species that can be marketed. The AAC determines the amount of raw material that will be available from the concession for sale and further processing. It is vital information for the planning of forest investment. The cutting cycle determines the rate at which the concession is developed and the requirements for detailed forward planning and infrastructure development.

The calculation of the AAC and the linked Annual Allowable Area (AAA) is based on the net productive forest area and the cutting cycle that is chosen by the concessionaire. The net productive forest area is computed as follows:

- (2) Total Productive Forest Area (ha) = Size of the Concession – Non-productive Forest Area

The non-productive areas are determined based on the vegetation types found within the management area. The GFC considers the following vegetation types to be non-productive forests:

- *Liana forest*
- *Mixed forest on high hills*
- *Low mixed forest on laterite*
- *Low forest occurring as patches*
- *Dakama-Muri forest*
- *Low swamp*
- *Dakama forest*
- *Clearings*
- *Marsh forest*
- *Muri shrub/white sand savannah*
- *Swamp on Pegasse*
- *Open swamp*

Should the concessionaire deem any of the above to be productive based on his market demands, commercial objectives and/or availability of suitable machinery; these should be taken into consideration in determining the net productive area.

Each large-scale concessionaire is required to set aside 4.5% of their concession as a biodiversity reserve, which typifies the representative ecosystems/forest types of the entire allocated area.

(3) Biodiversity Area (ha) = 4.5 % of Total Productive Forest Area

(4) Available Productive Forest Area (ha) = Total Productive Forest Area – Biodiversity Area

Twenty percent (20 %) of the Available Productive Forest is further deducted to cater for streamside buffer strips, rivers, declared protected areas under national legislation, areas of cultural importance (historical, archaeological and spiritual sites; settlements and farms), and areas required for community needs.

(5) Net Productive Forest Area (ha) = 80 % of Available Productive Forest Area

(6) Total Allowable Cut (TAC in m³) = Net Productive Forest Area (ha) × Harvesting Intensity (m³/ha)

(7) Annual Allowable Cut (AAC in m³/year) = Total Allowable Cut (TAC) ÷ Cutting Cycle (yr)

(8) Annual Allowable Area (AAA in ha/year) = Net Productive Forest Area (ha) ÷ Cutting cycle (year)

(9) Number of blocks = Annual Allowable Area (ha) / 100

2.2.5 Example of Calculation of the Annual allowable Area (AAA)

Below is an example of the calculation of the Annual Allowable Cut (AAC) for a given concession:

Cutting Cycle:	60 years
Cutting Intensity:	20 m ³ /ha
Total Concession Size:	54,914 ha
Non-productive Forest Area:	1,450 ha

(1) The maximum cutting intensity = 20 m³/ha per cutting cycle of 60 years

(2) Total Productive Forest Area (ha) = Size of the Concession – Non-productive Forest Area

$$\begin{aligned} &= 54,914 \text{ ha} - 1,450 \text{ ha} \\ &= 53,464 \text{ ha} \end{aligned}$$

(3) Biodiversity Area (ha) = 4.5 % of Total Productive Forest Area

$$\begin{aligned} &= 0.045 \times 53,464 \text{ ha} \\ &= 2,406 \text{ ha} \end{aligned}$$

(4) Available Productive Forest Area (ha) = Total Productive Forest Area – Biodiversity Area

$$\begin{aligned} &= 53,464 \text{ ha} - 2,406 \text{ ha} \\ &= 51,058 \text{ ha} \end{aligned}$$

(5) Net Productive Forest Area (ha) = 80 % of Available Productive Forest Area

$$\begin{aligned} &= 0.80 \times 51,058 \text{ ha} \\ &= 40,846.5 \text{ ha} \end{aligned}$$

(6) Total Allowable Cut (m³) = Net Productive Forest Area × Harvesting Intensity

$$\begin{aligned} &= 40,846.5 \text{ ha} \times 20 \text{ m}^3/\text{ha} \\ &= 816,930 \text{ m}^3 \end{aligned}$$

(7) Annual Allowable Cut (m³/yr) = Total Allowable Cut ÷ Cutting Cycle

$$\begin{aligned} &= 816,930 \text{ m}^3 \div 60 \text{ yr} \\ &= 13,615.5 \text{ m}^3/\text{yr} \end{aligned}$$

(8) Annual Allowable Area (ha/yr) = Net Productive Forest Area ÷ Cutting cycle

$$\begin{aligned} &= 40,846.5 \text{ ha} \div 60 \text{ yr} \\ &= 681 \text{ ha/yr} \end{aligned}$$

(9) Number of blocks = Annual Allowable Area (ha) ÷ 100

$$= 681 \text{ ha} \div 100 \text{ ha}$$

= 6.8 blocks,
rounded to = 7 blocks

2.2.6 Procedures for the approval of forest management plans (FMP)

1. The GFC makes a formal request via a letter to large concession holders for the submission of the FMP.
2. Submissions shall be made on or before the 31st December of a given year for assessment by the GFC.
3. If the plan does not meet the requirements of the GFC, the concessionaire shall submit a revised plan for a second review.

2.2 Annual Plan of Operations for Timber Harvesting

2.3.1 Outline of information requirements for an Annual Plan of Operations

Besides the long-term forest management plan, which has to be updated every 3-5 years, large concessionaires shall submit an annual plan of operations to the GFC that sets out the main activities to be undertaken in the upcoming calendar year.

The Annual Plan of Operations focuses mainly on the results of the 100% pre-harvest inventory of the Annual Allowable Area (blocks), the work planned for the coming year including 100% pre-harvest inventory, harvesting and infrastructural operations and social issues to be addressed; and a review of the operation carried out in the previous year.

The information requirements for Annual Plan of Operations are specified in detail in the Guidelines for Forest Operations (large concession).

2.3.2 Procedures for the approval of Annual Plans of Operations

1. The GFC makes a formal request via a letter for the submission of the AOP to large concession holders
2. Submissions shall be made on or before the 30th November of a given year for GFC assessment.
3. If the plan does not meet the requirements of the GFC, the concessionaire shall submit a revised plan for a second review.

2.3.3 Procedures for the approval of blocks to be harvested

Blocks are assigned based on the Company's Maximum Allowable Cut based on 100% pre-harvest inventory information (stock maps and data sheets), which is the lower volume figure of the Annual Allowable Cut (AAC) and the Inventoried Volume for all blocks that the company proposes to harvest in the coming operational year along with the AOP.

4. Large concession holders shall submit 100% pre-harvest inventory information (stock maps and data sheets) for all blocks that are proposed to be harvested in the operational year along with the AOP;
5. The approval of the blocks will depend on the results of scrutiny in the office and a 2.5% verification exercise in the field by the FRIU
6. Once the 2.5% verification exercise is completed, a report is submitted to the ACF-Inventories who reviews the results before final approval is granted for the inventoried block.
7. An approval letter to commence harvesting activities is prepared and sent to the company based on the recommendations of the ACF-inventories.
8. If the results of the 2.5% verification show that the submitted pre-harvest inventory information does not meet the standards and requirements of the GFC pre-harvest procedures, the company is informed of its deficiencies and of the corrective measures that shall be put in place.
9. Block approval letters are prepared after taking into consideration the Maximum Allowable Cut (MAC), which is the lower volume figure of the Annual Allowable Cut (AAC) and the Inventoried Volume.
10. All block approval letters are forwarded to the relevant officers within the GFC to effect monitoring and for filing/reference purposes. In addition to the letters, two copies of the inventory information are forwarded to FMD to effect monitoring within the approved blocks.
11. Depending on the circumstances, companies may be approved roll-over blocks, re-entry blocks, or advance blocks to uphold production.

Roll-over blocks

Roll-over blocks are blocks that had been approved for a specific year but have not been harvested for some reason. These blocks may be re-approved for another year for the commencement of harvesting activities.

Re-entry blocks

Re-entry blocks are blocks that have been harvested in a specific year without their maximum allowable cut (MAC) having been achieved (usually at the end of the year). These blocks may be re-approved for another year for the continuation of harvesting activities (i.e. the block is not closed), under the condition that the harvestable quota for these blocks be limited to the remainder of the volume that was granted in the first instance/approval.

Advance blocks

When a company has exhausted its quota but for some reason did not (e.g. low stocking) meet its production target, such company may be granted permission to harvest blocks in advance. These blocks will then be deducted from the subsequent year's quota, to ensure that sustainability is maintained by ensuring ecological as well as economic and social cohesion.

The company shall update its tactical (3-5 yr) forest management plan to demonstrate that it will adapt the planning of its operations to ensure that the long-term AAC for that concession is guaranteed.

3 REMOVAL DOCUMENTS AND LOG -TRACKING SYSTEM

3.1 The Log-Tracking System

The tracking system in Guyana was introduced in 2000 to verify the origin of raw material and to control the level of harvesting within State Forests provides detectable evidence on the legitimacy, geographical location, and magnitude of forest operations. The tracking system is regulated by the use of tracking tags, which are assigned to large concession operators for the trees to be felled in the blocks that are proposed to be harvested in the operational year. Tags are available to the operator free of charge. An operator's annual quota (forest produce volume) is calculated based on the chosen cutting cycle, the AAC calculated for the concession and the results of the 100% pre-harvest inventory (MAC). The quota is equated to the approximate number of standing trees which will yield the volume; the number of trees computed gives an estimate of the number of tags to be issued (one tag is equivalent to one tree).

Each operator is thus allocated a number of tags equivalent to his sustained yield and each operator is recognized by a unique sequence of numbers assigned to that operation. Log tagging is done at stump where half of the tag is affixed to the stump at the time of felling and the other part bearing the same sequence of numbers as recorded on the stump tag is affixed to the produce being conveyed. All forest produce including logs, lumber piles, poles and posts with the exception of the minor forest products (e.g. charcoal, spars, wattles) are tagged. It is the unique number on tags assigned that indicates who the operator is and gives an indication of the geographic origin of the forest produce within the forest estate.

GFC administrative control and monitoring of the tracking system is facilitated by a computerised database and its forest stations and forest officers who are supplied with a register of tag allocation by district. The system is supplemented by the use of operators' production registers, which are reviewed to ensure specifications of forest produce recorded on the removal permit are authentic.

3.2 Tracking Tags

- Tracking Tags carry unique sequence numbers and bar codes that make them individually different from each other and that indicate whom the operator is.
- Tracking Tag sequence numbers starting with 00B, 00D, 00E or 00N, are for use on State Forest areas, where the letter in the sequence number represents the monitoring division for which the Tracking Tag should be issued and used (B – Berbice; D – Demerara; E- Essequibo; N- North West). The Tag number thus indicates the geographic origin of the forest produce.



- With the approval of the DCoF or the ACoF of the FMD, the Tag Management and Issuing Officer of FMD issues Tracking Tags to concessions holders based on request, according to approved AAC quota (for large concessions according to Block Approval letter from FRMD).

- When requesting tags, concessionaires shall make such requests using the Tag Request forms provided.
- Tracking Tags are issued in sequence and batches. The concession holder shall give an account for Tags previously collected when requesting more Tags.
- If a Tag is damaged or lost, it shall be returned or reported promptly, to the nearest Forest Station. In the event a tag is lost, the sequence number should be given to the Forest Station.
- Log tagging is done at stumps where one half of the tag is affixed to the stumps at the time of felling (the half of the Tag that mark „STUMP“), and the other part bearing the same sequence of numbers as recorded on the stump Tag, is affixed to the produce being conveyed
- Tag numbers should also be painted on stumps and on produce being removed to make provision for the event of tags are damaged or lost during handling or transportation.
- All forest produce including logs, lumber, piles, poles, and posts, with the exception of the minor forest products (e.g. charcoal, spars, wattles), shall be tagged.
- A log or block can be transported in that form or it can be converted into a pile, pole, post, or lumber. In all instances, the second half of the Tag shall be placed on some part of the produce derived from the log.
- Tagging of multiple pieces (blocks) of forest produce originating from one tree shall use the same Tag number as the tree stump Tag, but labelled A, B, C, etc. as required for the number of pieces.
- The Tag number (sequence) shall be captured on the Removal Permit and production register next to the corresponding species and volume of the forest produce being conveyed.
- All unused tags shall be returned to the GFC annually or when requested by the GFC.

3.3 Infrastructural Tags

- Infrastructure can be defined as any road, bridge, culvert or building within a specific concession or leading to a concession area.

- Tracking tags issued for infrastructural purposes shall follow the same procedures as those issued under the normal tag issuance system.
- There are a number of requirements related to the issuance of infrastructural log tags:
 - The concessionaire shall make an application to the GFC stating the specific reason for the infrastructural tags requested.
 - The concessionaire shall state the number of tags required for the infrastructural work on the application.
 - All produce to be used for infrastructural works shall be declared as such on the Production Register.

In cases where salvaged produce is used for commercial purposes, the origin of the produce shall be verified by the GFC before the produce is transported and shall be declared on a Removal Permit for assessment of royalty.

3.4 Production Register

- Removal Permits shall be accompanied by a Production Register, which shall include additional production information on the timber products declared on the Removal Permit. Such information includes; log tag number, species name, log length, four diameter measurements (see Brereton method below), and calculated volume for each individual log or block being removed.
- For measuring forest products in Guyana standard units of measurements for different products are applied. For logs, length is measured in metres (m) and diameter in centimetres (cm).
- The Brereton method shall be used to calculate log volume by measuring the length of the log in metres and the diameter under bark at each end of the log in centimetres:

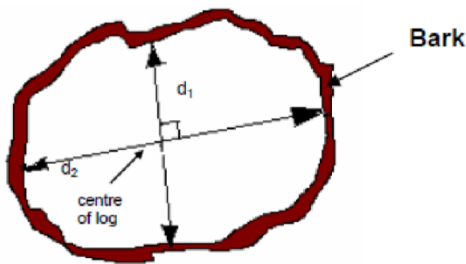
Length

1. Measure the length of the log in metres from the base to the crown end of the log.

2. Measure the shortest distance between butt and crown ends.
3. Record length to the nearest 0.2 metres (20 centimetres) rounded down.

Diameter

1. Measure diameter under bark in centimetres at each end of the log.
2. Measure two diameters at each end.
3. Find the point where the diameter is the shorter and measure it (d1), then measure the second diameter (d2) perpendicularly to the first measurement.
4. Repeat two diameter measurements at the other end of the log (d3 and d4).



5. Each line measurement shall pass through the centre of the end of the log.
6. Record diameters in centimetres, rounding down to the nearest centimetre.
7. Mark the points where the measurements are made on each end of the log.

Records

1. Enter log length (L)
2. Enter all four diameter measurements (d1, d2, d3, d4) on the form. Add all four measurements together and divide by 4 to find the mean diameter (D) of the log.
3. $D = (d1+d2+d3+d4) \div 4$ centimetres
4. Calculate volume (V) by using volume tables or the formula:

$$V = \pi \div 4 \times D^2 \times L \times 0.0001 \text{ cubic metres}$$

$$= 0.7854 \times D^2 \times L \times 0.0001 \text{ cubic metres}$$

$$V = \text{volume of log in m}^3$$

- See GFC Metrification Manual for Timber Products for further details and for measuring lumber, piles, poles, posts, spars, staves, and shingles.

3.5 Removal Permit

A Removal Permit is used to transport timber products from State forest areas. The Removal Permit is the legal invoice document that the GFC uses to collect royalty on the timber products that have been verified and branded by the GFC. Such timber products, accompanied with the Removal Permit, can then go through the first point of declaration to GFC for the payment of royalties or to the final destination for the payment of royalties to the GFC.

- Each active large concessionaire shall present his/her Removal Permit uplifting register, to convince the issuing Officer that he/she has no outstanding Removal Permits.
- Removal Permits are only issued to eligible individuals, which either are known to the issuing officer or can provide identification demonstrating that he/she is eligible.
- Removal Permits are only issued if royalties have been paid by the 15th day of the preceding month.
- Removal Permits are only issued if no specific instructions from CoF, DCoF, or ACoF were given not to issue Removal Permits to that particular operation.
- Once an active concessionaire is ready to transport forest produce beyond his/her regularized boundaries, the relevant parts of the Removal Permit shall be completed:
 - Date of removal
 - Destination
 - Vehicle type
 - Vehicle number
 - Name of driver/captain
 - Specification of forest produce and associated tags- (tags shall be listed according to species and product type)
 - Volume
 - Total tags used and any other relevant information
- The operator shall ensure that the aforementioned information is fully completed when submitting the Removal Permit.

- The operator is held responsible for the due care and accuracy of the Removal Permit.
- Removal Permits are valid for 30 days after the day of issuance; therefore, they shall be used within this period. Once a Removal Permit has not been used within the 30 days, it is considered expired and it shall be returned to the Forest Station for cancellation.
- Any forest produce that is transported with an expired Removal Permit will be treated as if it were transported without a document and will be detained.
- When surrendering a Removal Permit, the operator shall submit their Tag Production Registers for the produce removed on the Permit.
- All Removal Permits received at Forest Stations are assessed for the payment of royalty and thereafter sent to Head Office at mid-month and month-end.
- After the produce on the Removal Permit has reached its final destination, concessionaires have 24 hours to submit the Removal Permit to the nearest Forest Station.

3.6 Transhipment Permit

A Transhipment Permit is used to transport timber products from State forests for which royalties have been paid and for which the Removal Permit has been surrendered to the GFC. Such timber products, accompanied by the Transhipment Permit, can then go through the point at which the Removal Permit was surrendered to a final destination thereafter.

- Transhipment Permits are issued to the concession holder or to an agent acting on behalf of the concession holder; such persons shall be notarized and a copy of such notarisation shall be at the Forest Station for reference.
- Transhipment Permits are only issued if royalties have been paid on the Removal permit used to transport timber produce.
- Transhipment Permits are only issued if no specific instructions from CoF, DCoF, or ACoF were given not to issue Transhipment Permits to that particular operation.
- Once the operators are ready to tranship the forest produce after surrendering the Removal Permit, then the relevant parts of the Transhipment Permit shall be completed i.e.:
 - Date of removal

- Destination
 - Vehicle type
 - Vehicle registration number
 - Name of driver/captain
 - Specification of forest produce and associated tags (tags shall be listed according to species and product type)
 - Volume
 - Total tags used and any other relevant information
- Damaged or lost Transshipment Permits shall be surrendered or reported promptly.
 - One Transshipment Permit shall facilitate transport of produce on one single vehicle or vessel.
 - All Transshipment Permits and production are sent to GFC's Head Office with the midmonth or month-end production report of the Forest Station.

3.7 Trip sheet

A Trip Sheet is used in connection with the Removal Permit and is intended for use before the Removal Permit expires. Usually one or many Trip Sheets would be issued to accompany one Removal Permit. Trip sheets are used before the total volume of timber products are declared on the Removal Permit for the payment of royalty at the forest station. Trip sheets are used to transport 'sub-set' of timber products from the forest to a central location so as to enable the declaration of the total volume on a Removal Permit. Thereafter, further transport of the timber products use the Removal Permit to the final destination and the payment of royalties to the GFC.

- Trip Sheets are issued to the concession holder or to an agent acting on behalf of the concession holder; such persons shall be notarized and a copy of such notarisation shall be at the Forest Station for reference.
- A Trip Sheet is valid for a maximum of 30 days from the day of issuance; however, since it is issued in connection with a Removal Permit, it is expired at the time when the Removal Permit expires. Therefore, it shall be used within that same period as the Removal Permit.
- A Trip Sheet that has not been used within the period of the validity of the accompanying Removal Permit is considered expired, and it shall be returned to the

Forest Station for cancellation. One Trip Sheet shall facilitate transport of produce on one single vehicle or vessel.

- After the produce has reached its final log market/timber depot, the concessionaires have 24 hours in which to submit the Trip Sheet to the nearest Forest Station.

4 PRE-HARVEST PLANNING

4.1 Pre-harvest Planning

Pre-harvest planning is an essential component of Reduced Impact Logging. It involves a detailed assessment of the timber stock and terrain conditions in the blocks, which the concessionaire is allowed to harvest annually according to the AAC calculation in the FMP, by way of a 100% pre-harvest inventory. The harvest planning process should commence 1 to 2 years before harvesting (Table 1) and should produce an annual plan of operations detailing scheduled operations, actions to be taken, means to be employed and a detailed map (1:2,500 - 1:10,000) of the areas to be harvested.

A Schedule for the planning and implementation of harvesting operations must be done. See table below for this schedule.

Table 1 — Schedule for the planning and implementation of harvesting operations

2 years in advance:
<ul style="list-style-type: none"> • Demarcation of area to be harvested • Delimitation of non-harvest areas • Harvesting map at 1:2,500 or 1:10,000 • Planning of secondary forest roads
1 year in advance:
<ul style="list-style-type: none"> • Pre-harvest forest inventory and zoning of harvesting area; • Mapping, measuring, and preliminary marking of harvestable trees; • Identifying watercourses, buffer zones, steep slopes and other exclusion zones • Planning of skid trails and landings on the harvesting map
4-6 months in advance:
<ul style="list-style-type: none"> • Construction of secondary roads
1-3 months in advance:

<ul style="list-style-type: none"> • Final selection and marking of harvestable trees • Locating, marking and preparing of skid trails and landings on the ground • Locating and marking of protected trees close to skid trails and near harvestable trees
Harvesting:
<ul style="list-style-type: none"> • Opening of skid trails and landings • Felling, topping and trimming • Winching and skidding • Cross-cutting, scaling, marking and treatment of logs at roadside log markets (landings) • Loading, road transport (and water transport) Control, monitoring and reporting
Post-harvest activities
<ul style="list-style-type: none"> • Post-harvest assessment • Erosion control • Waste removal and management

4.2 Geographic Information Systems

A Geographic Information System (GIS) is a computer-based system, which, drawing from a variety of sources to compile, collate, process, analyse, combine, elaborate and display geographically related information, can effectively contribute to the management of natural resources.

A GIS permits four main types of activity: digital capture of geographical coordinates, navigation, thematic handling of data, spatial analysis, and establishment of maps.

Maps produced from remote-sensing, other geo-referenced data and data from the management level inventory and pre-harvest inventory can be digitized and fed into the GIS. These data can be:

- thematic maps (vegetation and forest types, geology, soils, etc.) or existing topographical maps;
- concession boundaries, compartments and harvesting blocks;

- GPS tracks and marked points; such as primary and secondary roads, skid trails, base camp and forward camps, wharfs, etc. ;
- ground observations.

All information fed into and processed by the GIS enhances the utility of an inventory as it permits the integration of a variety of attributes and constraints of terrain (topography, non-accessible areas, etc.). It can also help identify representative areas for conducting the pre-harvest inventory. The field data can also be fed into the GIS and can be plotted on maps for the different inventoried variables:

- geographical distribution of harvestable trees by species;
- geographical distribution of volume by species or diameter class.

The sophistication and complexity of GIS software and performance will depend on company requirements. It can be combined with management and logistics software in order to provide computerized operational data that will enable a company to plan and/or monitor activities relating to:

- the harvest areas and annual coupes, the road and skid trail network;
- the management of machinery, equipment and consumables;
- the workforce.

The use of computer equipment (computers, GIS, database software, etc.) and advanced tools such as GPS receivers require considerable investment. It is important to note that all planning techniques required for RIL practices (compilation and analysis of pre-harvest inventory, planning and layout of extraction network, mapping, etc.) can also be carried out using simple conventional means (manual compilation, pocket calculator, compass, clinometer).

4.3 Pre-harvest inventory

4.3.1 Objectives of the pre-harvest inventory

A pre-harvest inventory is an intrinsic prerequisite of Reduced Impact Logging and a mandatory requirement for all large concessions. The pre-harvest inventory operation does not only serve to provide data on the commercial timber stock in terms of volume and numbers, but also on the location of the harvestable trees. It may thus facilitate planning of the stages that follow. If planning is based on solid information, it makes the

operation more efficient, less damaging to the environment and future timber crop, and more beneficial in terms of operator safety. Because of the diversity of natural tropical forests and relative scarcity of harvestable trees, one can only locate all the harvestable trees by combing the entire harvesting area, hence by a 100% inventory.

The pre-harvest inventory operation shall therefore meet the following requirements:

- Identify, count, map, mark and number all (potentially) harvestable trees. The mapping shall be done with a relative accuracy of ± 5 metres;
- The pre-harvest inventory of the annual cutting area or coupe (AAA) shall be completed before the 30th November of the year preceding the operation year in question, but at least 3 months before the commencement of the harvesting operation;
- Supplement the existing topographic maps; i.e. mapping more precisely existing roads, existing skid trails, the drainage system, and any impediments for the harvesting operation;
- The pre-harvest inventory operation shall define zones that should be excluded from harvesting; such as watercourse buffer zones, hilly terrain with steep slopes (> 60%), etc.;
- The pre-harvest inventory operation shall allow optimisation of the layout and mapping of the secondary road network, skid trails and log markets in order to reduce the impact on the ecosystem (especially future crop trees) and allow easy locating of trees to be harvested.
- The pre-harvest inventory operation will be the starting point for the traceability of logs and monitoring of the operation from the standing tree to the final destination of the log (starting point for the log-tracking system is the felled tree at the stump).

Data processing shall result in an inventory report, in which the number of trees and volume (m³) are tabulated per species by compartment and by block with detailed harvesting maps. The inventory report constitutes the main content of the Annual Plan of Operations (APO) which has to be submitted to the GFC for approval (submission be made on or before the 30th November of the year preceding the start of operations).

The pre-harvest inventory shall be carried out using square blocks with an area of 100 ha. The blocks shall be demarcated on the ground by means of cut boundary lines and four labelled corner posts.

The GFC will upon request, conduct assessments of concession areas that have a lot of active mining. If it is determined that more than 25% of a block is impacted by mining in a non-contiguous manner, the requirement for conducting 100% inventory, and subsequent GFC verification prior to harvesting, may be waived (note that this would be on a case by case basis, and based on a thorough assessment).

4.3.2 Results to be produced by the pre-harvest inventory

- Tree location map on a scale between 1:2,000 and 1: 10,000, showing the following information:
 - Harvestable trees (with a relative accuracy of ± 5 metres)
 - Protected and future crop trees
 - Slope classes (10-20%, 20-40%, 40-60%, >60%)
 - Block boundaries and strip lines
 - Watercourses, ranked in order of importance (rivers ≥ 30 m wide, creeks ≥ 10 m wide, creeks < 10 m wide, gullies, and intermittent (ephemeral) streams)
 - Geographic coordinates (UTM coordinate system)
 - Existing infrastructure (primary, secondary and feeder roads, bridges and culverts)
 - Planned infrastructure (primary, secondary and feeder roads, bridges and culverts)
 - Existing skid trails
 - Planned skid trails
 - Limits of environmentally sensitive (exclusion) zones
 - Limits of non-productive (unworkable) zones
- Summary table of available timber stand and stock
 - The total harvestable volume and number of stems per species for the entire AAA;
 - The total harvestable volume and number of stems per species for each individual block;
 - The harvestable volume and number of stems by species in 15-cm diameter class for the entire AAA;
 - The harvestable volume and number of stems by species in 15-cm diameter class for each individual block.

4.3.3 Field procedure for pre-harvest inventory

The field procedure distinguishes two stages: the establishment of block boundaries and strip lines and the enumeration of harvestable trees within the strips. GFC strongly recommends strips with a width of 50 meters, because this width limits complications and facilitates better communication than wider (100-m) strips. It is also proven to produce high levels of accuracy in terms of tree location, species identification, and measurement of log length and diameter

Establishment of block boundaries and strip lines

Starting from a baseline (e.g. a road, an existing skid trail, or a former survey line) serving as topographical axis of reference and access, the harvesting unit is covered with a grid of survey lines:

- Block lines shall be established in East-West and North-South direction at intervals of 1000 m, producing square blocks measuring 100 ha. The length along the lines is measured by chain with slope correction and regularly checked. Pickets should be planted at 50-100 m (strip line) intervals along the base and back lines (East-West direction) and at 20-m intervals along the western and eastern block boundary (North-South direction). These pickets should be labelled with the block and strip number using a permanent marker pen or tags. The block lines shall be cleared by cutlass to a width of 1-2 m. They have to remain visible for 1-2 years as points of reference for final tree spotting prior to felling and for the control and monitoring of harvesting activities. GPS coordinates should be taken at the SW corner of each block and block numbers should be painted on the nearest non-harvestable tree with a diameter ≥ 30 cm. The location should be recorded of any creeks, other water features (including swamps), gullies, rock outcrops, and any other terrain features, which would affect the harvesting operation.
- Strip lines should be established at 50-100 m spacing with pickets being planted along them at 20-m intervals. The strip lines should be cleared by cutlass to a width of 0.5-1 m. The length along the lines should be measured by chain with slope correction. Pickets should be marked with block and line number and the distance (in metres) of the picket along the line, using a permanent marker pen or tag. At 200-metre intervals, the crew should measure the distance across the

strip to the last strip line, to check the width of the strip. The location should be recorded of any creeks, other water features (including swamps), gullies, rock outcrops, and any other terrain features, which would affect the harvesting operation.

When establishing block and strip lines, particular care shall be taken in setting compass bearings and in making slope corrections, as even small errors can have serious consequences. Ensure that the correct magnetic declination is set on the compass and that the chain and 30-m tape are in good working order. Ensure that care is taken in numbering pickets and that none are missed out - this will lead to serious problems later. For slope correction, refer to GFC's pre-harvest forest inventory procedure.

Method of enumeration of harvestable trees within the strips

Several enumeration methods will provide the desired results. The GFC has published a recommended pre-harvest forest inventory procedure on its website. The GFC manual is meant to provide guidance, but the procedure is not mandatory. If desired, the GFC is able to provide assistance in all aspects of pre-harvest inventory, including planning, field implementation, data processing, and mapping. Three examples of enumeration methods are outlined the Appendix 2.

4.3.4 Guyana Forestry Commission Pre-Harvest Inventory Report

Required information:

- Concession Name
- Large Concession Code
- Compartment number(s) covered
- Block number(s) covered
- Total area covered
- FMP reference, period, approval date
- Person submitting report, designation, date
- Team composition, recommendations, observations and conclusions

Description of work:

- If there are variations from the pre-harvest inventory procedures summarise and attach procedures manual.
- Office procedures – same
- List of personnel involved in the exercise (including designation and role within team). Breakdown of dates and time spent on line cutting, enumeration and processing of information.

Results

- Excerpt from concession map, showing compartment(s) and block(s) covered.
- Summary table containing information on each block covered:
 - * vegetation types
 - * number of harvestable trees and estimated standing volume
 - * terrain types
 - * accessibility
 - * sensitive areas
 - * special factors
- Stock map for each block (manual or GIS), showing:
 - * Block boundaries, internal strip boundaries, 10-m grid throughout
 - * Tree positions, numbered
 - * Terrain characteristics – watercourses, slope classes and aspect, rock outcrops, swamps
 - * Non-productive and/or unworkable areas (shaded)
 - * Sensitive areas - buffer zones, steep slopes

Table 2 — Stand and stock table per block (usually around 100ha)

Compartment number:			Block number:			Area (ha):		
			Stems/volume (m³) by Diameter Classes					
Species	Min dbh	Min length		35-50 cm	50-65 cm	65-80 cm	80+ cm	Totals

	(cm)	(m)						
Greenheart								
Purpleheart								
Wamara								
Kabukalli								
Simarupa								
etc.								
			Totals					

4.4 Non-harvest areas

Riparian zones

Riparian or streamside vegetated zones are recognized worldwide as having a key role in moderating the impact of land use on stream water quantity and quality. Riparian zones or buffer strips have a range of functions including maintaining the stability of the stream channel, providing riparian habitat, regulating light, and water temperature in the stream, influencing aquatic ecosystems and acting as a vegetative filter for runoff between the areas of disturbance and the stream network. This final function may be considered as the last line of filtering as sediment generated on roads, tracks, and other compacted areas frequently pass through the general harvest areas prior to entering the buffer strip.

Increased erosion on logged slopes

Soil erosion is the detachment and movement of soil by the physical agents of gravity, water, and wind. The dominant agent of erosion in many forests is water, which describes the detachment of soil particles by raindrops and overland flow, and their transport and deposition as sediment.

Harvesting timber may cause increased erosion rates due to exposure of mineral soil by removing the humus and litter layers from the soil surface, removing the vegetative cover that binds soil together, and causing heavy soil compaction from logging equipment. Wet, saturated soils will not be able to absorb as much rainwater, leading to higher levels of surface runoff and thus higher rainfall erosivity for a given volume of rainfall. Soil compaction affects the permeability of the soil to water, and hence the amount of water that flows away as runoff.

The topography of the land determines the velocity at which surface runoff will flow, which in turn determines the rainfall erosivity of the runoff. Longer or steeper slopes (especially those without adequate vegetative cover) are more susceptible to very high rates of erosion during heavy rains. Steeper terrain is also more prone to mudslides, landslides, and other forms of gravitational erosion processes.

Safety hazards when logging on steep slopes

The operation of logging equipment on steep slopes presents a serious hazard in the form of equipment rollover, which can result in serious injury or death to equipment operators and other workers. It is therefore crucial that logging equipment be operated within the manufacturer's safe operating stability limit. If the manufacturer's limit is unknown, the general rules for downhill skidding are:

- An agricultural tractor shall not be operated on a slope > 15%;
- A rubber-tired skidder shall not be operated on a slope > 35%;
- A track skidder, crawler tractor, excavator, etc. shall not be operated on a slope > 45%.

For uphill skidding maximum gradients are 30% for track skidders, 20% for crawler tractors, and 15% for wheeled skidders. It is unwise to exceed these slope stability limits and it shall be noted that these limits do not apply to cross slope skidding. Always avoid cross slope skidding and avoid winching of logs at an angle to the machine. For improved stability, always travel straight up or straight down slope keeping the logs tight to the apron and close to the machine. Turning the machine around at the felling site on a steep slope is one of the most hazardous phases of the work cycle because skidders are unstable when positioned crossways on the slope.

The thorough survey of the annual coupe during the pre-harvest inventory makes it possible to locate and demarcate areas to be excluded from harvesting. These zones shall be clearly marked on the tree location map.

4.4.1 Areas that shall be excluded from harvesting:

- Unharvestable areas: swamps and rock outcrops;
- Environmentally sensitive areas adjacent to watercourses or around swamps (buffer zones). The designation 'buffer zone' protects banks from erosion and excessive sedimentation. Such areas also function as small biodiversity reserves and points of refuge for animals during harvesting.

- Felling is not allowed on very steep slopes with a gradient (perpendicular to the contour) of 60% or more, because of enhanced risk of erosion;
- Overland, ground-based extraction (by e.g. track or rubber-tyre skidder) on steep slopes shall be limited to slopes with a gradient (perpendicular to the contour) of 40% or less, because of enhanced risk of erosion of exposed, churned and compacted soil; whilst extraction by winch will be allowed on slopes with a gradient up to 60%. (Serious safety hazards apply. It is crucial for overland cross slope skidding and winching at an angle to be avoided at all times);
- Tract slope on bladed skid trails for cross slope skidding (parallel to the contour) shall not exceed a gradient of 20%;
- Sites of cultural or religious value: sacred trees and forests (these need to be identified with the local population) and their buffer zones;
- Areas of ecological, scientific, or touristic importance: areas with extensive diversity of wildlife, habitat of endemic species, unique and fragile habitats, etc. and their buffer zones;
- Buffer zones along public roads.

4.4.2 Watercourse Definitions

Table 3 — Watercourse definitions

Watercourses	<p>Watercourses are natural channels, which carry water for some period in most years. Flows may be periodic or permanent. Watercourses include rivers, creeks, gullies, and intermitted streams. Classes are defined in terms of permanency of flow, bed material, width and bank slope.</p> <p>The width of a watercourse is the bank-to-bank distance during normal wet season (peak) flow, and may include a flood plain area. This adjacent flood plain may be a swamp or a stream meander</p>
Rivers	Rivers are watercourses wider than 30 m, where water flows all year round in most years and that are depicted and mentioned on the 1:50,000 Lands and Surveys maps
Creeks	Creeks are watercourses less than 30 m wide, where water may

	flow, or pond for more than six months in most years, or whose beds are of stony, gravelly, or exposed bedrock materials.
Gullies	Gullies are steep-sided channels. The slope of at least one bank exceeds 30%; the depth of the bank next to the bed may be 30 cm or more. Beds are of soil and may be covered with vegetation. Water will flow or pond for less than six months in most years.
Intermittent (ephemeral) streams	Intermittent streams are stable, non-incised depressions. Beds are of soil and often covered with vegetation. Water will flow or pond usually only after a rain shower.
Swamps	Swamps have (standing) surface water present for six months or more in most years.
Lakes	Lakes have surface water present all year round for most years

4.4.3 Width of buffer zones

Buffer zone widths depend on the nature of the protected area or watercourse. In case of watercourses, the buffer zone width is measured horizontally from the top of the watercourse bank, or the edge of the flood plain when present, or the point above the high bank where the slope becomes less than 50% - whichever provides the greatest distance from the edge of the watercourse bed. If necessary, exclusion areas, and their stewardship may be negotiated among partners (see Figure 1). The minimum widths for different situations are given in the table below:

Table 4 — Width of buffer zones

Type	Minimum required buffer strip protection
Formally recognised conservation and protected areas	One (1) km
Sites of cultural or religious value	100 m
Areas of ecological, scientific, or touristic importance	100 m
Public roads	50 m
(Very) steep slopes	No buffer zone required
Watercourses	Rivers (width > 30 m) 30 m on either side. Retain vegetation on

	Creeks (width \geq 10 m) both sides (felling not allowed) 20 m on either side. Retain vegetation on both sides (felling not allowed) Creeks (width < 10 m) 10 m on either side. Retain vegetation on both sides (felling not allowed) Gullies 10 m on either side. Machine access not permitted but felling allowed Intermittent streams No buffer zone required
Lakes, swamps and other wetlands	10 m from the peak level mark or edge of typical wetland vegetation

4.4.4 Requirements for non-harvest areas and buffer zones are

The concessionaire shall properly locate non-harvest areas and buffer zones, based on pre-harvest inventory results and maps, to exclude these areas from harvesting and to minimise negative impacts on the timber stand, environment, and the local population. Non-harvest zones and their environmentally sensitive areas shall be protected as follows:

- no tree shall be felled within these areas - except for gully buffer strips - and trees located in the immediate vicinity should, if possible, be felled away from the area and from watercourses;
- if a tree is inadvertently felled into a watercourse, all its debris should be removed causing as little disturbance as possible to the watercourse bed and banks;
- machinery is banned from these areas, except under special circumstances in which case the crossing distance should be as short as possible to minimize disruption;
- temporary log crossings may be authorized if machinery needs to cross a watercourse, for example to build drainage structures or bridges;

- when absolutely necessary, watercourses may be crossed on rock or gravel beds;
- no earth movement or grading work is allowed in these areas;
- no harvesting debris should be introduced into protected or environmentally sensitive areas.

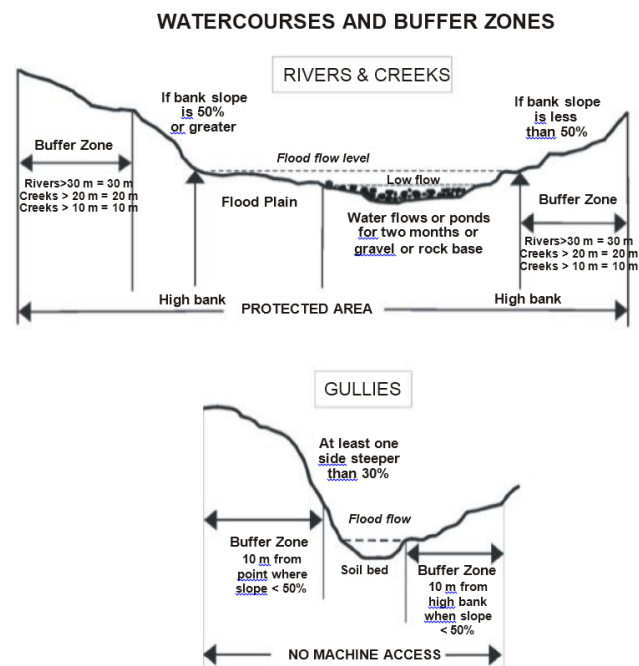


Figure 1 — Buffer zones along watercourses (FAO 1999)

4.4.5 Felling restrictions

The following trees and/or species shall not be felled without special permission:

- No tree shall be felled unless its diameter at a point 1.3 meters (4 feet 3 inches) from the ground ("breast height"), or in the case of a buttressed tree at a point immediately above the top of the buttress, is not less than 35 cm.

- Provided that the Commissioner may, where he is satisfied that under the system of working being practiced in any area adequate provision is being made for the establishment of seedling growth exempt the concessionaire from the provisions of this clause or such conditions as he may think fit.
- Trees felled for infrastructural purposes¹ may have a diameter of less than 35 cm at breast height, if a particular infrastructural work requires the application of timber of such size. There are a number of requirements related to the felling of infrastructural logs:
 - * The concessionaire shall make an application to the GFC stating the specific reason for the felling of infrastructural logs.
 - * The concessionaire shall state the number of logs required for the infrastructural work on the application.
 - * All produce to be used for infrastructural works shall be declared as such on the Production Register and tagged.
- No Bulletwood (*Manilkara bidentata*) tree shall be felled without permission in writing of the Commissioner first being obtained.
- No tree shall be felled within 8 m proximity of another stump to maintain the size of canopy gaps to a minimum during harvesting and to safeguard this way successful regeneration of commercial species and control the shooting or sprouting of undesirable vines, weeds, or non-commercial pioneer tree species without permission in writing of the Commissioner first being obtained. The proximity distance is measured from the centre of one tree to the centre of the other tree.
- Large concessions will be allowed to harvest trees without any restriction on proximity, provided that these trees are at least 40-cm DBH and over. The other GFC controls will remain e.g. 100% inventory, GFC verification, Annual Allowable Cut (AAC), Annual Allowable Area (AAA), tagging, and compliance with the other principles of the Code of Practice for Forest Operations etc.
- No tree shall be felled unless the block, where the tree is located, has been verified, and approved by the GFC without permission in writing of the Commissioner first being obtained.

¹ Infrastructure is defined as any road, bridge, culvert or building within a specific concession or leading to a concession area.

- No tree shall be felled unless it has been included in the pre-harvest inventory report and has been duly numbered, so as not to exceed the Annual Allowable Cut (AAC) for a GFC approved block without permission in writing of the Commissioner first being obtained.
- Concessionaires will be given consideration to harvest non-inventoried trees (with the required DBH) up to a maximum of 10% of the AAC of the specific GFC approved Block. However, a revised stock map (with skid trails) clearly indicating the non-inventoried trees must be submitted to the GFC within one (1) calendar month of this harvesting.

4.4.6 Trees to be protected during harvesting

A “keystone” or “cornerstone” species is a species that has a disproportionately large effect on its environment relative to its abundance. Such species play a critical role in maintaining the structure of an ecological community, affecting many other organisms in an ecosystem. Certain plant species are considered a keystone species because they are important to the animals in the forest; e.g. because the species bears fruit several times a year or during periods when few other species are fruiting.

The concessionaire shall not fell, injure, or kill any protected species without special permission. Trees that should be protected during harvesting belong to roughly five groups:

- Trees belonging to keystone species. They should be marked with a "P":
 - Hog Plum (*Spondias mombin*)
 - Ubudi (*Anacardium giganteum*)
 - Kokoritiballi (*Pouteria egregia*)
 - Duru (*Apeiba spp.*)
 - Pasture tree (*Trymatococcus paraensis*)
 - Sawari (Butternut) (*Caryocar nuciferum*)
 - Akuyuru (*Astrocaryum aculeatum*)
- Trees belonging to the following two species may be felled, but at least three trees of these species with a diameter at breast height greater than 40 cm shall remain in the block (100 ha) following logging:

- Aromata (*Clathrotropis brachypetala*)
- Maho (*Sterculia pruriens* and *S. rugosa*)
- Potential crop trees:
 - These trees will reconstitute the harvestable volume after one cutting cycle. They should be protected so that the harvested volume can be reconstituted and should be marked with a “Ø”
- Heritage trees:
 - Social studies conducted during the development of the management plan will identify any heritage trees. These trees are of great social importance and should therefore be protected. They should be marked with a "P".
- Seed trees:
 - A certain proportion of the commercial trees that have been inventoried and numbered should serve as seed trees. They should be marked with a “P”. These trees should be selected according to the following criteria:
 - * A minimum of 0.02 trees per hectare or 2 per 100 ha of each harvested species should be retained;
 - * Trees should have a grade A or B (perfect or acceptable stem quality);
 - * Preferably with a very large diameter (≥ 120 cm), or in diameter classes with the highest fructification rate according to phenological studies.

4.5 Planning and optimising the secondary road network

The pre-harvest inventory provides all the information required for:

- optimizing the layout of the secondary road network (pre-harvest inventory also provides location of trees, which information can be used when planning secondary road works);
- identifying and marking of trees that are considered harvestable based on species and quality;
- planning the layout of skid trails and log markets (landings) network and optimizing realization on the ground;

- deciding on the company's commercial annual programme: species to be harvested, volumes, quality gradients and harvesting schedule.

These operations should be carried out by specialized teams, other than the inventory team.

4.5.1 Layout of the secondary road network

An efficient and low-cost transportation network is necessary for sustainable forest management. Roding and skidding are the most expensive and destructive operations in the forest environment, unless carefully planned and evaluated. The layout and realization of access and main road networks should be carried out based on information provided by the tactical (3-5 year) forest management plan. However, planning the secondary road network within a harvesting unit needs to be based on the findings of the pre-harvest inventory and is carried out one year before harvesting.

The secondary road network has to ensure that the harvesting unit is properly accessible, while maintaining a balance between skidding distance and network intensity. Layout will be determined by:

- relative abundance (distribution, volume and quality of species);
- topography and drainage system;
- terrain characteristics.

These three features will determine the harvesting period (i.e. dry or rainy season) and thus the characteristics of the roads to be built. The road network will avoid areas with few harvestable trees and areas with serious topographical and terrain constraints (steep slopes, swamps). It will also seek to protect potential crop trees and heritage trees. The provisional layout will be based on the annual harvesting map and additional ground inspections. The annual harvesting map should have a scale of 1:10,000 and cover all blocks of the annual coupe and preferably the adjacent blocks.

In practice, the maximum skidding distance for a track type tractor is 200-400 m and for a rubber-tired skidder 800-1000 m. However, the maximum skidding distance is factually determined by economics, not by physical limitations of the machines. Longer skid distances increase the cycle times and skidding costs, while shorter skidding

distances reduce the skidding costs and increase the road density and the road-construction costs.

The balance between skidding distance and road network density is approximately optimal when

$$S = \sqrt{\frac{4R}{C \cdot V}}$$

where S is road spacing in m, C is variable skidding cost in \$/m³/m, V is yield harvested in m³/turn, and R is road construction cost in \$/m.

Secondary roads for access and logging can be a major source of erosion and sedimentation problems. Given the recognized importance of the roads and skid trails network in both the generation and delivery of runoff and sediment, emphasis should be given to these areas during the planning stages of forest harvesting. Maximizing the distance between the road and skid trail network and the drainage system can be readily accommodated at the planning stage through the location of roads away from streams and by skidding logs uphill (see Figure 2). Uphill skidding is a key measure in minimizing connection between compacted surfaces, sediment sources, and streams. This results in a down-slope divergence of the associated skid trail pattern.

Among the most risky road locations are those immediately adjacent to streams, because any eroded soil can quickly enter the stream, and flooding may even wash entire road sections away. Other hazards near the bottom of steep slopes are the large amounts of water that drain from them, and unstable soils. If roads must be routed near stream bottoms, it is especially important to keep them above flood levels and to retain a strip of undisturbed vegetation between roads and larger streams. This buffer strip can help filter any eroded soil and prevent disturbance to the streambed and banks. Swamps, springs, and other wet spots should be avoided. The number of stream crossings should be kept to a minimum and placed at right angles to the stream to reduce channel and bank disturbance.

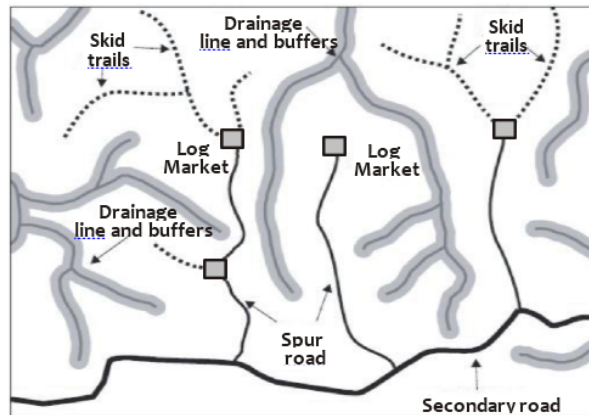


Figure 2 — Road network in a logged catchment. The distribution of road networks throughout the catchment is best achieved during the planning phases where roads can be located along ridge-tops or at maximum distances from the stream. Uphill skidding and skidding is to be strongly encouraged as it results in a network of tracks that are divergent and away from the main stream-network. (Croke 2004).

4.5.2 Road planning in practice

Road planning should start with establishing a provisional alignment using GIS or existing maps. The provisional alignment is initially established by identifying the main valley and ridge lines which constitutes a sketch showing the essential features of the terrain. The road alignment is then further refined step-by-step by identifying control points and indicating the provisional route. Control points are those areas where it is either desirable to build or wise to avoid building a road. The following are control points that deserve consideration:

- **Landings** — With ground-based logging, logs should be skidded to a landing location that minimizes the skidding distances.
- **Saddles** — Ridge top roads usually should pass through saddles (low points along the top of a ridge). When roads are located in saddles, you have access to both sides of the ridge system. This makes saddles good landing sites.
- **Benches** — Benches are natural breaks between slopes where easy road construction and good landing locations often are available. These locations should be used whenever possible.
- **Steep hillsides and rock outcrops** — It is generally difficult and expensive to construct roads on steep hillsides or with rock outcrops

- **Slumps and slides** — Roads on unstable terrain can cause problems during construction and may trigger massive problems of slope stability (see Figure 3).

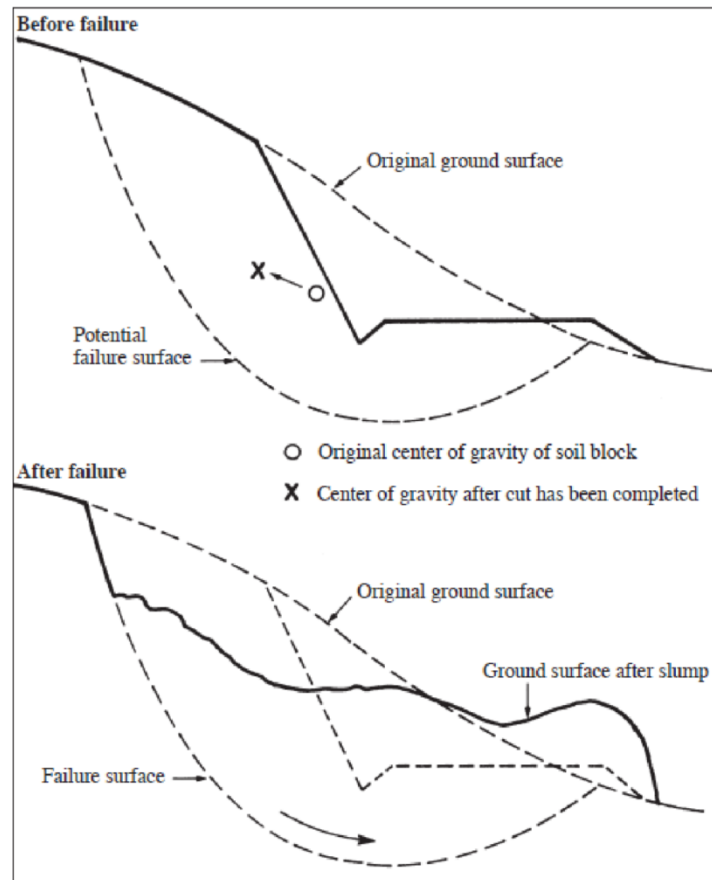


Figure 3 — The effects of improper road location on a slump area (Oregon State University 1983)

- **Marshes, swamps, drainage channels and springs** — Avoid road locations that expose subsurface water or that cross wetlands.
- **Potential stream crossings** — Suitable locations for stream crossings depend on the type of crossing and the ease of constructing it. A bridge requires a narrow channel with stable stream banks.
- **Sharp ridges and gullies ("V" draws)** — Construction problems are likely to occur when sharp ridges require heavy excavation to create a stable roadbed. Crossing V shaped draws also can cause problems if the excavated material becomes unstable and slides away underneath the roadway.

Control points of obligatory passage, points considered impassable and possible connecting lines should thus be determined to form the provisional road alignment on the map. Generally, roads should thus be located:

- along ridgelines on gentle terrain for minimal earthwork, easier drainage and preferable uphill skidding;
- along slope flanks to connect one elevation to the next, where ridgelines are not continuous;
- along valley bottoms on steep terrain where these are sufficiently broad;
- following the natural terrain (landform) by conforming to the contour, rolling the grade and minimizing cut and fills;
- with due attention to protected areas, avoiding as far as possible environmentally sensitive areas and other non-harvest areas;
- at least 40 m away from the edge of buffer strips (viz. 70 m from the banks of rivers (width ≥ 30 m), 60 m from the banks of creeks ≥ 10 m, 50 m from creeks < 10 m wide and gullies), except at designated watercourse crossing points;
- avoiding unstable and problematic locations such as swamps, marshes, landslides, steep slopes, massive rock outcrops, flood plains, and highly erosive soils; while minimising the number of watercourse crossings.

Provisional road alignments have to be verified with the reality of terrain by means of surveys on the ground, which are best done in the rainy season to get a true picture of soil characteristics, swamp limits, and maximum width and depth of watercourses.

4.6 Verification of pre-harvest inventory and final tree marking

Based on the pre-harvest inventory and market considerations, the species to be harvested and their minimum cutting diameters will be determined. With the aid of the tree location map, all inventoried trees should be checked to verify whether they indeed meet the harvesting requirements in terms of species, quality, minimum commercial diameter, and accessibility. Non-inventoried, overlooked trees that meet the harvesting specification can be added to the inventory list and tree location map once certain conditions are met.

1. Trees that have been overlooked during the pre-harvest inventory and thus do not appear on the tree location map can be included as harvestable, but it should be

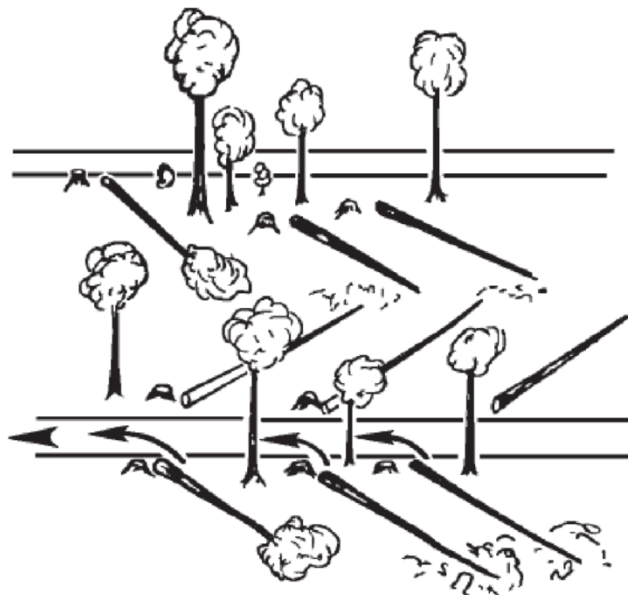
very exceptional and limited to those trees whose quality and diameter certainly meet the minimum harvesting specifications. Concessionaires will be given consideration to harvest non-inventoried trees (with the required DBH) up to a maximum of 10% of the AAC of the specific GFC approved Block.

- a. Trees that were overlooked but are considered harvestable can thus be included during the verification exercise and shall then receive an inventory number. The number should be marked with paint, lumber crayon or label below felling height (e.g. on the buttress). Because tree numbers shall be unique for each felling block numbering shall continue from the last number issued for the block during the pre-harvest inventory.
 - b. In case the maximum of 10% of the AAC is exceeded, the non-inventoried but qualifying trees should serve as seed trees and be marked with a "P".
2. Trees that have been identified as seed trees according to the requirements in section 5.4.6 should be deducted from the list of harvestable trees and marked with a "P" with paint, lumber crayon, or label at breast height or above the buttress.
3. Trees that occur in the pre-harvest inventory list and on the tree location map, but cannot be relocated, shall be crossed out on the tree location map and their inventory number removed from the felling list.
4. Trees to be harvested shall be accessible. Inventoried trees occurring on the tree location map should only be harvested in keeping with the reduced-impact logging guidelines. This implies that trees shall not be marked for felling if their extraction will require passage through environmentally sensitive zones and other non-harvest areas, such as steep slopes or wetlands. These trees should be marked with a "P".
5. Trees that were considered exploitable during the pre-harvest inventory but are rejected during the verification exercise, because their diameter appears to be too small or because they are of poor quality, shall have their number crossed out on the tree location map and have their inventory number removed from the felling list.
6. All trees to be felled should be marked in the field with paint, flagging tape, or blaze before felling.

7. The felling direction should be indicated by blazing or painting a vertical line to the root of the tree (see section 6.1.4. for the particulars of directional felling).
8. Potential crop trees, seed trees and protected trees within a radius of 15 m around the tree to be felled should be marked for retention and protection. Potential crop trees should be marked with paint with a "Ø". Seed trees and protected trees should be marked with a "P".
9. All lianas attached to the trees selected for harvesting should be cut

4.7 Layout of skid trail network

Rubber-tired skidders can cause substantial soil disturbance. Repeated travel over the same skid trail can produce deep ruts and a high degree of soil compaction. Do not use skidders on sensitive soils or closer than 10-30 metres (30-90 feet) to streams depending on stream size. Reduce soil disturbance and skid trail density by restricting operations to the drier times of the year and by using directional felling (see Figure 4). Minimize damage by having machine operators stay on skid trails and pull the winch line 10 to 20 metres (30-60 feet) rather than manoeuvring the skidder to each log. When planning skid trail layouts, make every effort to keep them as straight as possible. When trails are straight, operators achieve higher speeds and spend less time deciding where to position the skidding machine.



**Figure 4 — Directional felling with the butts of the trees toward the skid trail
(Washington State University 1999)**

4.7.1 Choice of layout for the skid trail network

The following two criteria apply to the selection of the optimum skid trail layout:

1. Find the shortest route to extract the logs;
2. Minimize the total length of the skid trail network.

Flat or gently undulating terrain

1. On flat terrain, the two criteria above are the most important. A compromise should be sought between the two criteria. A slightly longer route can be selected if this reduces the total length of the skid trail network.
2. The most efficient compromise is the application of a herringbone pattern (see Figure 5).

Hilly and broken terrain

1. On hilly or broken terrain, the main skid trail should follow the ridge or the contour (bladed trail);
2. On hilly or broken terrain, branch trails should join the main trail at right angles, but the branch trail should join the main trail in a gentle curve (see Figure 6);
3. If the extraction of a second log along the same trail can both reduce the total length of the trail network and the length of the extraction route, it should be preferred (see Figure 7);
4. For logs located at the end of main trail, the latter log should be extracted at an angle of about 45° (see Figure 8);
5. Avoid slopes greater than 20%, especially on main trails along which a large volume will be extracted. On steep slopes (20-40%), establish the trail at the flank of the slope (blade the trail). If the extraction of a certain log would require the passage of a very steep slope (> 40%), the log should be winched or the tree should not be felled.

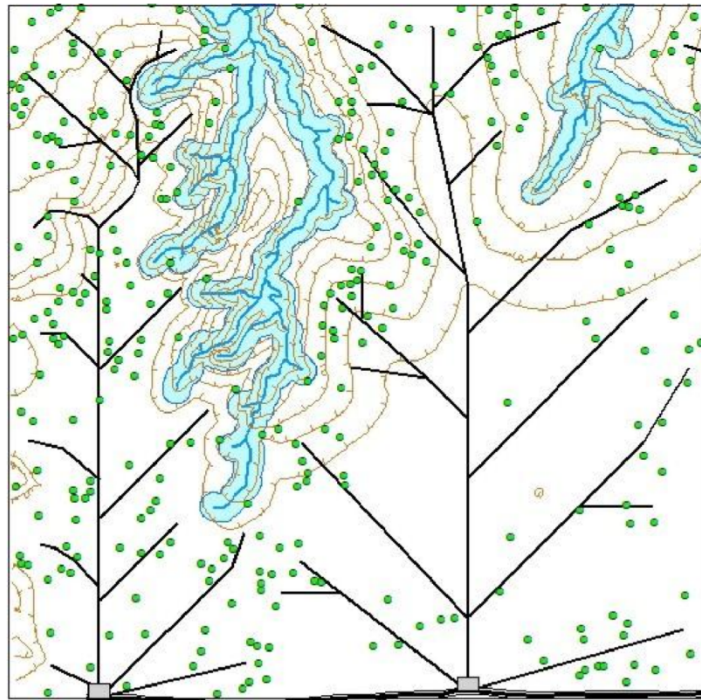


Figure 5 — Herringbone skid trail pattern on flat or gently undulating terrain (Forestry Training Centre Inc 2004)

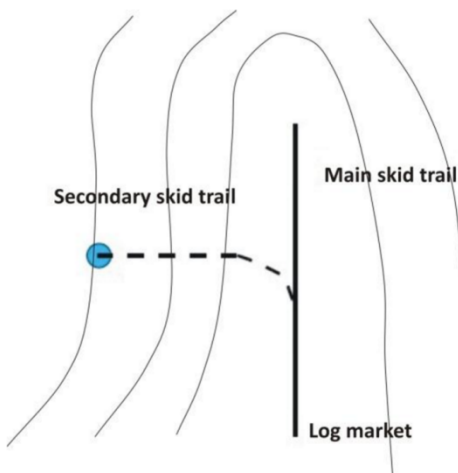


Figure 6 — On hilly or broken terrain, branch trails should join the main trail at right angles, but the branch trail should join the main trail in a gentle curve (Forêt Ressources Management 2005)

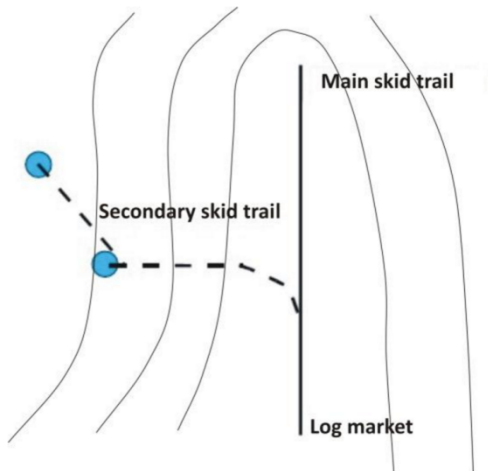


Figure 7 — Indirect trail to a second log; extraction of a second log along the same trail is preferred if it both reduces the total length of the trail network and the length of the extraction route (Forêt Ressources Management 2005)



Figure 8 — Branch trail at the end of a skid trail at an angle of 45 degrees (Forêt Ressources Management 2005)

4.7.2 Other considerations for skid trail alignment include the following:

1. Minimize the area of land used for trails and landings. The total area occupied by skid trails should not exceed 8% of the total area of the block or compartment (or a total linear distance of 200 m per hectare).
2. When planning main and branch trails, the alignment should consider the relative abundance of harvestable trees.
3. All skid trails should be as straight as possible for the longest practical distance, especially main trails, to minimise damage to residual trees, to prevent damage to the log being extracted, and to maximise skidding efficiency.

4. All skid trails should avoid environmentally sensitive areas and other non-harvest areas, with the exception of designated watercourse crossing points.
5. Main skid trails should be located:
 - a. at least 20 m away from the edge of buffer zones (width 10 m, 20 m or 30 m) and unstable areas
 - b. on ridges where possible to allow proper drainage
6. Skid trail slope gradients affect skidding productivity, especially if the area has much length in unfavourable (adverse) gradients. The slope gradients shown in Figure 9 are examples of maximum gradability (extreme limits).
 - a. Recommended maximum slope gradients for main or long skid trails are 10% unfavourable (adverse) and up to 20% favourable.
 - b. Short pitches of adverse [for example, 30 metres (100 feet) uphill] of up to 20% are reasonable if the main skid trail is straight or if the skidding machine is on level or favourable gradients before and after the short segment.
 - c. Recommended maximum slope gradients for minor/branch skid trails are 20% unfavourable and up to 30% favourable.

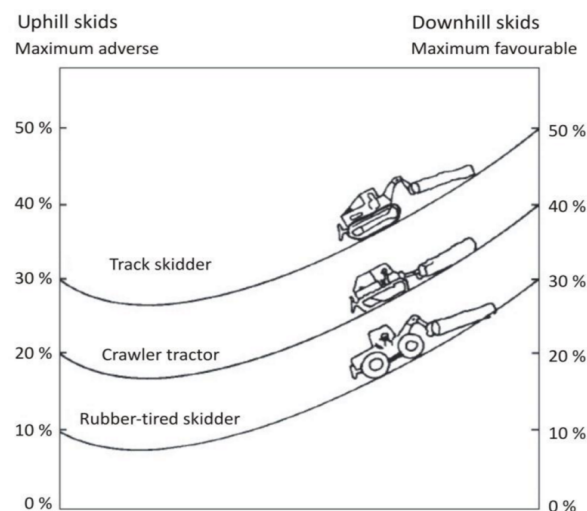


Figure 9 — Left and right sides of the graph represent traction under the best conditions, but soil and weather conditions may reduce gradability (Forest Engineering Research Institute of Canada 1976)

7. On hilly or broken terrain, where a location as mentioned above is not possible, the trail should follow the flank of the hill; the trail should be bladed so as to keep lateral (side) slope below 5% (a side slope of more than 5% causes downhill sliding of the log).
8. Make intersections preferably at 45-degree angles or less with respect to travel toward the landing.
9. Minimum curve radius on skid trails should be 25 m (see Figure 10).

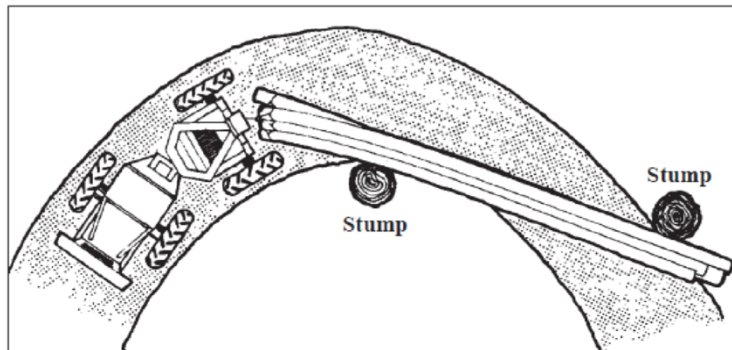


Figure 10 — Problems arise when winching logs out of tight spots at too sharp an angle or when turning too sharply while skidding. The load may lodge against trees, stumps, rocks, or road banks (U.S.D.A 1970)

10. Avoid branching from the main trail directly opposite another trail branch.
11. Avoid sharp curves at the bottom of steep uphill or downhill trail segments.
12. Lianas along and dead boles lying across the trail alignment should be crosscut before the trails are opened up.
13. It makes sense to use skid trails from previous logging operations—if they can be identified and if they are suitable. Reusing these trails minimizes the area in trails, but sometimes these trails meander excessively, or they are just not in the correct position.
14. Crossing (intermittent) streams or gullies with ground-based equipment may cause unacceptable disturbance, and must be strictly controlled. The number of stream crossings should be kept to an absolute minimum. Stream crossings should be placed at right angles to the stream to reduce channel and bank disturbance and temporary log crossings should be installed.

4.7.3 Demarcation of skid trail alignments on the ground

- Skid trail alignments should be marked on the ground by cut lines before felling commences. The start of each trail and each intersection should be marked with a picket. The number of harvestable trees beyond the picket should be indicated by notches made on the picket. The notches should be painted once the trees have been felled. Visibility of the cut lines should be enhanced by tying ribbons on small trees and shrubs or by placing flagged pickets at the approximate centre of the skid trail alignment.
- The provisional layout will be based on the alignment on the annual harvesting map. The annual harvesting map should have a scale of 1:10,000 and cover all blocks (tree location maps) of the annual coupe and preferably the adjacent blocks.
- The skid trail demarcation can be done using block and strip line labels, a GPS receiver and/or a field compass to track the alignment on the map. Because the exact location of the harvestable trees may deviate by ± 10 m, the alignment may have to be adjusted to the true location of the trees. It is therefore recommended to send a crewmember ahead to either the last tree to be extracted along a branch trail or to a tree located further down the projected main trail. Crewmembers then call one another to find the most direct route towards the last tree.
- Demarcation of the skid trail alignment on the ground should take place in three stages; first, the alignment on the map is followed, while observing and recording obstacles; subsequently the alignment is adjusted; finally, the alignment and potential crop trees and protected trees that should be circumvented are marked. The last two stages can take place in one go. See Appendix 2.

5 CONSTRUCTION OF ROAD NETWORK, DRAINAGE STRUCTURES AND WATERCOURSE CROSSINGS

Roads provide needed access to the forest. At the same time, roads can produce significant amounts of sediment and can be one of the greatest adverse impacts on the local environment, on water quality and on aquatic life. Roads can produce significant erosion, cause gullies, and have an impact on groundwater, wildlife and vegetation.

Road planning is essential to ensure that a road meets the current needs of the user, that it is not overbuilt, and that it minimizes impacts on the environment and to the people along the road. A well-planned, located, designed, and constructed road will be cost-effective in the long term by preventing road failure, eliminating repair needs, and reducing maintenance.

Roads should be planned to minimise the sum of skidding and road construction impacts, which in turn will also lead to cost minimisation. The most efficient spacing of roads can be derived by looking at the cost trade-offs between skidding distance and road spacing.

5.1 Road standards

In specifying logging road standards, one must consider cost, the volume of timber to be hauled over the roads, the time of year that the roads will be used, the type of trucks using the roads, the length of road to be built, the available road construction equipment, and the time it will take to construct the roads. In addition, the use and availability of temporary road stabilizing or surfacing options like crushed rock, or laterite should be considered. These are best applied at potential "trouble spots" before a problem occurs.

5.1.1 Road classification

Main or primary road	Designed for permanent, all-weather use. It has an 8-10 metres
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² The subgrade is the layer of naturally occurring material the road is built upon, or It can refer to the imported fill material that has been used to create an embankment upon which the road pavement is constructed.

Secondary roads	(25-30 feet) wide subgrade ² , permanent side ditches, cross drain culverts, stabilized banks, and occasional laterite surfacing. A primary road is expensive and can only be justified where the road will be used for several years. In practice, this main route should be in existence before felling starts. All-weather roads providing access to a logging compartment, and connecting feeder roads and log markets to main roads.
Spur roads	They have a narrower subgrade than a primary road, with side ditches, but without any surfacing. Temporary roads providing access to 100-ha felling blocks. They are designed as a temporary road that will be "retired" immediately after logging is completed. A spur road is usually not much more than a 4 metres (12 feet) wide trail where the surface organic material has been graded off. There is no surfacing, and drainage is handled through a few, well-placed water turnouts.

In specifying logging road standards, one must consider cost, the volume of timber to be hauled over the roads, the time of year that the roads will be used, the type of trucks using the roads, the length of road to be built, the available road construction equipment, and the time it will take to construct the roads. In addition, the use and availability of temporary road stabilizing or surfacing options like crushed rock, or laterite should be considered. These are best applied at potential "trouble spots" before a problem occurs.

The forest road network usually has features that distinguish it from the public road network:

- The roads are generally private; their characteristics are often determined solely by the demands of the concessionaire.
- The purpose of these roads is to collect goods rather than connect locations. Vehicles do not therefore need to travel fast and roads can be wind around terrain contours, requiring less earthwork.
- The volume of traffic is limited to the extraction of forest products and related activities. A main road will therefore carry a limited number of vehicles per day.

- Access roads will have to be kept open all year for the regular supply of timber to log yards and mills and for logistics to camp facilities and harvesting units.
- The direction of transport is mainly from the forest to the log yard or mill, with vehicles returning unladen; hence able to handle steeper slopes than outgoing vehicles travelling laden.
- Most of the roads are built for a limited life span, especially secondary and spur roads, which will serve to remove timber and then be closed until the next rotation some 25 to 40 years later. Construction standards and resilience can therefore be lower than for public roads.
- Some areas with difficult access are only harvested during dry weather, so secondary roads servicing these areas will be of lower standard than all-weather roads.

The above points justify the following rules, which are typical of forest roads:

1. All expenditure for permanent construction of too high a standard should be discarded in favour of an economical temporary solution adapted to the present needs.
2. The selected gradients of the route up and down should be as easy as possible, as the majority of the traffic consists of heavy logging vehicles.
3. Maximum ruling gradients uphill in the direction of the forest (returning unladen) can be considerably greater than the downhill ruling gradients coming out (travelling laden). It will be seen later that 8 and 4 percent, or even 12 and 6 percent can be accepted according to the terrain.
4. Generally, a forest road consists only of a single track with some widening at special points: on bends and tops of slopes.
5. Taking the exploitation area as a whole, a longer winding route can be more economical than one shorter and more direct.

Each road is defined by three elements:

- its profile or cross section;
- its horizontal layout;
- its longitudinal section (projection along the vertical axis).

5.1.2 Cross section of a road

The standard profile or cross section defines the different parts of a road:

1. the carriageway made for the passage of vehicles;
2. the formation or roadbed, between the ditches or tops of embankments, including the carriageway and the shoulders;
3. the roadway or clearing between the extreme limits of the earthworks;
4. the road reserve, which corresponds to the limits of the forest affected by the road.

The roadway corresponds to the width of stumping. The formation or roadbed should be wide enough to allow passing or overtaking of vehicles on single-track roads. The carriageway of a forest road is nearly always a single track because of the relatively small number of vehicles using it each day. Each cross section must comply with three essential conditions: it must ensure drainage of the road; maintain stability of vehicles; and allow passing and overtaking.

Cross section of roadway

A convex shape is nearly always used; this makes for stability of the carriageway and allows rain falling on the road to run off to the sides. The choice of slope in the cross section must be a compromise; it must be steep enough to ensure the rapid runoff of water and gentle enough to prevent any gullyng. It is desirable to ensure that the runoff of rainwater should be in the form of a sheet of water of reasonably uniform depth, thus reducing infiltration and gullyng to the minimum.

The surface drainage of the road is easier the narrower the road. The most effective slope is from 3 to 5%. To avoid puddles or an accumulation of water it is better to make a slope, which increases from the centre to the edge. The shape of the road is usually defined in terms of the camber, that is, the slope from the centre to the sides (see Table 5 and Figure 11).

Table 5 — Elevation of centre of road over edge of carriageway (in metres)

Width Carriageway	of	Side slope or gradient	
		3%	5%

3.50	0.05	0.09
4.00	0.06	0.10
4.50	0.07	0.11

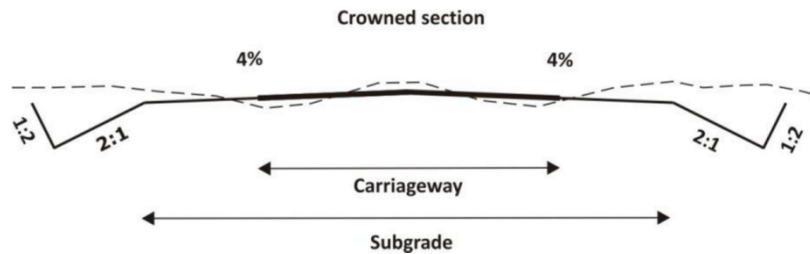


Figure 11 — Cross section of roadway (FAO 1963)

Width of carriageway

The width of a carriageway depends on the amount of traffic envisaged for the road. It is sometimes thought that the need for logging trucks to pass each other makes it necessary to plan for a double track. However, passing and overtaking can be achieved without difficulty if the lighter vehicle reduces speed and makes use of the shoulder. It must be agreed that priority is always given to the laden vehicle. The empty logging truck, or the light vehicle, can get out of the way on to the shoulder and allow the laden vehicle, which is travelling on the crest of the road, to pass. When a light vehicle is overtaking a logging truck, it will overtake as on a normal road, by using the right hand shoulder where the rule of the road is to drive on the left. Sufficient visibility is ensured by a good alignment in both plan and profile, and by subsequent maintenance in controlling the regrowth of vegetation at strategic points.

Shoulders

Roads on stabilized soil are made so that the shoulders are flush; i.e., continuing the camber of the roadway. Their transverse slope should be at least equal to that of the road to facilitate the complete run-off of water; i.e., 4 to 5% toward the ditch. They can be made use of by light vehicles when they are passing or being overtaken on a single-track road. The width of the shoulders often varies and is only limited by the need for loaded trucks to pass each other. In practice, a minimum width of 1.5 to 2 meters is sufficient for all needs.

Ditches

To ensure drainage of the subsoil under the carriageway the bottom of the ditch should be 50 centimetres lower than the crest of the road. Ditches must be planned sufficiently wide to fulfil their function; the width at the top should be 1 to 1.50 meters as required (see Figure 12). There are two obstacles to be avoided: deposits of debris or silt, which may block the drains and erosion, which may threaten their shape. The longitudinal slope should be greater than the minimum to avoid silting up, but also less than the maximum of about 5% to avoid gullying which might destroy the shoulders.

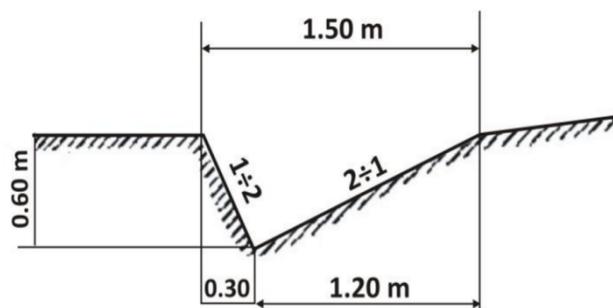


Figure 12 — Dimensions of a ditch made by a grader or bulldozer (FAO 1963)

In conclusion, the roadway comprising the carriageway, shoulders and ditches between the extreme limits of the earthworks, extends over a width of at least 8 to 11 meters on a straight alignment. To allow for earthworks and subsequent maintenance of the road, clearing and stumping must be done on a strip in accordance with the needs of these operations; the width of the strip must be chosen to meet each particular case (see Figure 13, Tables 6 and 7).

- Where side cutting is not necessary, earthworks should be limited to the width of the carriageway, shoulders plus ditches on either side
- Feeder roads shall be located on ridges wherever possible to minimise side casting
- Primary and secondary roads on clay and loam soils should have trees removed alongside the road to allow sunlight onto the road to dry the surface quickly after rain. Roads on white sand soils should be protected from rain and direct sunlight by limiting clearing to the roadbed and ditches to maintain trafficability
- An East-West road requires less width clearing than a North-South road as it has longer sunlight exposure.

- On primary and secondary roads, tree stumps should be grubbed on at least one side of the road to allow for movement of tractors and other heavy machinery that would damage the road surface
- Passing spots shall be provided on roads with a roadbed narrower than 7 m, at least every 500 m and at bridge approaches and hillcrests.
- On hilly terrain, width clearing is always broader on upslope side

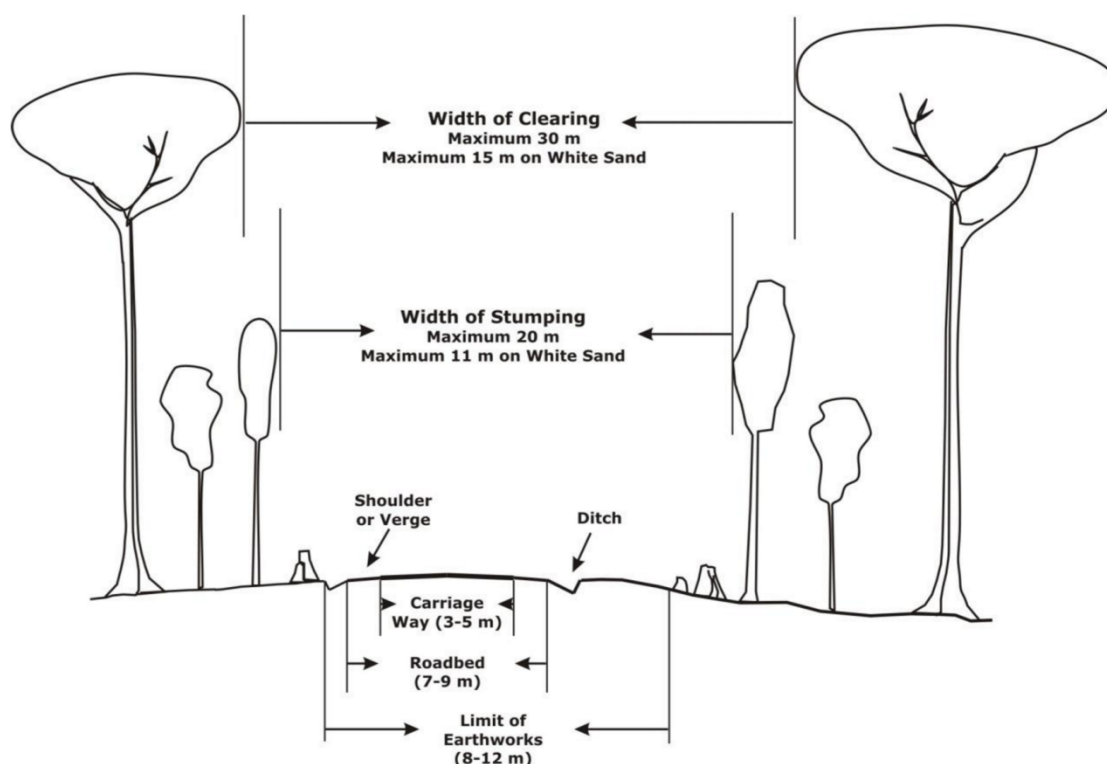


Figure 13 — Cross section of road on flat terrain; left, a narrow opening suitable for white sand soils with early exposure to the sun; right, a wide opening for clayey soils, with late exposure to the sun (FAO 1963)

Table 6 — Maximum road widths in metres

Road class	Limit of canopy clearing	Limit of earthworks	Limit of roadbed subgrade	Limit of / carriageway

Main road	30	12	9	5
Secondary road	20	10	8	4
Spur road	15	8	6	3

Table 7 — Maximum road widths in metres on white sand soils

Road class	Limit of canopy clearing	Limit earthworks	Limit of roadbed subgrade	Limit of / carriageway
Main road	15	12	9	5
Secondary road	12	10	8	4
spur road	10	8	6	3

5.1.3 Curves or bends

Three factors need to be examined when designing curves:

1. stability of vehicles under the action of centrifugal forces (banking);
2. ability of vehicles to negotiate curves;
3. visibility, particularly in side cuts or on bends.

Stability of the vehicle - minimum radius - banking

In the action of turning, a vehicle is submitted to centrifugal forces. Its stability is only ensured if it can stay on the road without slipping. The tendency to skid toward the outside when his vehicle is travelling fast round a sharp bend is greater the shorter the radius of the curve and the more slippery the road. At a low speed, therefore, the minimum radius of a curve is given by the outside radius of the turning circle of the vehicle. For long vehicles like trucks and tractors with semitrailers, this radius is from 15 to 20 meters but, to avoid sudden braking by heavy vehicles, it is preferable to allow a minimum radius greater than that of the turning circle (see Table 8).

Table 8 — Curve radius

	Minimum radius	Recommended radius
Gentle terrain	40 m	100 m
Steep terrain	20 m	40 m

To give vehicles more stability on a bend it is possible to raise up or bank the outer part of the curve. For a curve of a given radius, the banking should be higher when the surface of the road has a poorer vehicle-holding capacity. However, a bend cannot be raised too much on an earth carriageway; the banking must remain moderate in order not to hinder slow vehicles and not to cause cross gullying. The slope should not exceed 5% on an earth road. On a banked curve the camber is not kept and the roadway is given a constant side slope or cross fall.

Widening curves

Articulated vehicles, such as logging trucks with semitrailers, have difficulty in negotiating small radius curves. When the direction of the front wheels is changed, the back wheels of the tractor describe a trajectory of increasing curvature. They tend to cut the corner. The vehicle is thus taking up more space than its width along a straight line. This extra width in the curve must be planned by a symmetrical widening on both sides of the curve or on the inside. This extra width in the bend is gradually decreased until it reaches the straight alignment before the beginning and end of the curve (see Figure 14 and Table 9).

Table 9 — Widening and adjustment of curve

Radius of curve (R)	Extra width (S)	Length of tangent (T)
20 m	2.5 m	20 m
50 m	1.0 m	30 m
100 m	0.5 m	30 m

Visibility in curves

Visibility in curves is also an essential safety requirement.

- The minimum visible distance should be twice the braking distance for a given speed.
- Fit curves to the topography; i.e. along the contour
- Shoulders may need to be cleared on the inside of the curve to obtain the required sight distance
- The minimum radius of the curve is related to the visibility and the speed the vehicles will be travelling on the road:

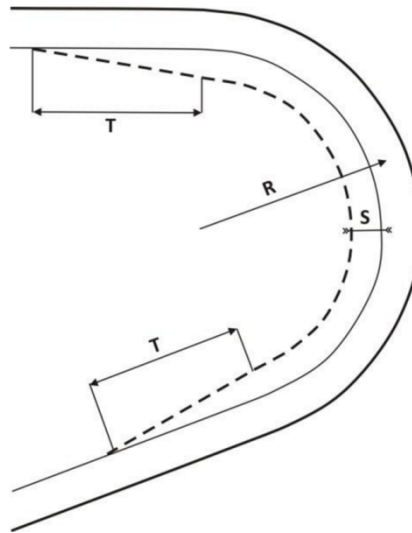


Figure 14 — Gradual widening on a curve (FAO 1963)

Table 10 — Braking distance at different speeds and required sight distance

Maximum speed (km/h)	Braking distance (m)	Sight distance (m)
30	20	40
40	30	60

50	45	90
60	60	120

The figures are obtained from the formula: $D = (2V/5) + (V^2/100)$;

Where D = stopping distance in meters, and V = velocity of vehicle in kilometres per hour. The first part of the formula is the distance travelled during the delay in the driver's reaction, and the second part the distance travelled between applying the brakes and stopping (see Table 10).

To enhance visibility on hilly terrain, a ledge can be cut into the hillside at the height of the driver's line of vision, about 1-1.25 m above the surface of the roadway.

When the terrain requires a curve of a very small radius (less than 50 meters) on a steep side slope of more than 80% for a section of road including both cutting and embankment, it is sometimes easier to build two parallel tracks than to make a single track of the same length. Making two tracks, one for each direction and stretching for 2 to 300 meters results in less extensive earthworks, quicker construction and easier drainage on curves

Bridge approaches

Bridges are often narrower than the roadbed or even the carriageway. Even if their condition does not require vehicles to stop before crossing, it is essential to have the bridge approaches in a straight line for at least 30 meters to reduce the danger of accidents (see Figure 15).

Two curves in opposite directions should be separated as much as possible by a straight alignment – of 40 meters on easy terrain and 10 meters in broken or uneven terrain.

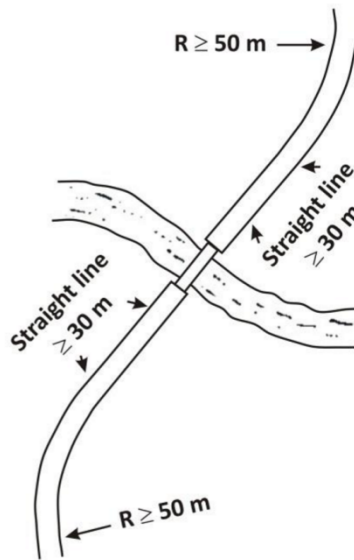


Figure 15 — Bridge approaches should be in a straight line for at least 30 meters (FAO 1963)

5.2.4 Longitudinal profile

The longitudinal profile should fulfil several conditions:

1. ensure the run-off of water;
2. avoid a marked slowing down on the part of heavy trucks on slopes;
3. avoid too sudden braking on steep slopes;
4. ensure good visibility at all points.

Discharge of water and gullying

Standing water on the carriageway should be avoided at all costs on all roads, especially on earth roads. A slight slope is therefore necessary and always preferable to a level section. A slope of 1% should be considered the minimum. On the other hand, the scouring due to gullying caused by rainwater increases very quickly as the slope becomes steeper on earth or stabilized roads. Above a slope of 5%, scouring gets worse and therefore necessitates particularly extensive maintenance. As the gradient becomes steeper and the slope longer, the scouring due to gullying increases.

Vehicles on ascents and descents; recommended and maximum slope gradients

In general, resistance to movement is composed of four elements: resistance to rolling in the driving axles and free axles; air resistance (drag); truck weight (when ascending or descending); and acceleration when the speed is not uniform. When a (laden) truck climbs a slope, the weight of the truck is by far the greatest resistance that has to be overcome. It is not unusual to see logging trucks slow down and labour on hills. Various studies have shown that heavy trucks when laden cannot climb slopes of more than 6% except at a very slow speed and at the cost of excessive fuel consumption and wear and tear on the engine and transmission (see Table 11).

In the same way, descents mean incessant braking which is partly achieved by special systems or appliances called speed retarders.

Table 11 — Bearing in mind the effect on gullying and on transport expenses, generally the following limits on gradients should not be exceeded

Type of terrain	Travelling laden	Travelling unladen
Fairly even ground	4%	8%
Very uneven ground	6%	12%

A steeper grade is acceptable, if unavoidable, but only for a very short section. It is important to note that:

- the gradient on curves should be less than on straight stretches;
- gradients should be zero on hairpin bends
- any two sections of road at maximum gradient should be separated by 100 m of level gradient;
- level or gently sloped intersections should be built into long ramps;
- slopes in the direction of generally unladen travel should not be too steep to prevent the occasional traffic of laden trucks towards the forest and logging camps (e.g. trucks carrying equipment, tank trucks).

Table 12 —Maximum slope gradient; only applicable if unavoidable and only for a short road section – 50 metres (150 feet)

Road class	Travelling unladen	Travelling laden
Main road	10%	8%
Secondary road	15%	10%
Feeder road	18%	12%

5.2 Planning the road alignment

5.2.1 Procedure for planning the alignment

There are six phases in the systematic and increasingly detailed procedure for planning the alignment:

1. examination of general information from maps, aerial reconnaissance and aerial photographs, and pre-harvest inventory, if completed before roads are being planned (see section 5.5);
2. drawing up of provisional alignments in the light of the information collected (see section 5.5);
3. detailed reconnaissance on the ground of the possibilities of the provisional alignment;
4. fixing the final alignment by correcting the provisional one in the light of information gained by the reconnaissance on the ground;
5. Opening the alignment by establishing a pioneer road with a small (150 hp) crawler dozer;
6. Final correction, marking out, and staking the selected alignment with regard to the detailed irregularities found on the ground.

Annual harvesting map (1:5,000 - 1:10,000)

A preliminary examination of the harvesting map makes it possible to pick out the best zones in the forest in which a road of predetermined specifications can later be constructed. Marked on this sketch should be (section 5.5):

1. the areas to be exploited and therefore to be provided with roads;
2. obligatory points, such as a narrow part of a stream for a crossing or a saddle which could be a point to cross a ridge of hills;
3. places to avoid: marshy land, or land under water in the rainy season which would need an expensive embankment and which might often be unstable;
4. savannahs and other areas without exploitable trees, where the absence of stumps would make crossing easier.

Locate and flag the provisional logging road gradient line or centreline

- The provisional alignment on the annual harvesting map should be compared with the configuration of the ground in the course of a reconnaissance survey. The provisional alignments comprise successive sections planned in suitable areas, which are separated by obligatory points. Each suitable area and each obligatory point should be the subject of a detailed reconnaissance. The best time to do this is during the rainy season; it is then that characteristics of the soil, the limits of marshy places, and the width and level of watercourses can best be appreciated.
- When considering a crossing over a watercourse, a check must be made that there is not another place nearby which had been overlooked when the map was studied and which would be more suitable. To determine the highest flood level of the water, the height of masses of debris brought down by the floods and traces left on the stems of plants in the neighbourhood should be noted. If it is likely that the route will cross the line of a ridge or a watershed between two valleys, the line of the main ridge and the lines of the secondary ridges or spurs are walked over systematically. It is often essential to work up the valleys to discover the highest part suitable for a crossing.
- Areas where sand, or lateritic gravel are predominant should be noted for later use in the construction of the road.
- A good procedure is to first attempt to plot the gradient line on a topographic map, connecting the positive control points while keeping the road at an acceptable grade (for a secondary road a maximum 15% grade for no more than 50 metres at a time). Ideally, the grade should be kept at 10% or less. With a topographic map, the gradient of the proposed route between two control points can be determined by estimating the on-the-ground distance by the map's scale, then divide that into the gain or loss in elevation as estimated by counting the contour intervals between the

control points. Adjust (lengthen or shorten) the route on the map until the acceptable grade is reached.

- In the forest, flag a "trial" gradient line with the help of a tape, compass, and measuring slope-determining instrument such as a clinometer set at the desired gradient and following the proposed map route as closely as possible. It often requires some "adjusting" on the ground to make it work.
- Locating a centreline on relatively flat terrain is usually somewhat easier. Soils, large trees, and rocks are often the main considerations; locate the road on well-drained, stable soils, with good load bearing capacity, like clay or sandy clay loams with a solid base. In either case, the centreline location must consider log truck characteristics such as tractor/trailer "tracking" and "tail swing" when laying in curves or switchbacks. The relationship between gradient and "loaded" travel direction must also be considered when locating a curve near the bottom of a grade or in a location that will cause the driver to shift gears.

Other considerations:

- Avoid as far as possible environmentally sensitive areas and other non-harvest areas;
- Locate centreline at least 40 m away from the edge of buffer strips (viz. 70 m from the banks of rivers (width ≥ 30 m), 60 m from the banks of creeks ≥ 10 m, 50 m from creeks < 10 m wide and the edges of a gullies), except at designated watercourse crossing points;
- If possible, the centreline should pass large trees > 40 cm diameter at a distance of 4 m in a smooth curve; these trees should rather be felled than being pushed over and grubbed (uprooting and grubbing would result in dips in the surface of the road, which in turn would need to be filled and compacted separately);
- If possible, the centreline should pass potential crop trees, seed trees and trees of protected species at a distance of 4 m from in a smooth curve; these trees should be spared if possible.

5.3 Road construction

Road construction costs are mostly influenced by the standard of road built, particularly road width, type of surfacing, and the steepness of the terrain. A road

with cuts and fills on steep cross slopes greatly increases the time of construction, amount of earthwork, the areas of clearing, and adds length to cross-drains and other drainage structures

5.3.1 Timing of construction

- Secondary and feeder roads should be completed 3 months before logging
- Construction should commence within 12 months before logging
- Preliminary roadway clearing should take place within 1 month of final construction to reduce sedimentation from poorly drained sites

5.3.2 Roadway development requirements

- Merchantable stems along the road reserve should preferably be felled and extracted before clearing;
- While clearing, trees should be pushed into the road reserve and not into the adjacent forest - it is recommended to crosscut large trees before side casting;
- Soil heaps, banks and debris stockpiling along the roadway are not permitted; instead topsoil should be stockpiled for use in cut and fill batters and/or in borrow pits;
- Organic debris should not be used as fill;
- Gravelling is recommended for primary and secondary roads, especially of bridge approaches and culverts;
- All road fill and paving material shall be compacted;
- Minimum compacted gravel thickness is 15 cm;
- All road drainage works shall be completed before gravelling work commences;
- Hazardous trees, which have a significant probability of falling onto the roadway, should be removed during construction.

5.3.3 Clearing procedure

- Before actual construction can start, a *pioneer road* should be built. The pioneer road follows the flagged road alignment and its width should be limited to the blade width of the crawler tractor (more or less 4 m). The pioneer road also

services to skid felled merchantable logs to the decking area. The pioneer road provides the first indication of unforeseen problems with the road location. Hidden rock, springs, and poor soil are often discovered during pioneer road construction.

- The pioneer road also will provide a clear overview of the road reserve. This provides the opportunity to circumvent large trees (> 40 cm diameter), lateral slopes, etc. The final road alignment can now be staked. Final staking should include the centreline of the roadway as well as the width of the roadbed (excluding ditches) to be excavated.
- Remove stumps and all organic debris from the roadbed and excavate and side cast the top soil (with fine roots and humus) until the subgrade is reached. Once the topsoil has been removed and the earth bladed, the natural soil is usually sufficient to serve as roadbed.
- Once the road has been excavated to the subgrade, it should to be compacted. Compaction will make a dirt road more stable, less erosive, and better for traffic. Soil will compact most efficiently at the correct range of soil moisture. If the soil is too wet or too dry, it will compact very little or not at all.
- Straightforward compaction from rainfall and the passage of bulldozers, front-end loaders, and dump trucks is the usual form of stabilization of forest roads. Once the earthwork is complete, the natural soil profile is shaped by motor grader. The road should then be left untouched for a period of natural compaction from rainfall. Finally, before use, the roadway is re-graded and if necessary, a wearing layer aggregate added. Roads should therefore be in place at least one year before harvesting.
- If the road is to be surfaced with loam or laterite, surfacing should start at the back; the gravel trucks will provide some compaction by tracking over the entire sub grade surface rather than in the same tracks. Another option is to surface the subgrade after it has settled during the rainy season (be sure to provide for drainage before the rainy season).
- Practical guidelines for clearing and grubbing are given in Appendix 3.

5.3.4 Constructing of fills or embankments

- Road fill sections typically are used to cross-stream drainages, flat areas, and swamps. A fill must support traffic, so it should be constructed of adequate

materials and be compacted to a specific level to develop strength. It is important to estimate the expected width of the fill area and prepare the contact surface so the fill materials adhere to the original ground surface. The width of fills on flat ground is, at a minimum, three times the road surface width (depending on the height of the fill). Fills on gentle slopes may not extend as far on the uphill side as on flat ground, but they will extend further on the lower side (see Figure 16). Practical guidelines for constructing fills or embankments are given in Appendix 3.

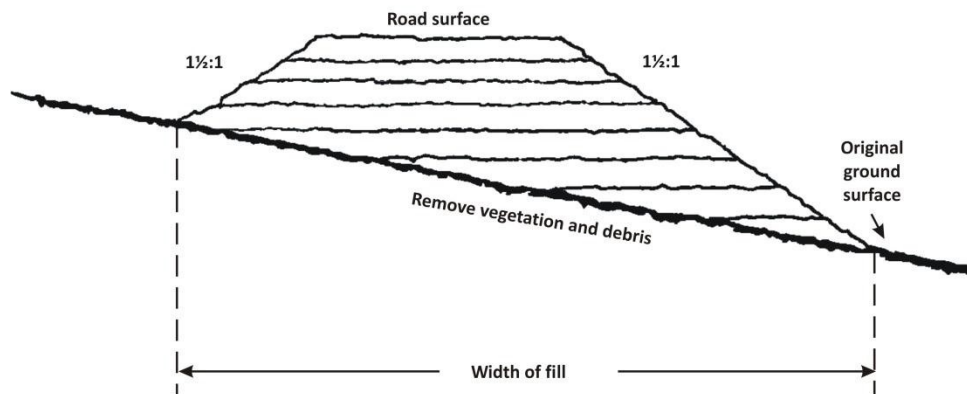


Figure 16 — Fill on a gentle slope (Oregon State University 1983)

5.3.5 Construction of ditches

An angle dozer can make a shallow ditch at the sides of the road. It is especially efficient in making lateral outlets. Outlets should be opened between the side ditches when the earthworks are under construction. Delay in opening these outlets until the earthworks are finished makes the work much more difficult. These openings can be either made with the blade as a bulldozer working at right angles to the line of the ditch, or inclined as a tilt dozer working in the general direction of the ditch.

5.3.6 Works on the hillside

Sometimes roads have to be built on a hillside. In these circumstances, the transverse profile consists partly of cutting and partly of embankment. The road design and field layout marks the top of the cut slope, indicates the steepness of the cut slope, and provides the vertical distance down to the final grade. A section of road on a hillside should be started as high up as possible to obtain the advantage of working downhill. The first stage is to make a more or less horizontal platform on which the tractor can

operate. Two methods can be used according to the steepness of the slope. These are given in Appendix 3.

5.3.7 Full-bench, partial bench and balanced roads

The road design will indicate whether the road is to be built with balanced road sections, full-bench sections, or partial fill sections (side cast materials forming part of the road surface). During construction, the initial handling of excavated material and its final deposit are crucial.

Full-bench roads are usually built on slopes over 65%. The entire running surface is on previously undisturbed (and presumably stable) soil (see Figure 17).

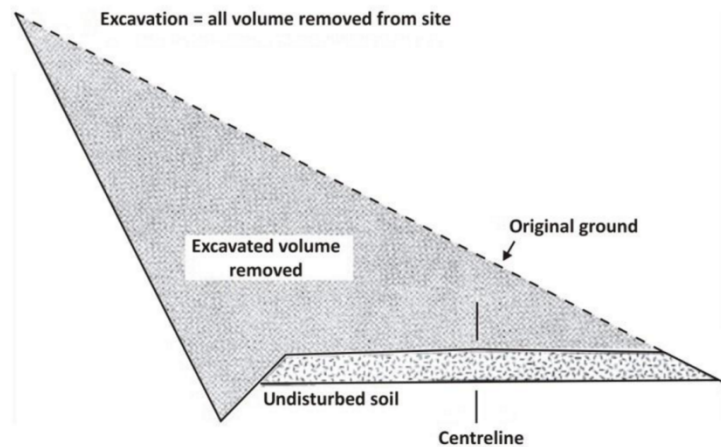


Figure 17 — Full-bench construction cross-section (Oregon State University 1983)

On gentle slopes only part of the roadway needs to be built on a stable bench and the excavated material can be used to build a portion of the running surface. All debris and woody material should be removed from the side slopes and clean fill material deposited to minimize road failures (see Figure 18).

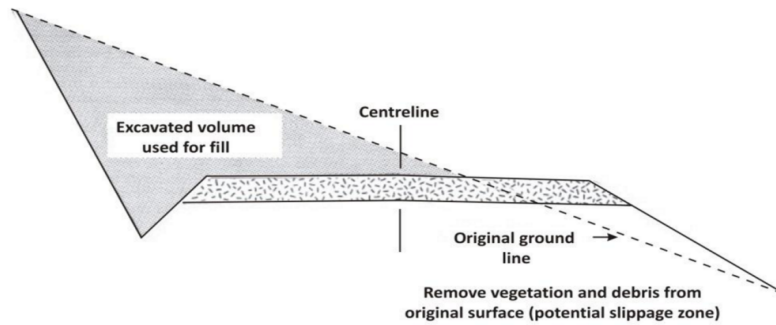


Figure 18 — Road cross-section with partial fill (Oregon State University 1983)

It is possible to calculate the amount of fill material needed and excavate only the amount for a road cross-section (whereby an allowance for shrinkage should be included). When the excavated material matches the required fill, the cross-section is balanced (see Figure 19). Balanced sections will minimize the amount of earthwork excavation and materials handling. Extra excavation will be needed on both sides of a fill section to provide material for the fill. The extra excavation depends on the amount of shrinkage and on the degree of compaction of the fill.

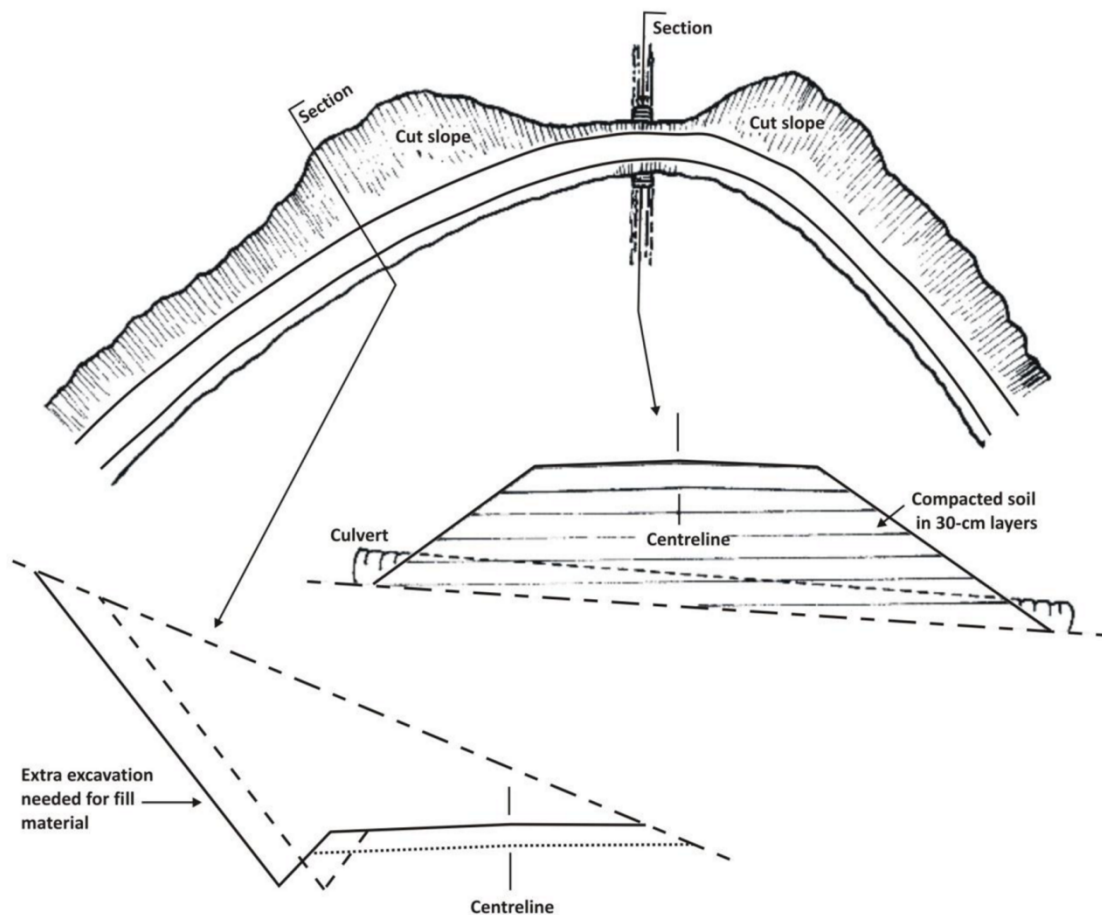


Figure 19 — Balanced cut-and-fill, whereby the excavated material is deposited in the fill section (Oregon State University 1983)

Cut slope gradients must match the soil type's ability to hold the slope's steepness. Steep hillside slopes of soils that are high in clay can hold a $\frac{3}{4}$:1 cut slope, while gentle slopes with loose, non-cohesive soils need a 1:1 cut slope. On some steep slopes, the cut slope will fail if it is too steep for the soil to hold (see Figure 20).

Fills should be designed to have a $1\frac{1}{2}$:1 slope, because at this gradient non-compacted or loose earth will hold (see Figure 21). The stability of fills on sloped terrain depends on the original ground's steepness. Fills on slopes that are more than 65% will not catch (attach to the original ground) or provide support; material will ravel (slide away) down the hillside (see Figure 22).

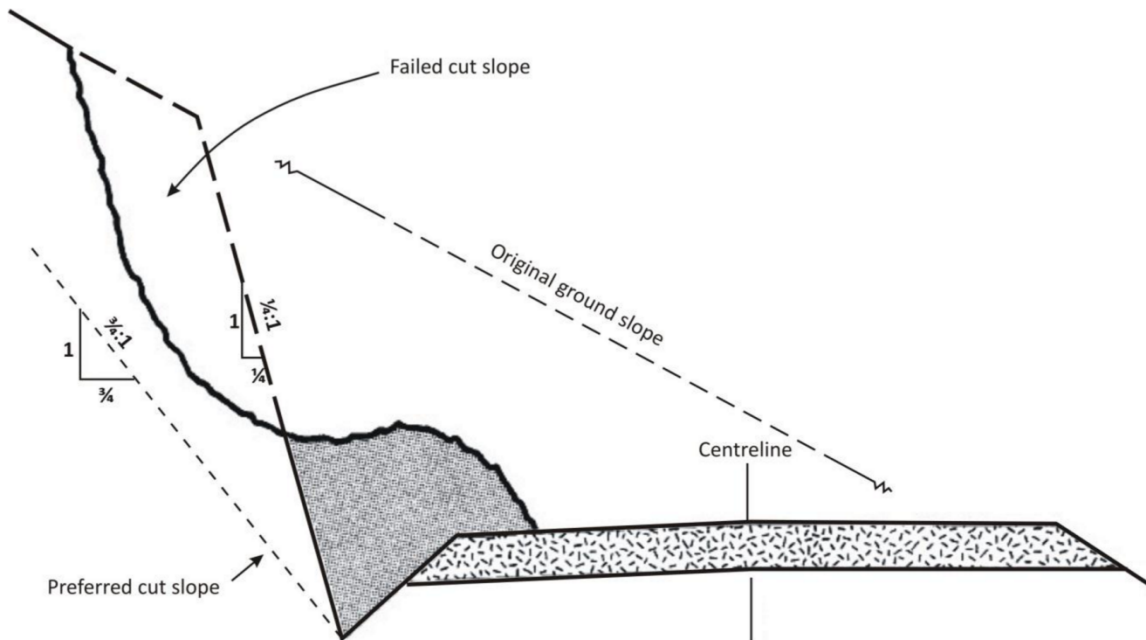


Figure 20 — Cut slopes that are too steep may fail (Oregon State University 1983)

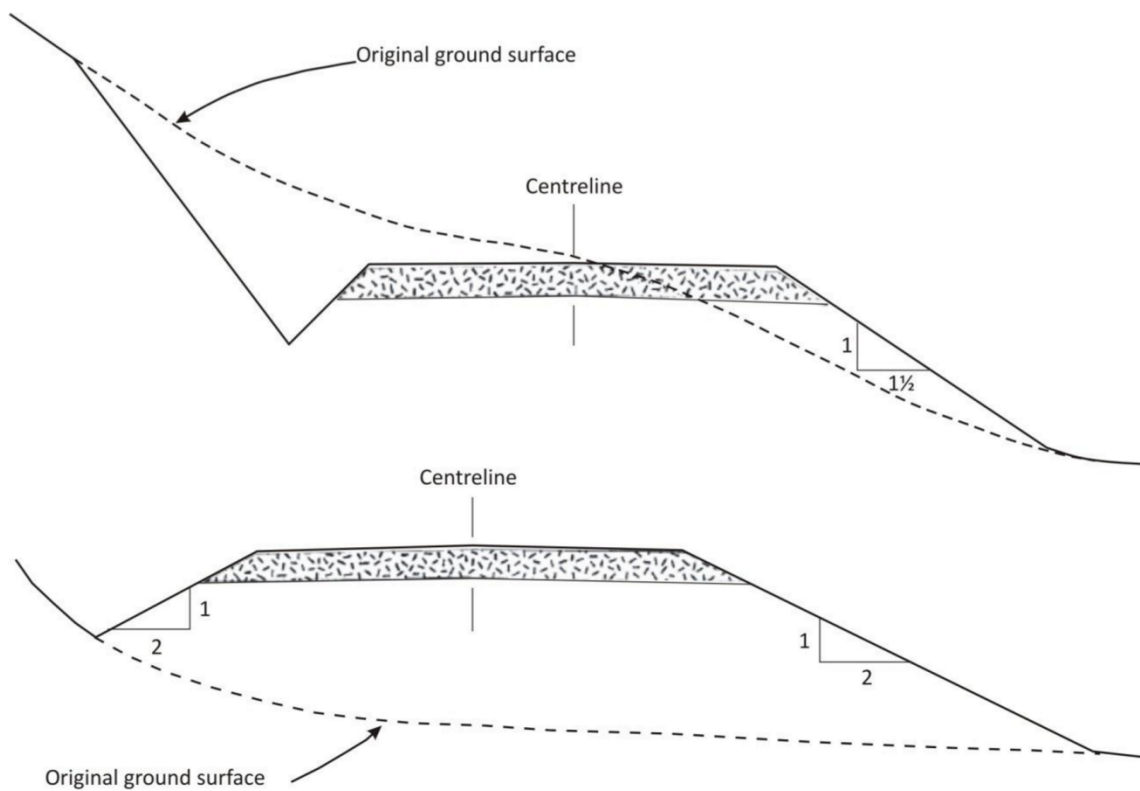


Figure 21 — Partial fills at $1\frac{1}{2}:1$ (top) and $2:1$ (bottom) fill slopes (Oregon State University 1983)

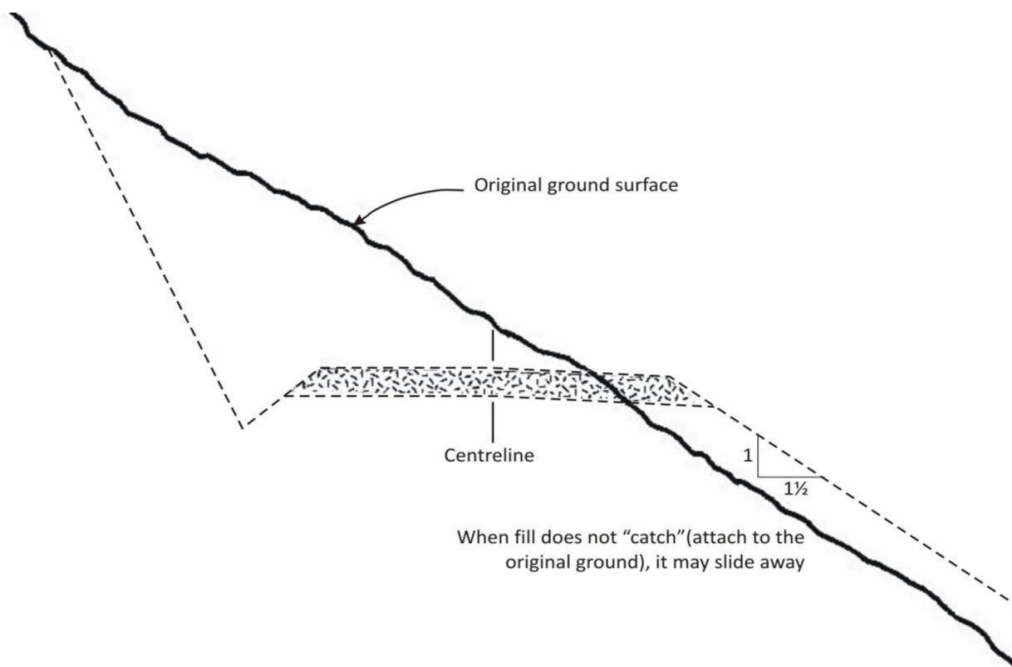


Figure 22 — Fill slopes will not hold on steep slopes (Oregon State University 1983)

5.3.8 Spreading materials – finishing off

Once the road is excavated (or filled) to grade, there are a number of finishing details to consider. The final surface grading - to make sure ditches and road surfaces are smooth and functional - is usually done with a road grader. However, good bulldozer operators can "shape up" short stretches of roads.

A distinction must be made between the natural soil and the surfacing layer. The surfacing layer is very often made up of unsorted laterite extracted from selected natural deposits and transported direct to the compacted and levelled natural soil. The operator can obtain a suitable surface, when pushing a little material in second or third gear. Good results can be obtained at the end of a pass by back-blading, i.e., going in reverse with the blade resting on the ground to smooth out little irregularities. It is always advisable to leave the site at the end of the day with an even top surface, to avoid damage due to erosion and to soaking soil, which is in the process of being handled and in the course of compaction.

5.4 Drainage

Drainage problems often cause the largest impacts from roads with regard to erosion, sedimentation, and degradation of water quality. On the other hand, traffic on a roadway with poor drainage will cause ruts, scouring, gulying and potholes that cannot be repaired until the end of the rainy season. Furthermore, standing water and seepage under the roadbed may lead to road failure. Thus, poor drainage can incur major operational constraint and added cost. These aspects make road drainage the single most important aspect of road construction and maintenance.

With appropriate structures, water can be rapidly evacuated and roadways only superficially soaked and thus able to dry off within hours and sustain logging traffic. Penetration of water subsequent to maximum compaction should therefore be prevented. Road degradation is usually caused by reduced stability of terrain or roadway from the action of water.

The measures to be taken should tend to:

1. prevent penetration of rainwater into the roadway;
2. ensure rainwater running off the road;
3. ensure the different roadway layers are sufficiently drained;
4. prevent water rising by capillary absorption;
5. facilitate evaporation from the surface.

5.4.1 Avoiding water penetration

Rainwater penetration is limited by reduced permeability of upper road layers after compaction. The compactness and cambered shape of the roadway reduces surface absorption, as water flows immediately to the side drains before being able to soak into the substrate (see Section 6.2.2.).

If earthworks are carried out in the rainy season, work should not be stopped until the road is cambered and the rainwater can be certain of running off into temporary ditches. Maintenance work, especially in very rainy areas, regularly renews the camber to avoid water standing in puddles.

5.4.2 Evacuation of rainwater runoff: side drains, outlets and culverts

The function of ditches is to collect all the water falling on the road and to evacuate it toward the streams or rivers, which are the natural outlets. Several categories of ditches

can be distinguished, each one fulfilling a different requirement in a well-defined role. These are:

1. side ditches (side drains),
2. outlets toward the drainage channels,
3. catchwater or intercepting ditches,
4. culverts under the roadway.

Side ditches

- The removal of water by side ditches (side drains, lateral ditches) should take place as quickly as possible. The side drains serve to collect roadway water and take it to outlets from where it can be discharged without damaging the road. It has already been stated that the camber given to the road is designed to facilitate the rapid runoff of this water toward the side ditches. This water must not stagnate in the ditches or it will penetrate into the actual earth of the carriageway itself and inevitably tend to diminish its strength and cause ruts and potholes (see Figure 23).

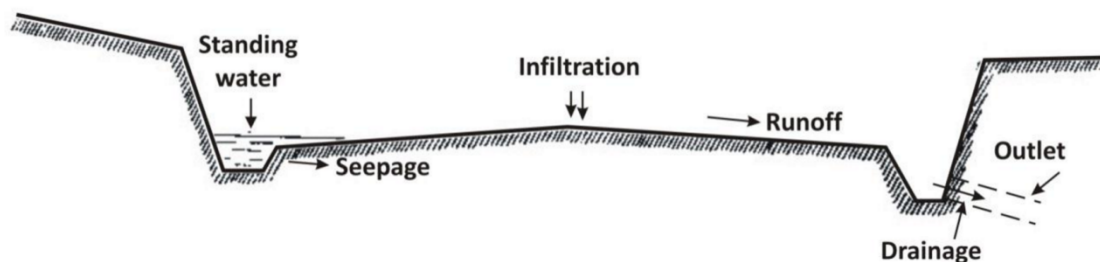


Figure 23 — The function of ditches and outlets: left, a ditch with no drainage; right, a ditch of adequate depth (FAO 1963)

- For water to flow away to the outlets, the gradient of the side ditches should be more than about 1 or 2% in order to avoid deposits of sediment, mud, or sand, but less than 5% to avoid gulying which would destroy the banks. It is essential, therefore, to make sufficient outlets to ensure the removal of water after heavy rain. When sufficient outlets are not provided, there is the risk of the side ditches being rapidly eroded and thus becoming very deep. There is a danger of the sides falling in thus cutting back into the shoulders or even into the carriageway itself.

- Where the side ditch has a slope steeper than 5%, special protection is required against erosion such as log or rock bars; stepping and very frequent outlets to reduce scouring
- Side ditches are generally dug by motor grader after the earthworks. It is very important that these ditches be dug as soon as possible and at latest immediately after the earthworks are completed.

Outlets

The function of these outlets is to evacuate the water in the side ditches toward the natural drainage channels (see Figure 24). Their number and spacing will be based on direct ground observation. High outlet frequency is needed in both the following cases:

- where the side ditch has a gentle slope of 1 to 2%, where the water will only flow away slowly;
- where the side ditch has a steep slope (5%), where water flows away quickly and can lead to rapid erosion.

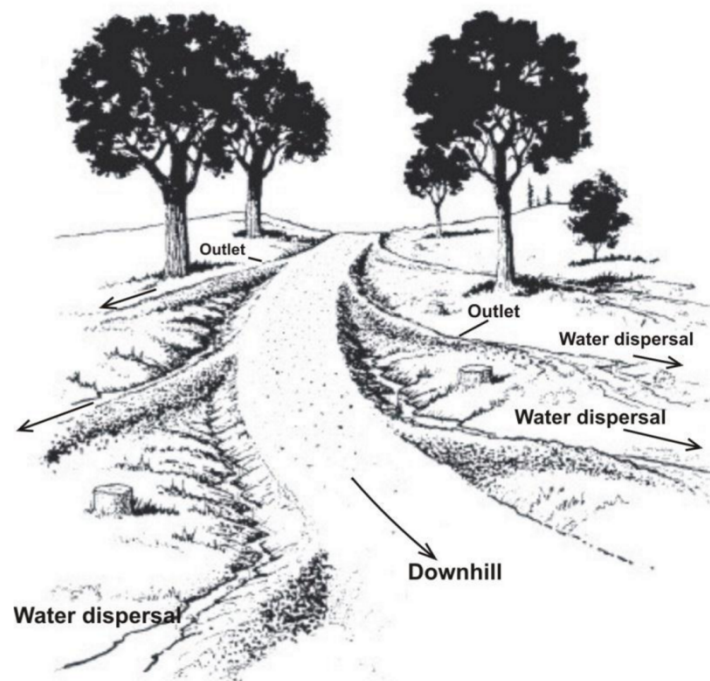


Figure 24 — Side ditches and outlets constructed by bulldozer during earthworks (Oklahoma State University 1991)

The outlets, opened by bulldozer during earthworks at the same time as the side ditches, should follow the natural slope draining the roadway. Their construction should meet certain requirements:

- they should actually discharge onto lower terrain (a requirement often ignored, producing the opposite effect of outlets; retaining water or flowing back);
- their width and depth should be at least the same as those of the side drain they are servicing so that water flow is equal or faster than that of the side drain;
- their slope must be the same or if possible steeper than that of the adjoining side ditch;
- their slope should increase from the ditch down the hillside or toward the drainage channel to avoid the silting up of the outlet;
- as the outlet is usually built with a bulldozer, the operator must be sure that the spoil from the outlet construction is scattered and not allowed to form a dam at the end of the outlet;
- plug the ditch immediately downhill of the entrance of the outlet to direct all water into the outlet; such plug is normally created while the outlet is being opened by bulldozer or re-opened by motor grader during maintenance.

Cross-drain culverts

- On hillside sections of a road where outlets cannot be inserted into the cut slope, the side ditch should be discharged by means of cross-drain structures (e.g. culverts) that take the water across the roadway. Without a cross-drain structure, the water will pass over the road; the road then taking on the role of a spillway, which inevitably will result in a rut in the road. In addition, the water, which remains in the ditch at the end of a rainstorm, tends to seep into the soil and lessen the strength of the roadway.
- The best way of ascertaining whether ditches and outlets are sufficient to carry all the rainwater is to visit the site immediately after heavy rain. It will then be seen that the outlets are nearly always inadequate.

5.4.3 Cross-drain or outlet spacing

- An outlet or cross-drain culvert has to be placed at each low point along the longitudinal profile (see Figure 25) - without a relief culvert, the trapped water

can migrate into the subgrade, causing potholes or saturating the fill and causing erosion or slump failure; and

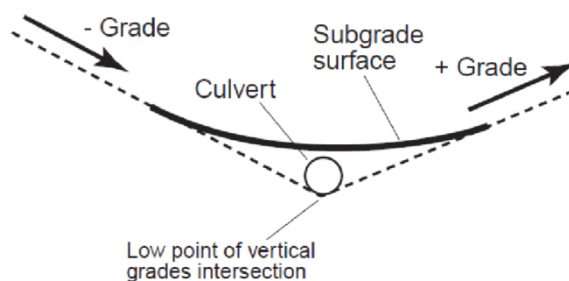


Figure 25 — Ditch relief culvert installed at the low point in the ditch line (Oregon State University 2001).

- at a certain minimum spacing to move water from the (uphill) ditch before the flow gains sufficient volume to erode the side ditch;
- the appropriate spacing between cross-drains or outlets depends on the steepness of the road gradient and the erosivity of the soil. The steeper the grade, the greater the velocity of the water, and the closer water diversion structures must be placed together (see Table 13).

Table 13 — Suggested spacing between outlet, cross-drain culverts, and other water diversion structures on forest roads

Road gradient (%)	Spacing (m)
0-2	100
3-4	60
5-7	40
8-10	30
10+	20

A common rule of thumb for the spacing of outlets, and cross-drain culverts is:

Spacing between devices: (in feet) = $(400 / \text{slope gradient } \%) + 100$
 (in metres) = $(120 / \text{slope gradient } \%) + 30$

5.4.4 Discharge of side ditches, outlets and cross-drains

- avoid discharging water from an outlet or cross-drain directly into a stream; this discharge should flow through a streamside management zone before entering a stream or other water body;
- outlets shall be installed at least 50 m before meeting a watercourse to prevent the intrusion of sediment. Where outlets are not practicable, drainage diversion by means of a cross-drain culvert should be considered (see Figure 26);
- all cross-drain culvert and outlets should be protected by vegetation or rock or log barriers, particularly in fill areas;
- sumps or silt traps shall be constructed at inlets of cross-drain culverts; in steep terrain, silt traps should be constructed at the end of outlets.

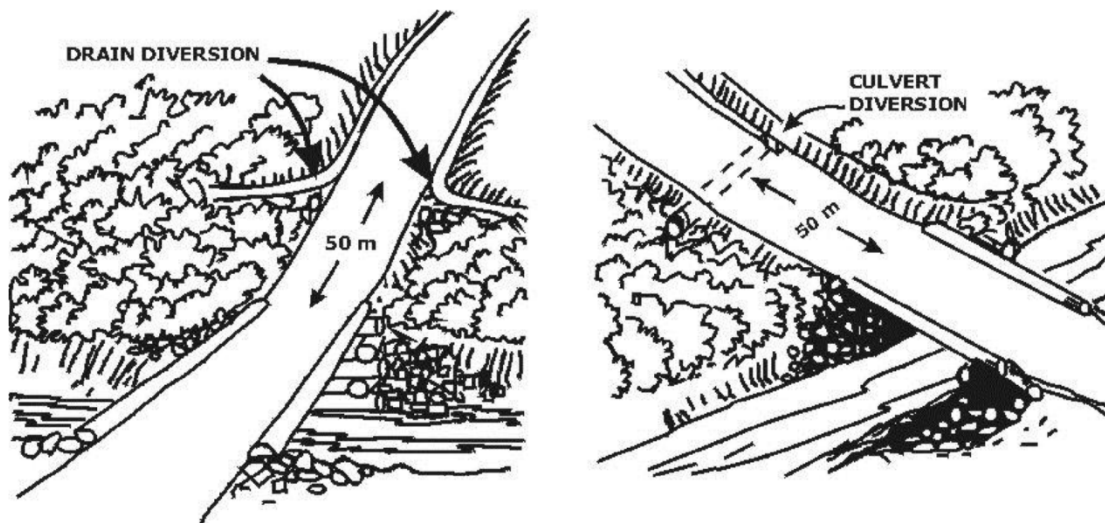


Figure 26 — Water discharge diversion by outlets or cross-drain culvert (Forest Practices Board 2000)

5.4.5 Culverts

Disposal of runoff from roadway ditches will help preserve the roadbed, ditches, and banks. Strategically placed culverts, along with road ditch outlets, will help maintain a stable velocity and the proper flow capacity for the road ditches by timely discharging water from them. This will help alleviate roadway flooding, reduce erosion, and thus reduce maintenance problems. In addition, strategically placed culverts help distribute roadway runoff over a larger riparian filtering area. Culverts preserve the road base by draining water from ditches along the road, keeping the sub-base dry.

A culvert is a conduit used to convey water from one area to another, usually from one side of a road to the other side.

- All culverts should be placed on a 2 to 4% gradient and at a 30-degree angle downgrade across the road to allow smooth entrance of water at the inlet. This will help make the culvert self-cleaning of sediment (see Figure 27).



Figure 27 — Install culverts at a 30-degree angle and protect outfall (Oklahoma State University 1991)

- To be sure that no water bypasses the inlet, install a control backstop of earth, riprap, sandbags, or half-culvert sections on the downhill level of the inlet.
- Size the cross-drain culvert adequately to handle the maximum water volume expected. A 45-cm (18-inch) minimum diameter is recommended. Culverts smaller than 45-cm plug easily and present maintenance problems. Smaller diameter culverts should only be used in temporary applications where the culvert will be removed at the end of the use of the road.
- A proportionate fill should be placed on top of the culvert; at least one-half the culvert diameter—but not less than 30-cm (12-inches).
- The culvert will stay in place if the surrounding earth is firm and uniformly compacted in successive 25 cm layers (see Figure 28).

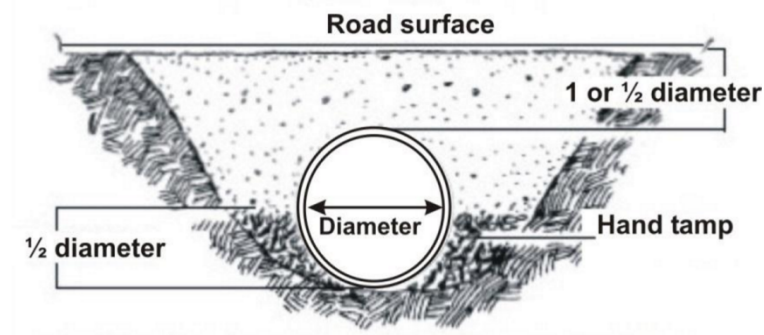


Figure 28 — Fill over top of culvert should be the greater of 30 cm or half of the culvert diameter (Alabama Cooperative Extension System 1995)

- The cross-drain culvert length should extend 30-60 cm (1 to 2 feet) past any fill.
- Outfall protection, such as brush or riprap, should be placed at the outlet end of the culvert to prevent erosion and road undermining. and to minimise erosion caused by flow discharging; sediment traps of logs, rocks, straw bales, etc. will be required in place where high water flows are expected (see Figure 29).

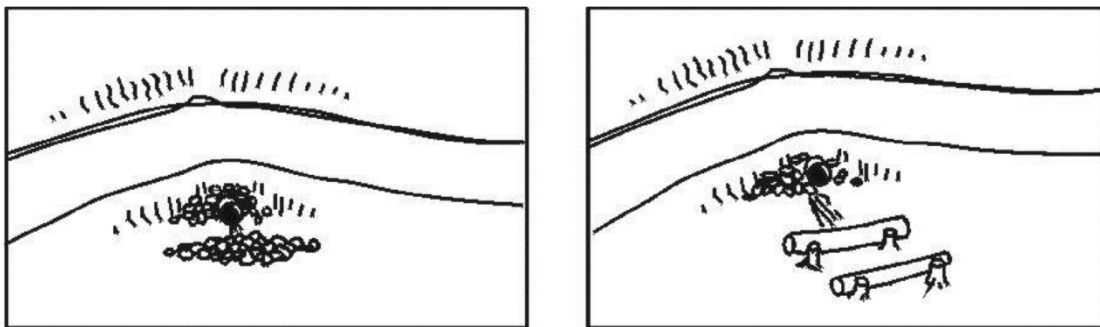


Figure 29 — protection works (riprap, logs, rocks, etc.) should be used on highly erodible terrain to limit erosion at culvert point of exit (Forest Practices Board 2000)

- Sumps should be installed at culvert inlets to minimise erosion caused by flow entering (see Figure 30).

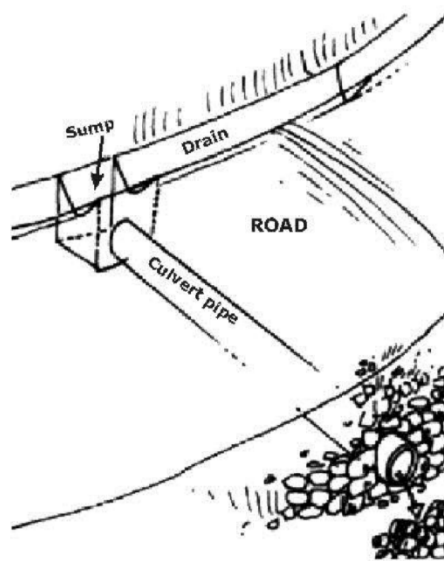


Figure 30 — Provisions at culvert inlets (sumps) and outlets (energy dissipaters) to minimise erosion caused by flow entering or discharging (Forest Practices Board 2000)

- The fill on top of a culvert should be protected by logs alongside the fill to prevent sediment from flowing into the drainage channel.
- Culverts should be set at or marginally below the level of the natural drainage channel if present.

Several structures are available for draining water across the road. These range from simple earthwork structures like open-top, wooden culverts, “bridge-type” log culverts, three-log culverts, hollow logs and pipe culverts of various materials. Road class, expected life span, and available resources will determine the materials used to make the culvert.

- Bridge-type (“Japanese”) culvert: dig a trench across the road and place two logs with a minimum diameter of 40-cm at either side of the trench. On top of the two logs, small stems or planks are placed in the direction of the longitudinal axis of the road (see Figure 31). Make sure the crosswise logs are pegged (shored) properly before placing the small logs or planks; notch small logs before placing. The construction is covered by a layer of earth.
- Hollow logs: large-diameter hollow logs can be used, always placing the narrower opening upstream to avoid plugging. Hollow logs are not suitable for

primary and secondary roads because they plug or collapse easily, but they can be used on feeder roads.



Figure 31 — Construction of a “Japanese” culvert (Photograph P. van der Hout)

- Planks: a trench is dug across the road to the required depth, and timber frames measuring 50×50 cm or 60×60 cm are placed at regular intervals of 1.50 to 2 meters along it. These frames serve as supports to planks, which are placed round the frames like shuttering. The trench is then filled with earth and compacted. These culverts can be sure of giving good service for two or three years (see Figure 32).

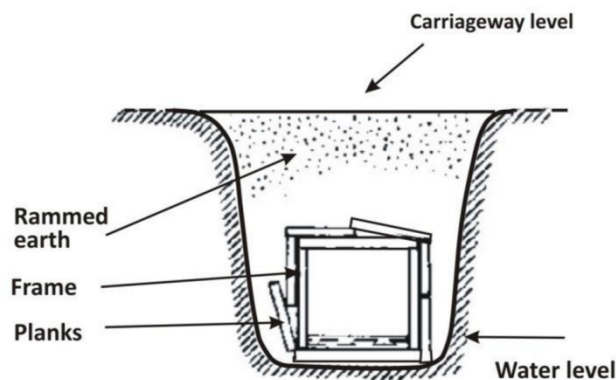


Figure 32 — When rejected boards or slabs with a reasonable amount of durable heartwood are available culverts can be constructed with such boards or slabs (FAO 1963)

5.4.6 Sunlight exposure

Evaporation from the surface of the road depends directly on the amount of exposure to air and sun. In the forest, the sun is screened by large trees bordering the roadbed. Shadows casted by such trees prevent the road from drying, particularly in the early morning. Therefore, no tree should be left standing when its crown is over a road; this causes shade on the road, and drops of water continue to drip onto the surface long after each fall of rain. The best rule is that there should be no shade on the roadbed after 10:00 a.m. between the side ditches. Any tree giving shade at that time should be felled.

- Clearing for sunlight exposure of a roadway should be done by chainsaw;
- the side exposed to the morning sun dries faster than the other side and clearing should therefore be less wide on that side;
- clearing for sunlight exposure should be wider upslope than downslope;
- an East-West road receives the necessary sunlight exposure from a narrower clearing than that needed for a North-South road;
- a roadway with clayey soil will need broader clearing than one of sandy soil; a main road should be more broadly cleared than a secondary road.

5.4.7 Canopy bridges and roadside banks

- In areas that are relatively safe from erosion or where the road does not need drying after rainfall, canopy bridges should be maintained at regular intervals as these provide uninterrupted plant cover and thus aerial passage for certain animal species.
- In addition, regular openings should be maintained in roadside verges and heaps of debris to facilitate the movement of large wildlife.

5.4.8 Weather problems

Even with a carefully prepared road construction schedule, unexpected rainstorms and can cause problems. If completion problems are anticipated, it is best to get the road to the point where, if necessary, it can be left over the rainy season. Drainage features (side ditches, culverts, and cross-drains) should be functioning by the start of the rainy seasons (mid-April and mid-November).

5.5 Road maintenance

- Regularly inspect ditches, culverts, outlets, and water bars for blockage and restore to working condition.
- Soil, vegetation and other materials that can obstruct water flow, shall be cleared from side ditches.
- Road surface maintenance should be performed as needed. Camber and cross section profile should be maintained to allow effective drainage
- Surfacing gravel or loam should not be pushed to the road edge or into drains
- Bridge decking foundations and side walls should be checked regularly
- Any debris that has been pushed into the watercourse shall be removed
- Water should flow freely under bridges
- Silt traps should be cleaned regularly

5.6 Watercourse Crossings

Table 14 — Types of Crossings

Bridges	Bridges shall be used for road crossings of all creeks. They may also be used to cross other watercourses
Culverts	Culverts should be used for crossing gullies and waterways (if bridges are not used)
Fords/low-level crossings	<p>Fords are only permitted on feeder roads. They are only acceptable if:</p> <ul style="list-style-type: none"> • Bank height is less than 1 metre • Approaches to the watercourse are less than 10% • Depth of normal water flow is less than 0.5 m • The bed is stable (gravel or sand)

	It is always desirable to corduroy fords
Corduroy with earth fill	Corduroy with earth fill is not allowed for crossing any watercourse in any situation because this would effectively block the water flow and may divert the course

5.6.1 Location of crossings

Generally, the best rule regarding stream crossings is not to have any, if possible. They can be expensive and a potential source of major environmental and water quality problems. However, if it is determined that a stream crossing is necessary, choosing the proper location is critical. Look at the stream width, water depth, stability of the stream bottom and banks, the approach topography and soils, and the high water mark. Choose a location that will minimize the chance of stream sedimentation arising from logging as well as hauling operations.

Select crossing points which:

are immediately downstream of straight and stable watercourse sections;

- have easy high bank access;
- do not require deep box cuts;
- require minimum alteration to the high bank;
- where crossing at right angles is possible;
- straight line bridge approaches for at least 30 meters are possible.

5.6.2 Temporary stream crossings for the passage of construction machinery

When road construction involves complicated stream crossings such as bridges, large culverts, and large fills, you may need a temporary crossing to get beyond the streams or drainages to excavate the rest of the road and to build the embankment and bridge approach on the other side.

Temporary crossings for the passage of construction machinery can be made by placing hardwood logs on the riverbed in the direction of the water flow:

- the width of passage should be limited to 4 m;
- passage should follow the line of the road or structure to be built;

- disruption to vegetation in the buffer zone, on river banks and along the river channel should be kept to a minimum;
- logs and accumulated debris should be removed as soon as passage is no longer needed;
- cover the logs with gravel to form a travel surface. If gravel is not available, take care to keep soil out of the stream when you remove the temporary crossing; do not allow temporary crossings to produce dams or block water-flows.

5.6.3 Earthworks during construction of stream crossings

- In the construction of roads and bridges creek beds shall not be filled in;
- During bridge construction oil, chemicals, excess concrete, or other waste shall not enter the creek;
- All earthworks shall be carried out to prevent soil from entering the watercourse;
- All spoils should be removed to outside the buffer strip or placed in road fills where possible;
- Watercourse buffer strip vegetation should be retained to the edge of the crossing.

5.6.4 Construction of bridges

Bridges span rivers and creeks with permanent flow. There are many types, depending on the span width and the required service life, but in practice a log bridge is built. The following points need to be considered:

The bridge needs to be passable in all seasons, so its deck should be at least one metre above the highest water level ever recorded to permit passage of debris in floodwater.

- The floodwater level will indicate the maximum width of riverbed and thus the length of the bridge.
- The bridge should span at least 120% of the width of the watercourse measured from bank to bank; i.e. extend beyond the creek channel by 10% on either side.
- Approaches should have a straight and level alignment for a minimum of 30 metres on either side.
- Foundations should be excavated to a solid base and not formed by pushed material.

- The stream banks adjacent to the bridge should be stabilised using wing walls of durable logs or other equivalent construction.
- Side ditches should be diverted at least 50 m before the crossing if possible; otherwise, silt traps shall be installed in side ditches at the four corners of bridges.

Abutment and cribbing

A simple log bridge has an abutment, made of one or two 70-100 cm diameter head (sill) logs placed across on firm level ground to support the stringers. Normally, however, the bridge approach is built on an embankment. Therefore the (notched) head logs are placed on a crib of (notched) round or squared logs, thus dispersing the load and reducing the pressure on the soil to an acceptable level. Where necessary, to raise the bridge deck to a higher level, or to improve the anchorage of the abutment, logs are stacked in right-angled layers (cribbing). Abutments are covered by the backfill providing access to the bridge.

- Fill retaining logs should be placed on both sides of the bridgehead before the fill is deposited to prevent the fill from collapsing or sediment from entering the watercourse.

Stringers

The superstructure of the bridge consists of stringers, joists, and decking. Stringers are support beams made of whole (notched) logs of 60-90 cm diameter, depending on the span of the bridge. Because the bridges are constructed for one-way traffic, four stringers (two on each side) are sufficient to form a 3.5 m roadway if placed under the vehicle wheel tracks.

Decking

Planks are the best and lightest material for building decks. There are usually two types of superimposed, cross-aligned deck, each serving a particular purpose:

- Joists (weight distribution deck), which are laid at right angles to the stringers, spread the carrying load equally among the superstructure. They are not connected to facilitate rainwater runoff;

- The wearing deck, also referred to as the flooring, is intended to withstand the constant wear of heavy vehicle passage and is usually made up of running planks in the same direction as the stringers.

Laterite decking

In case an earth fill is used as decking, stringers must cover the entire width of a bridge, usually 5-6 logs of 60-90 cm. The gaps between the stringers should be plugged with 2-4 cm diameter poles or sawmill slabs; the saplings or slabs are in turn covered by green litter (twigs and leaves) to prevent the fill from passing through the poles/slabs before it is compacted. Finally, the deck is formed by covering the whole structure with a layer of earth (preferably laterite). Although this technique has the advantage of being simple, it has the drawbacks that the laterite adds an extra 3 to 5 tonnes per linear metre demanding heavier (and more) stringers than a wooden deck.

- Fill retaining logs should be placed on both sides of the deck before the fill is deposited to prevent sediment from entering the watercourse.

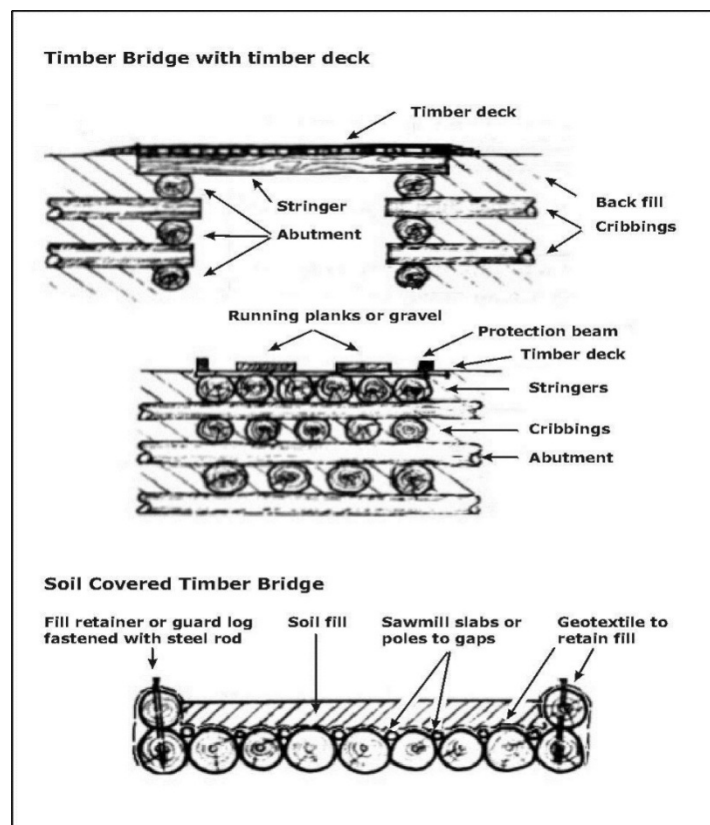


Figure 33 — Longitudinal and transverse section of a log bridge with timber deck (top) and one with earth fill (bottom) (FAO 1999)

5.6.5 Culverts for stream crossings

When installing culverts for stream crossings, the following points must be considered:

- The original and natural full bank capacity (cross-sectional area) of the channel should be maintained.
- The culvert shall be aligned and centred with the existing stream channel whenever possible. As a minimum, align the culvert with the centre of the channel immediately downstream of the outlet.
If channel excavation is required to help align the culvert, the upstream channel should be excavated to fit the culvert entrance and align the outlet with the existing natural channel. Minimal disturbance of the channel at the culvert outlet should be the priority consideration.
- Inasmuch as possible, the grade of culverts should be determined by the grade of the existing channel, but usually not less than 0.5% nor more than 1%. The outlet should discharge at the existing channel bottom.
- Keep disturbance of the channel bottom, sides, adjacent land, and surrounding natural landscape to a minimum during installation. Install energy dissipating structures at the outlet where scour and erosion are likely to occur from high exit velocity due to steep culvert installation, near proximity to channel banks, drops at the end of the culvert, etc.
- Establish and maintain at least 30-cm of roadbed cover over all culverts. A cover of 60-cm or more is desired.

Requirements for cross-drain culverts (section 6.5.5.) also apply to culverts used for stream crossings.

5.7 Log markets (Landings/Log decks)

Log markets should be constructed to facilitate log sorting and loading activities. Spacing and size of log markets depend on road density, topography, volume to be harvested, projected skid trail pattern, log size, storage time, and loading equipment used. Hence, spacing and size of log markets should be determined during the planning phase.

Remember that roads should be planned to minimise the sum of skidding and road construction impacts, which in turn will also lead to cost minimisation.

5.7.1 Location of log markets

- Log markets should be sited at such intervals to minimise the number and total length of skid trails; but should normally not be less than 250 m and not more than 1000 m apart.
 - They should be located:
 - on well-drained, gently sloping ground (1-2%) or on ridges or benches to allow for free drainage and to reduce the amount of side cutting;
 - at least 40 m from the edge of environmentally sensitive zones (viz. 70 m from the bank of a river, 60 m from the bank of a creek ≥ 10 m wide, 50 m from the bank of a creek < 10 wide or a gully), so that mud and debris do not flow into watercourses;
 - at sites that accommodate efficient skidding patterns and directions;
- Avoid concentration of run-off downslope to the landing by encouraging uphill skidding to disperse runoff into surrounding vegetation.
- Log markets should not form part of the roadway since this would lead to deterioration of the road formation and road drainage structures, except when this would significantly reduce earthworks while maintaining adequate drainage of both road and market.

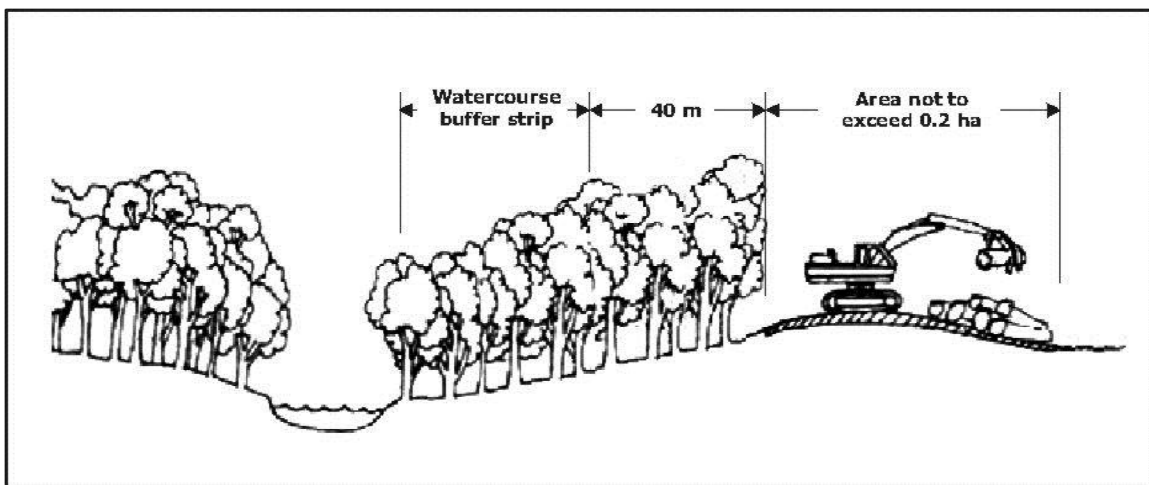


Figure 34 — Location and size of log markets (Forest Practices Board 2000)

5.7.2 Size of log markets

- The size of the log market would depend on the volume and number of logs to be stockpiled
- Landings should be large enough to accommodate trucks, the loader, and log stacking
- The market should be large enough to facilitate sorting of logs, to allow for entry (skidder) and exit (loader) points and to prevent excessive stacking of logs
- Log markets should not exceed 2000 m² (40 m x 50 m) in size, the total area occupied by markets not exceeding 0.8 ha per unit area of 100 ha

5.7.3 Log market construction

- All merchantable trees shall be felled and extracted before clearing Log markets shall be well drained. Proper drainage requires:
 - a. a domed surface to prevent ponds and mud pools
 - b. drains to channel runoff to vegetated areas; the slope of the drains should be 1-3%
- Log markets should have designated entry (skidder) and exit (log loader) points

5.7.4 Log market operations

- Mud and water shall be prevented from entering log markets from skid trails or roads
- Skid trails should therefore approach landings from below to avoid directing runoff of water to the landing
- Minimize skidding across the roadway because this would lead to deterioration of the road formation and drainage structures such as side ditches
- Avoid the use of heavy machinery on saturated soils to minimise erosion, ponding, rutting, mixing and compaction of the soil
- Avoid hauling on wet roads to minimise erosion, ponding and rutting, and deterioration of the road formation
- Debris and waste should be placed so as not to restrict drainage of the landing

5.7.5 Post-harvest restoration

- The surface of log markets should be restored to its original state to allow proper drainage:
 - a. Drain areas where water may pond.
 - b. Install drains with a gradient of 1-3%
- Bark and debris should be disbursed evenly across the site to assist in stabilisation
- All refuse and waste shall be removed from the log market; including oil- and fuel drums, broken wire rope, containers, etc.

5.8 Borrow Pits

Forest roads are typically built from local materials that must support heavy logging trucks and should have a surface that, when wet or when extremely dry, will provide adequate traction for vehicles. In many cases, the native soil material is too soft, too unstable or impossible to compact (such as white sand). Surfacing both improves structural support and reduces road surface erosion. Laterite, loam and white sand are the most common improved surface materials used.

Use of local material sources, usually borrow pits, can produce major cost savings, compared to the cost of hauling materials from distant sources. Typical borrow pits can have major adverse impacts, including sediment discharge from a large denuded area and impacts on wildlife. Thus borrow pit planning, location and development should be done with care.

- Extraction of laterite, loam or white sand from road cutting areas during the formation of the road is preferred to the development of large borrow pits
- All merchantable trees shall be harvested on the proposed borrow pit site
- Catch drains should be constructed around the uphill side of the pit to prevent runoff entering the area
- The face of the pit shall be maintained in a stable condition at all times – recommended steepness of the slope cut is ½:1 (maximum steepness ¾:1)

6 LOGGING OPERATIONS

Properly planned and executed logging operations, which include pre-harvest forest inventory; application of tree marking rules; marking (and constructing) skid trails before felling; and directional felling, can mitigate most of these impacts. Proper felling techniques (directional felling and proper crosscutting) will reduce splitting and breaking of logs, and hang-ups, thereby increasing volume recovery and improving felling efficiency. Efficiency of skidding is greatly enhanced by pre-constructing skid trails and aligning logs for easy extraction.

6.1 Controlled felling

6.1.2 General requirements related to felling

- Respect general felling restrictions as prescribed in section 5.4.5.
- Respect restrictions related to protected trees as prescribed in section 5.4.6.
- Trees showing signs of decay at their base need to be probed by machete or chainsaw (with a vertical plunge cut).
- The decision to fell and the selection of felling direction are up to the feller who cannot be obliged to fell a tree he considers dangerous.
- Appropriate directional or controlled felling techniques shall be applied.
- Once sawing of a tree has started, that tree should be felled completely, also when it is unsound.
- Stump height should be as low as practicable to maximise merchantable timber volume, but at least less than 30 cm from the ground, or in the case of a buttressed tree less than 10 cm above the top of the buttresses except to avoid unmerchantable timber.
- Stump heights over 30 cm are acceptable:
 - where butt defect is obvious; or
 - in case of a buttressed tree, stump height should not be higher than the point at which buttresses can be trimmed to provide a diameter equal to that immediately above the buttressed section

- When it is not appropriate to trim the buttresses the tree should be cut immediately above the buttress
- While bucking or topping, the stem should be cut completely (especially at the top and when the log is crosscut into two blocks) to avoid damage to the log during extraction and to facilitate easy extraction.
- Avoid losses of merchantable timber by maximizing log length, consistent with the highest value - usually this point is at the first heavy branch or a top diameter of 20 cm.
- Buttressed, knots and branches should be cut flush with the stem:
 - to maximize quality and volume of the merchantable timber for each tree;
 - to minimize soil disturbance and skidding resistance during extraction.
- The felling of species that deteriorate quickly after felling due to drying shakes or fungus (such as Simarupa, Wadara, etc.) should be postponed until extraction commences so that they can be handled with priority.

6.1.3 Felling preparations

After reaching a tree, checking, and recording its harvest number, which should be marked on the trunk or attached tag - the feller has to carry out certain observations and actions regarding the tree and its immediate vicinity in order to:

- a. Decide whether to fell the tree or not
- b. Determine the direction of fall
- c. Make escape routes

The final decision to fell and the selection of felling direction are up to the feller who cannot be obliged to fell a tree or to fell it in a direction that he considers dangerous. The feller has to identify potential crop and otherwise protected trees marked by the tree marking crew and decide how to avoid damaging them.

The direction of fall should be determined by balancing the preferred direction of fall with the natural lean of the tree.

To determine the preferred direction of fall, the following points should be considered simultaneously:

- the felling direction should not pose any danger to the chainsaw operator or crewmembers;
- trees should not be felled into watercourses or their buffer zones;
- trees should not be felled down steep slopes;
- potential crop trees and protected trees should not be killed or damaged;
- trees should not be felled across obstacles such as felled, fallen or dead (takuba's) tree trunks, rocks, etc.;
- trees should be felled in a position that facilitates skidding (winching);
- trees should not lodge in neighbouring trees (hang up);
- trees should be felled into existing canopy gaps (natural or by felling) when present.

Normally, it is not possible to satisfy all the requirements mentioned above and the feller will need to find a compromise which best satisfies most requirements.

To determine the natural lean, the following points should be considered:

- Whether the tree is standing straight (trunk perpendicular and not off plumb).
- the estimated gravity centre of the crown (weight distribution within the crown in relation to trunk axis);
- the position of heavy branches;
- presence of any (small) defects in the buttress;
- any attachment to the crown of a neighbouring tree by liana;
- presence of any hangers (widow makers, dead branches) in the tree to be felled or in neighbouring trees;
- Wind direction and speed.

Where the preferred direction of fall deviates significantly from the natural lean of a tree, directional felling without auxiliary means will be extremely difficult. In such cases, “controlled” felling must be applied. Controlled felling means that the tree has to be harvested:

- in the safest possible manner for the crew;
- for the efficient recovery of the felled timber;
- With as little damage as possible to the remaining stand and soil; for greatest ease of subsequent log extraction.

6.1.4 Directional felling

Directional felling is defined by the application of (Figure 35):

1. Directional notch ("scarf", "belly")
2. Back cut (felling cut).
3. Hinge (holding wood, "key").

The first two cuts create the directional notch and are made on the side the tree should fall. After the directional notch has been cut out, the back cut is made on the side away from the planned direction of fall and slightly above the bottom of the notch. However, the cuts must not meet. Some holding wood must be left uncut between the directional notch and the falling cut. This is the hinge on which the tree swings when it falls and is the key to steering the tree in a chosen direction.

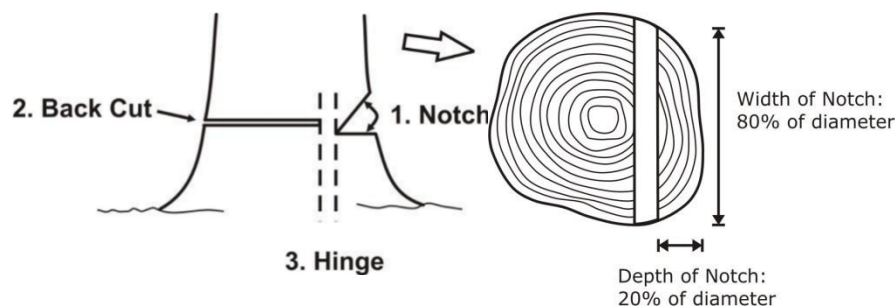


Figure 35 — Basic cuts for directional felling (Forest Operations Institute of Sweden 1984)

Functions of the notch:

- Determines the direction in which the tree will fall;
- Controls tree during fall (allows smooth steady fall of tree); Serves as a means of breaking holding wood; Helps to prevent tree from splitting up.

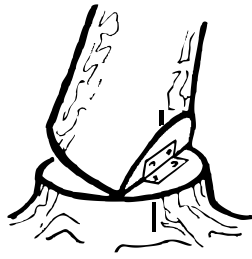


Figure 36 — The hinge is key to steering the tree in the chosen direction (Forest Operations Institute of Sweden 1984)

The direction of fall of the tree is determined by the front edge of the hinge or, in other words, by the way in which the notch is cut (Figure 36). Consequently, if the notch is oriented incorrectly, this cannot be compensated for by leaving one end of the key thicker than the other end.

The back cut should be 2.5 cm to 5.0 cm (1-2 inches) above the level of the base of the notch; thereby:

- Providing a step, which prevents the tree slipping backwards over stump;
- preventing damage to the butt log through splinters being torn out of log or stump (barber chair).

The felling team should be equipped with a properly functioning and well-maintained chainsaw including felling aids such as aluminium alloy wedges, a mallet and a cutlass.

As far as possible, trees should be felled in such way that the direction of fall is at an angle of 30°-60° relative to the skid trail (alignment) with the crown away from the skid trail (see Figure 48).

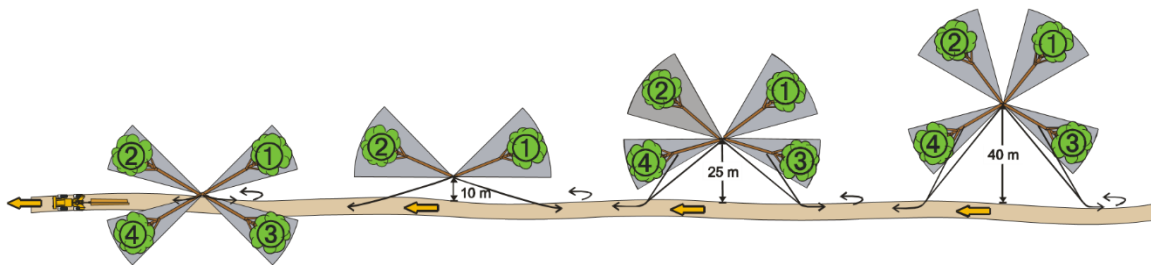


Figure 37 — The felling direction should make an angle between 30 ° and 60 ° with the (projected) skid trail, wherein four possibilities exist (1 = first preference, 4 = least

preferred); the exact direction will depend on the distance from the tree to the trail. (Forestry Training Centre Inc 2004)

Practical felling guidelines are given in Appendix 4.

6.2 Topping, cross-cutting and trimming

6.2.1 Topping

The crown should be separated from the trunk at the felling site. Crown removal or topping is normally done under the first large limb. It can be done:

- by the feller himself immediately after felling,
- by a special crew operating a few days or several weeks after felling, as dictated by the species (some loggers prefer this practice which allows the tree to settle before extraction, to release sap pressure and thus to eliminate or reduce the internal tensions that can trigger splitting), or
- at the time of extraction by a chainsaw operator working alongside the skidding crew.

In the case of delicate species, the work has to be aligned with the extraction to reduce the risk of insect or fungal attack and thus avoid chemical treatment or splits due to drying.

6.2.2 Butt trimming

The stem base is trimmed whenever its weight or shape could hamper extraction. Butt trimming takes place at the same time as topping. It is not necessary if the buttresses have been cut flush before felling or when the operator removes them before skidding to facilitate movement and recover an extra section of timber.

6.3 Skid trail construction

6.3.1 Opening of skid trails

The skid trail layout was already planned and marked on the ground by cut lines and ribbon or paint marks when preparing the harvesting area. Main skid trails should be

established before felling, while secondary trails can be laid out afterwards, provided they have been pre- marked.

- It is strongly recommended to open skid trails by bulldozer so as to create straight skid trails;
- Skid trails on the flank of steep slopes shall be constructed by bulldozer because blading is required for safety reasons;
- Blading is not allowed if the slope gradient is less than 20%;
- Skid trails should preferably be constructed in dry weather;
- The width of the trail should not exceed 4 metres;
- Maximum hill slope for side cutting along the contour is 60%;
- Side cutting is not allowed on minor trails (minor trails should not follow the contour but run straight up and down slopes);
- Box cuts through hill tops are not allowed; instead the trail should be contoured;
- Using the bulldozer the operator follows the markings along the skid trail alignment, and opens up the trail, with the blade raised (see Figure 38);

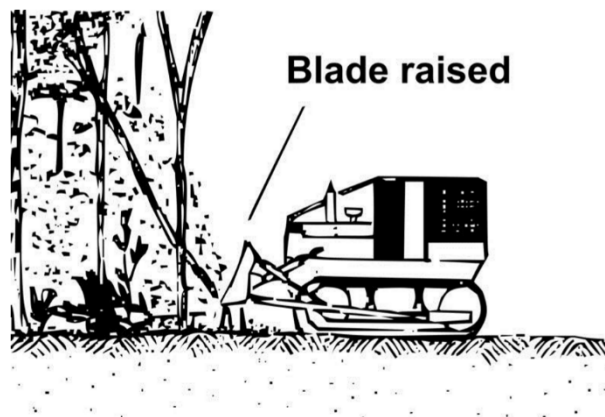


Figure 38 — Open the trail with the blade raised and without scraping the topsoil

- Obstacles such as (large) fallen (dead) tree trunks should have been cut during skid trail preparation, thereby making removal of these trunks easier, mitigating damage inflicted to the vegetation and soil, increasing productive machine time and reducing wear and tear (see Figure 39).

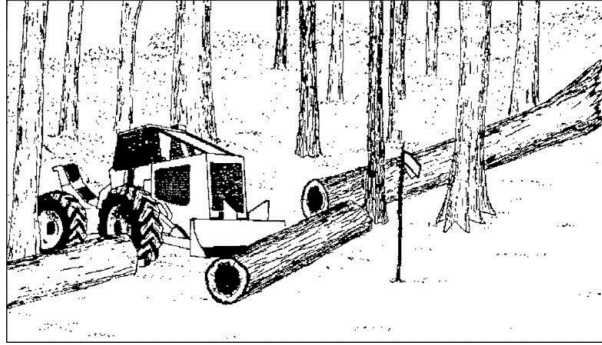


Figure 39 —Large fallen (dead) tree trunks should be cut before skid trails are opened

6.3.2 Watercourse crossings

Crossing streams with ground-based equipment may cause unacceptable disturbance, and must be strictly controlled. Temporary bridge crossings may provide one method for crossing the stream within allowable disturbance limit (see Figure 40).

- Watercourse crossings shall be indicated on the harvest map;
- Skid trails should not cross any creeks, except where the streambed is shallow with a solid (rocky, gravel) bottom
- Select crossing points of gullies and waterways in places where:
 - a. bank slope is less than 15%
 - b. the bed is firm
- Skid trails shall cross waterways and gullies at right angles with straight approaches of at least 10 m on either side

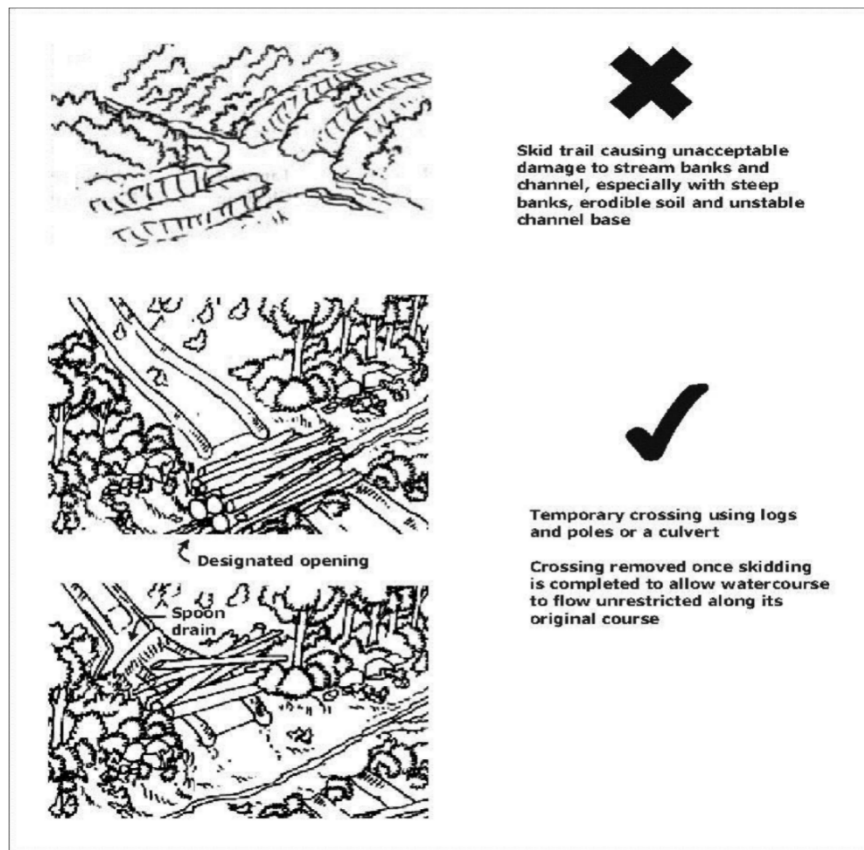


Figure 40 — Temporary crossings for (intermittent) stream and gullies (Forest Practices Board 2000)

- Temporary crossings (log culvert with corduroy) shall be provided to cross gullies in any situation, and waterways if water is flowing at the time of operation
- Crossings should be constructed in dry weather
- Width of the crossing should be less than 4 metres. Buffer strip vegetation shall not be disturbed otherwise
- Use non-commercial logs for crossings where appropriate
- Abutments, if present, and approaches should be higher than the stream banks
- Soil should not be pushed:
 - a. past the high bank
 - b. into watercourses

- c. onto the top of a crossing
- Corduroy with earth fill is not allowed because this would effectively block the water flow and may divert its course
- Crossings shall be removed after completion of the operation. Crossing material should be placed more than 10 metres away from the high bank
- Removal should not disturb the watercourse banks

6.4 Skidding

- Skidding in high-risk areas - those with fine-textured soils, poor drainage, and low gravel content - should be avoided during wet weather.
- Avoid wet spots, springs, and drainage channels as skid trail locations. Depending on rock sizes, rock outcrops and rocky places generally are damaging to tracked and rubber-tired vehicles.
- Logs should be winched the maximum distance possible, to reduce soil disturbance associated with skidding, especially within canopy gaps.
- Winches shall be fitted to the machine with wire rope with a preferred length of 45 m and a diameter of 19 mm (3/4 in.); maximum diameter for wire rope is 22 mm (7/8 in.) and the minimum length of 30 m.
Blading of skid trails on slopes < 20% slope should be avoided.
- Skidder and tractor blades shall be raised when opening skid trails, travelling empty and laden; blades should only be lowered to restore rutted trails (when returning empty) or to serve as an anchor when winching.
- Slash on skid trails should be retained to cushion the effects of compaction. However, it may present traction problems for rubber-tired skidders. Tire damage may result also from limbs, knots, chunks, etc.
- When the skidder leaves the skid trail to collect a log, it should reverse towards the log and follow directions by the hooker or choker setter.
- Machines used for ground-based skidding operations should be equipped with an integral arch to lift one end of the log off the ground to avoid soil damage and to reduce skidding resistance.

- Logs should preferably be lifted at the bigger (butt) end to reduce skidding resistance, increase ground pressure on the rear of the machine (hence enhance machine traction), improve fuel efficiency and reduce drag on the skid trail, thereby minimizing the creation of pathways for water to accumulate and flow (see Figure 41).

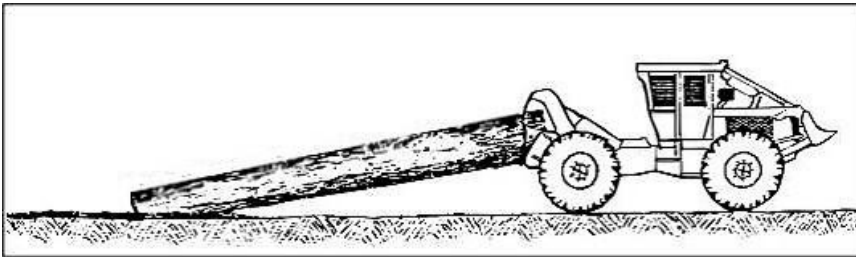


Figure 41 — Logs should preferably be lifted at the bigger end to reduce skidding resistance and increase machine traction

- Avoid unnecessary damage to soil and standing trees and regeneration along skid trails, particularly of marked potential crop trees and other protected trees.
- Slash should be left in the skid trail when the unit is logged from the end of the skid trail toward the landing, rather than starting near the landing first. Slash will accumulate on the trail behind the skidding operation.
- The capacity of the skidder should be exploited to its full potential to enhance cost-effectiveness of the operation. This also applies if the distance to the log market is short; it may seem to save time if logs are extracted one by one when the distance is short, but total fuel consumption will be higher.
- Crosscut long logs (>15 m) to reduce skidding damage consistent with highest value of merchantable logs.

Spinning wheels or tracks on adverse skids can cause soil damage that can lead to increased siltation as well as increase fuel consumption and wear and tear on the machine. As soon as wheels start spinning the load should be dropped and logs winched ahead once the machine has travelled through the difficult spot (see Figure 42)

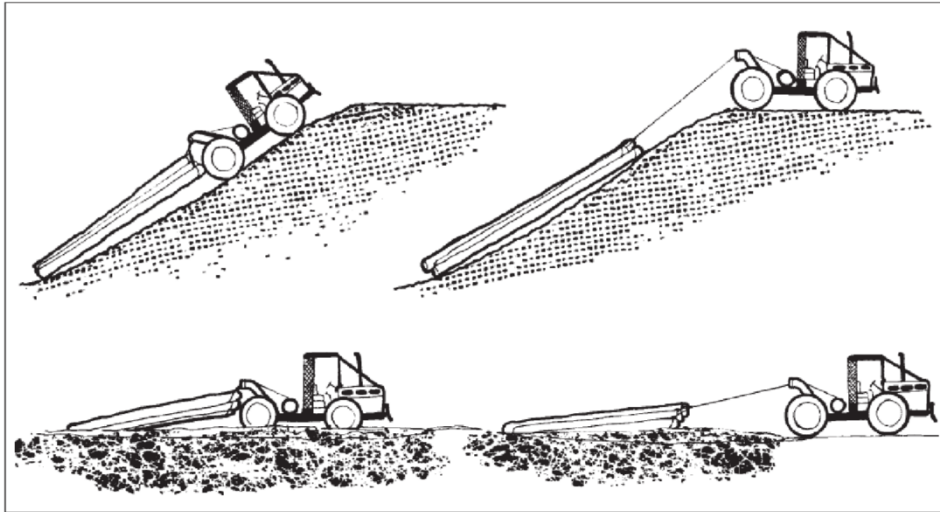


Figure 42 — Steep slopes and muddy areas often necessitate moving the wheeled skidder forward, then winching the logs to the skidder (Oregon State University 1983)

Winching

- When positioning the skidder for winching, keep the angle of pull as small as possible;
- Winch slowly at severe angles for better laying of the mainline on the drum;
- Watch the mainline as it is wound onto the winch drum, as this is when damage to the mainline usually occurs;
- Operate the hydraulic articulated steering slightly to change the winching angle as the mainline is winding onto the winch drum;
- After the log has been winched a short distance, a smaller winching angle might be attained by repositioning the skidder;
- Do not impact-load the mainline. It is a very dangerous practice and seriously damages the machine.

6.5 Weather limitations on logging operations

6.5.1 Felling

Felling should cease when:

- wind force prevents accurate and safe directional felling

- ground conditions are too slippery to allow the felling crew to move safely and quickly away from the falling tree
- extraction or hauling is not possible due to weather and/or soil conditions

During short period of inclement weather, felling should be limited to ensure volumes cut at any one time can be promptly skidded and hauled

6.5.2 Road construction and skidding

Skidding and road construction operations should normally cease for the day when rain starts to fall, particularly when logging on fine-textured soils, such as loams and clays, or on moist soils or slopes. Skidding should definitely be halted for the day under the following conditions:

- soils are saturated and turbid water or mud is flowing down a skid trail or road for more than 10 metres; or
- soils become rutted to a depth of more than 50 cm below the original ground level over a section of 20 metres or longer; or
- sludge or slurry is present on a skid trail or road to a depth of more than 20 cm over a 20 m section or longer; or
- turbid water or mud is flowing from a skid trail or road into a watercourse; or
- blading of mud or soil is necessary to maintain trafficability of a skid trail or road

The affected section of the trail or road should not be by-passed by opening up a new trail/road alongside or close by if on similar saturated ground conditions as long as the rainy weather conditions persist.

6.5.3 Log market operations

Construction or operations on log markets should normally cease for the day when rain starts to fall, particularly when log markets are located on fine-textured soils, such as loams and clays. Loading should definitely be halted for the day under the following conditions:

- water is ponding on the surface of the log market; or
- soils are rutted to a depth of more than 30 cm over more than 50% of the market area

6.5.4 Trucking

Trucking should normally cease for the day when rain starts to fall, particularly when trucking on fine-textured soils, such as loams and clays without laterite surfacing and slopes. Trucking should definitely be halted for the day under the following conditions:

- trucks cannot move unassisted along the roads because of slippery conditions; or
- turbid water, slurry or mud runs in wheel ruts, which are more than 10 cm below the road surface, for a length of 20 metres or more

6.5.5 Recommencement of operations

Soils need to be allowed to drain after heavy rainfall events before forest operations recommence.

7 POST-HARVEST ACTIVITIES

Rehabilitation of logged areas is required to prevent further deterioration of the logged area and downstream soil and water values, and to encourage forest regeneration. All areas should be left in a clean and tidy condition.

7.1 Block closure

- Blocks should be closed once logging has been completed.
- Blocks that have been harvested in a specific year without their maximum allowable cut (MAC) having been achieved (usually at the end of the year) may be resubmitted and re-approved for another year for the continuation of harvesting activities (i.e. the block is not closed), under the condition that the harvestable quota for these blocks be limited to the remainder of the volume that was granted in the first instance/approval.

7.2 Roads and skid trails

7.2.1 Cross-banks or water bars on decommissioned roads and trails

Construction of cross-banks or water bars at regular intervals along forest roads and tracks is an effective control of overland flow, sediment movement and soil loss (see Figure 43). These features do not need to be great tall mounds and are designed primarily to divert track runoff onto adjacent terrain to promote infiltration and sediment deposition. Other techniques of slowing water flow rates on roads and trails include logging debris or siltation barriers (see f

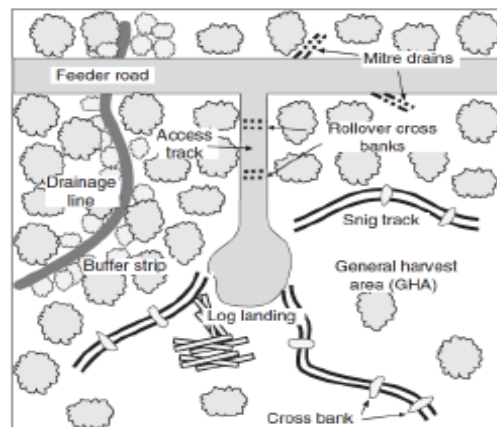


Figure 43 —Range of sediment and runoff sources within a typical logged forest. Priority should be given to high runoff and sediment production areas such as roads and skid trails (Elsevier 2004)

Figure 44 — Siltation barriers on skid trail made from sawmill waste (Photograph P. van der Hout)

- To divert water from the road and skid trail surface, water bars should be constructed according to the spacing in Table 15, and build the water bar according to Figure 45.

Table 15 – Water bar spacing guide

Road grade %	Soil type		
	Loam or sand (m)	Clay (m)	Laterite (m)
2	275	300	300
4	175	250	300
6	150	175	300
8	125	150	275
10	100	125	250
12	50	125	225
15	50	100	150
20	50	50	100
25+	25	50	50

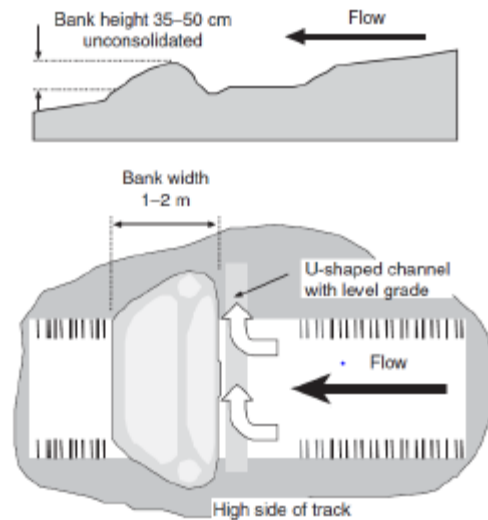


Figure 45 — Water bar construction (Oregon State University 1983 & Elsevier 2004)

7.3 Roads

- Once the annual coupe has been completely harvested, including all felling blocks that form part of the annual coupe, all roads (secondary or spur roads) that provided access should be closed by means of a physical barrier, e.g. by digging a trench or piling a few large logs across the road (make sure that the barrier extends beyond the roadway – see Figure 46).
- The road surface should be left in good condition so the road can be reopened when required and erosion and sedimentation of creeks is prevented. There should be no ruts in the surface, the road surface should be crowned - camber should be 2-4% - and without rills or gullying.
- Cross-drain culverts should be removed and the original drainage channel restored, to prevent culverts from becoming plugged or collapse thereby blocking the drainage system.
- Culverts used for stream crossing and temporary bridges on decommissioned roads should be removed to ensure unobstructed water flow.
- Side ditches, outlets and cross-drain culverts drainage that will not be removed shall be left in good working condition.
- All bridges and culverts that will not be removed shall be properly checked for faults, including decking foundations and soil retainer logs and wing walls.
- All debris that has been pushed into the watercourse shall be removed.

- Water should flow freely beneath all bridges or through all culverts that will not be removed.
- Clear all silt traps/sumps.



Figure 46 — Road barred by means of a trench dug across the road (Photograph P. van der Hout)

7.4 Skid Trails

- Temporary skid trail crossings of (intermittent) streams and gullies shall be removed after completion of the operation.
- Removal should not disturb the watercourse banks
- Place material at least 10 metres away from the watercourse
- Where skid trail are rutted to a depth of more than 30 cm below the original grounds level, over a section of 20 m or longer, the skid trail should be restored by blading and construction of outlets
- Where a watercourse is diverted onto a skid trail at a crossing point, action shall be taken to restore water flow to its original watercourse

8 OPERATIONAL HYGIENE

Not maintaining a clean and tidy operation is a sign of poor worker attitude, careless management and disrespect for the environment.

8.1 Workshop Facilities

- Locate workshop facilities at least 100 m away from any watercourse or water body
- Workshops, garages, schools and community centres and as far as practicable all other buildings must be approved by the relevant authority prior to its use.
- Electrical wiring and accessories in any building or structure shall be approved by the competent authority.

8.2 Field Servicing and Maintenance

- Field fuel cisterns, fuel and oil drums, fuelling, refilling hydraulic and lubricant in the field and maintenance areas are only allowed:
 - a) in well-drained areas such as log markets or road junctions
 - b) outside areas excluded from harvesting and their buffer strips
 - c) more than 100 m away from any watercourse

Figure 47 — Suitable equipment should be used for the refuelling of vehicles and machinery (Photograph P. van der Hout)

- Care shall be taken to prevent spillage during refuelling or repairs; adequate equipment – e.g. hand pumps, cistern with fuel pump – should be provided and used (see Figures 47 and 48).
- Sump oil shall not be dumped in the harvesting areas, but collected and removed to the main disposal facility
- All containers used in the transport, storage and use of toxic materials shall be leak proof, marked as “hazardous” and clearly labelled with the contents’ name.

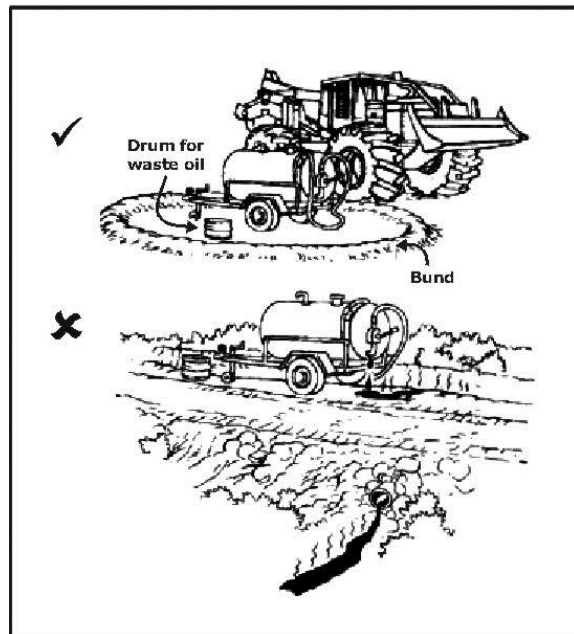


Figure 48 — Care shall be taken to prevent spillage during refuelling in the field; equipment maintained to minimise leaks (Forest Practices Board Tasmania 2000)

8.3 Fuel, Oil and Hazardous Chemical Handling and Storage

- Hydrocarbons (fuels, lubricants, oils, etc.) shall be appropriately stored, transported and disposed of according to the environmental permit.
- The GFC shall be notified and give approval before a company starts using any pesticide or preservative in or near the forest. The company must obtain the relevant “Chemical Technical Data Sheet” and submit a copy to the GFC as part of the annual plan.
- Chemicals shall only be used when necessary to achieve defined management aims described in the Management and/or Annual Plan, or subsequently approved by the GFC, and in accordance with the manufacturer’s instructions.

- The types of chemical to be used, concentrations and application levels shall be specified in the Annual Plan.
- Locate main fuel, oil, and hazardous chemicals storage:
 - a) in a well-drained area at least 100 m from any watercourse; and
 - b) no closer than 100 m to any habitation
- Drains shall be directed to a closed, stable and flood free disposal pit, situated at least 50 m from a watercourse or water body
- Fuel, oil or hazardous chemicals shall be stored in a locked, dry, well-ventilated storeroom. Wet products are to be effectively separated from dry products. All entrances are to be clearly marked with a sign reading “warning – hazardous chemical storage - authorised persons only” or equivalent
- Containers shall not be stored on the floor, but are to be elevated above the floor on pallets or other means, to allow regular inspection and rapid identification of leaks
- Concrete bunds (firewalls) with a capacity of twice the storage capacity of the largest storage container shall be installed around all storage facilities to prevent spills and reduce fire hazard (see Figure 49).



Figure 49 — Fuel tanks must be placed within a concrete bund to prevent spills and reduce fire hazard (Photograph P. van der Hout)

- Access to the storerooms of fuel, oil or hazardous chemicals should be restricted to authorised personnel

- Smoking is not allowed in or adjacent to any storeroom of fuel, oil or hazardous chemicals.

8.4 Waste Management

- Toxic substances include (spent) hydraulic fluid, coolant, lubricants, fuel gasoline/diesel/kerosene), industrial cleaners, paints and resins, preservatives (including timber treatment chemicals), distillates, insecticides and herbicides, and workshop waste, waste oil and contaminated sludge
- The use of toxic substances should be minimised and wherever possible biodegradable substitutes used
- Solid and fluid waste should be segregated, collected in (securely sealed) containers and either dumped at a designated disposal facility, returned to the supplier or buried in an appropriately lined waste pit (see Figure 50)



Figure 50 — Waste segregation and removal (Photograph P. van der Hout – Cameroon)

- Biodegradable solid waste should be buried and covered with at least one (1) m of soil
- Provide sullage pits for fuel and oil waste. Sullage pits are to be constructed so that:
 - a) they are at least three(3) m above the groundwater table
 - b) runoff water does not enter
 - c) they are at least 100 m from a watercourse or water body
- All waste pits should be covered with at least one (1) m of soil and located at least 100 metres from any watercourse or water body and at least one (1) m above the groundwater table. Signs should be erected identifying the waste pits

- Excess chemicals shall be either removed from the forest or chemically treated (neutralized)
- Empty containers should be safely disposed and not reused
- Toxic materials shall never be disposed of into watercourses or lakes. Equipment used for applying chemicals shall not be washed in watercourses.
- All refuse introduced to the forest e.g. pieces of wire rope, packing material, bottles, containers, etc. shall be removed from the forest, segregated placed , collected in containers and either dumped at a designated disposal facility, returned to the supplier or buried in an appropriately lined refuse pit, buried and covered to a level surface.

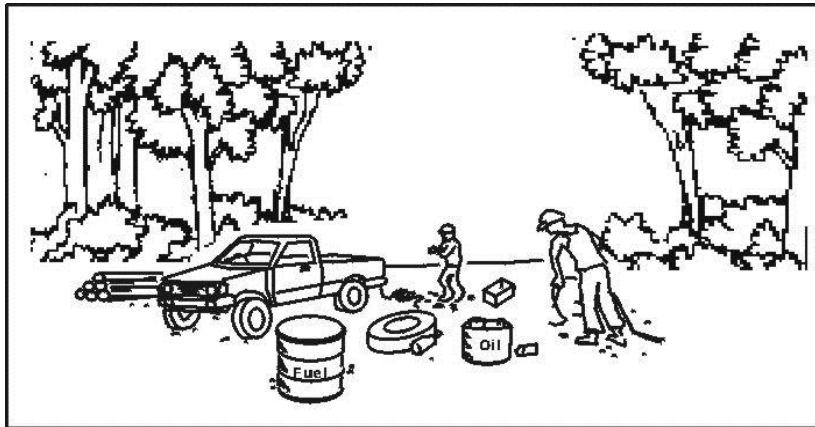


Figure 51 — All rubbish, such as piece of wire rope, plastic wrappings, fuel and oil drums, and oily rags should be removed from the forest (Forest Practices Board 2000)

- Fuel and oil drums, used oil filters, oily rags, empty grease gun cartridges, worn machinery parts, paint tins, etc. shall be removed to a designated disposal area; or returned to the supplier
- Discarded machinery shall be removed to the base camp.

9 CAMP HYGIENE

9.1 Water supply and domestic waste water

- Camps are to be supplied with potable water obtained from running streams, rainwater, or wells.
- Water storage tanks should be properly screened to prevent the breeding of mosquitoes.

9.2 Waste and refuse disposal

- An adequate number of plumbed toilets or pit latrines (one per household) shall be provided; plumbed toilets should drain into a septic tank.
- Pit toilets shall be located at least 100 m away from watercourse and water bodies
- Sewage shall be discharged so it does not enter:
 - a) the catchments of drinking water supplies or intakes
 - b) into a stream
- Sullage shall be directed to a disposal area (or septic tank) at least 20m away from the nearest building
- All drains (sullage and sewage) should be kept covered
- Provide refuse disposal areas:
 - a) in pits that are above the groundwater table
 - b) where runoff water cannot enter
 - c) at least 100 metres away from watercourses, habitation or farmland
- Cover refuse with soil to depth of 30 cm at least once per week

9.3 Water ponding

- Camp areas shall be well-drained so that water does not pond or create mosquito breeding areas
- The camp shall be checked regularly for any areas where stagnant water can accumulate

10 HEALTH AND SAFETY

Forest operations are hazardous. At every step in the logging process, from felling the tree to transporting it to the mill or yard, workers are subject to a variety of hazards from the environment, type of work, equipment, and physical and emotional strains. Still, many forest workers either are not fully trained or approach their tasks with a risk-taking attitude. While some hazards and risks as well as unsafe worker actions are difficult to control, most can be controlled, reduced, or eliminated. Not every accident or injury will be prevented, but proper safety and loss control management will minimize many risks and injuries. Safety at work is not only an ethical imperative, but it also makes “dollars and sense”, by reducing e.g. sick leave, medical bills and down time.

Nearly all logging accidents can be prevented with a strong and consistent commitment to safety by concessionaires, supervisors, and workers; mandatory use of appropriate personal protective equipment; periodic, frequent safety training for all workers; close supervision of new and/or inexperienced workers, zero tolerance for violation of safe working rules; and a healthy dose of common sense.

10.1 General rules of health and safety

10.1.1 Responsibility for safety

1. Every concession holder shall, in carrying out activities under the logging permit, provide, in accordance with the Occupational Safety and Health Act, Cap. 99:06, for the occupational safety and health of workers involved in those activities a safe work environment and enforce safe work practices.
2. Each employee shall be held responsible for performing all work in a safe manner so that injuries to that person and to others will be avoided.
3. Employer, supervisor, employee, or designated person shall instruct new employees in safe practices.
4. Employees shall be familiar with the location and use of all safety, emergency care, and fire suppression equipment located at the jobsite.
5. An employee shall notify his employer or supervisor before attempting any work, which, in the employee's opinion, appears hazardous beyond normal operating conditions.
6. An employee shall report all injuries to his employer or supervisor without delay, regardless of the nature of the injury.
7. Good housekeeping of all work areas and equipment shall be practiced.

10.1.2 Legal requirements pertaining to health and safety

1. Where not less than fifty persons are employed on any woodcutting grant, the lessee shall employ thereon a sicknurse and dispenser registered under the provision of the Medical Service Act unless there is a Government hospital or dispensary within 10 miles of such grant;
2. Access to basic medical facilities should be guaranteed to workers and families where they are accommodated on-site;
3. The employer shall keep, maintain and make available to workers in the workplace, in a location that is readily accessible, a medicine chest with contents as prescribed, and shall ensure that first aid, including trained personnel, is available at the workplace;
4. A joint workplace safety and health committee is required or at least one safety and health representative from among the workers at the workplace who does not exercise managerial functions;
5. It is the function of the joint safety and health committee to:
 - a) identify situations that may be a source of danger or hazard to workers;
 - b) make recommendations to the employer and the workers for the improvement of the health and welfare of workers;
 - c) recommend to the employer and the workers the establishment, maintenance and monitoring of programmes, measures and procedures respecting the safety of workers;
 - d) obtain information from the employer respecting-
 - i. the identification of potential or existing hazards of materials, processes or equipment; and
 - ii. safety and health experience and work practices and standards in similar or other industries of which the employer has knowledge.
6. The employer shall prepare and review at least annually, a written occupational safety and health policy in consultation with the committee or safety and health representative, if any, or a worker selected by the workers to represent them and develop and maintain a programme to implement that policy;
7. The employer shall ensure that -
 - a) the equipment materials and protective devices and clothing as prescribed are provided;
 - b) the equipment, material and protective devices and clothing provided by the employer are suitable and adequate and maintained in good condition;

- c) the equipment, materials and protective devices and clothing provided by the employer are used as prescribed;

8. The employer shall further-

- a) provide information, instruction and supervision to a worker to protect the safety and health of the worker;
 - b) provide and maintain a safe, sound and healthy and secure working environment as far as reasonably practicable;
 - c) ensure that the workplace, machinery, equipment and processes under his control are safe and without risk to safety and health as far as is reasonably practicable;
 - d) ensure that, as far as reasonably practicable, the chemicals, physical agents and biological agents under his control are without risk to safety and health when the appropriate measures of protection are taken;
 - e) carry out such training programmes for workers, supervisors and committee members as may be prescribed;
 - f) provide to every worker, training on the safe and healthy manner of carrying out his work;
 - g) ensure that a worker exposed or likely to be exposed to a hazardous physical agent receives, and that the worker participates in such instruction and training as may be prescribed
- Supervisors shall ensure that a worker:
 - a) works in a manner and with the protective devices and clothing, measures and procedures as prescribed;
 - b) uses and wears the equipment, protective devices and clothing that the worker's employer requires to be used or worn
 - A register of all workplace accidents and injuries shall be kept by the employer and appropriate investigations conducted;
 - Where any accident arising out of and in the course of the employment of any worker occurs and causes loss of life to such worker; or disables such worker, for more than one day, written notice of the accident shall be sent by the employer to the Occupational Safety and Health Authority and the safety and health committee, safety and health representative or trade union, if any;

10.1.3 Personal conditions

1. Any employee who has intoxicating substances in his possession, uses them on the job, or reports to the jobsite under their influence shall be removed from the jobsite immediately and shall be subject to appropriate disciplinary action by the employer.
2. Indulgence in practical jokes, horseplay, scuffling, and other actions deemed unsafe by the employer are forbidden.
3. Employees shall observe and adhere to all relevant employer operations and safety policies.

10.1.4 Employment of minors

Logging operations are rated as hazardous occupations. No child shall be employed in any logging operation, or in any business trade or process ancillary to the logging operation. No one under 18 years of age should be employed or allowed to work on or near any phase of a logging operation.

10.1.5 Weather conditions

Work shall be terminated and employees moved to a place of safety when environmental conditions such as but not limited to electrical storms, high winds, heavy rain, dense fog, fires, mudslides, and darkness may endanger employees in the performance of their jobs.

10.1.6 Training

1. Every worker in a forestry operation must receive the training necessary to safely perform the worker's duties.
2. The employer shall provide training for each employee, including supervisors, at no cost to employees.
3. Current employees assigned new work tasks, tools, equipment, or machines and new employees prior to starting work shall be trained immediately in at least the following:
 - a) Recognition of and preventive measures for the safety hazards associated with their individual work tasks.
 - b) General recognition and prevention of safety hazards in the logging industry.
 - c) Procedures, practices, and requirements of the employer's worksite.
4. Training must be provided whenever an employee demonstrates unsafe job performance.
5. Employers shall record in writing and maintain a record as proof of compliance dates of training; periods when guidance is provided; and dates on which proficiency is demonstrated for current employees, new hires, and workers who change job responsibilities. Employees are not required to be retrained in initial training elements.

6. On request of a worker, a copy of the records under subsection (3) that pertain to the worker shall be provided to the worker.

10.1.7 Safety meetings

1. The employer shall hold safety meetings for each employee, individually or in groups, at least once each month.
2. The employer should maintain a monthly safety meeting record to document the employees present, safety topics discussed, and date of the meeting.
3. Before a crew of workers starts work in a new work location, a crew safety meeting shall be held to inform the workers of any known or reasonably foreseeable risks in that location and the actions to be taken to eliminate or minimize those risks.
4. If a worker did not attend the crew safety meeting under subsection (2) for a new work location, before starting work in that location, the worker should receive a safety orientation that covers any known or reasonably foreseeable risks in that location and the actions taken to eliminate or minimize those risks.
5. Records should be kept of the crew safety meetings and safety orientations provided under subsections (1) - (4).

10.2 Emergency rescue

- Provision should be made for the quick evacuation of a person in the event of an injury or illness, which requires medical assistance.
- Transport or a means of communication should be available at the worksite to contact rescue services in case of an emergency.
- At permanent worksites, a place should be provided where an ill or injured person might rest in comfort until the evacuation is under way.
- Where professional help is not available within a reasonable distance, consideration should be given to the creation of the necessary dispensing and health-care facilities.

10.3 Personal Protective Equipment

The use of proper personal protective equipment is essential for reducing logger injuries. Often hazardous elements cannot be removed or corrected, therefore, it is vital to protect the worker. Proper personal protective equipment is as important a part of any logging operation as a chainsaw, skidder, and loader. Properly protected and trained workers have better work habits, better attitudes, and produce more wood at lower costs. Proper personal protective equipment properly

used can greatly reduce the number of logger injuries. Table 1 shows what PPE must be worn by loggers based on job activity.



Figure 52 — Personal protective equipment

10.3.1 Personal protective equipment

- Gloves, leg protection, hard hats, eye protection, high-visibility clothing and first aid kits shall be provided by the employer at no cost to the employee.
- The employer shall assure that personal protective equipment, including personal protective equipment provided by an employee, is maintained in a serviceable condition.
- The employer shall assure that personal protective equipment, including personal protective equipment provided by an employee, is inspected before initial use each work shift. Defects or damage shall be repaired or the unserviceable personal protective equipment shall be replaced before work is commenced.

Table 16 — Personal protective equipment by logging activity

TIMBER HARVESTING SAFETY						
ACTIVITY	SAW CHAPS	PERSONAL HARD HAT	PROTECTIVE HARD TOE BOOTS	EQUIPMENT EYE PROTECTION	HEARING PROTECTION	GLOVES
Chainsaw	X	X	X	X	X	X
Skidder		X	X	X	X	As Needed
Fellerbuncher		X	X	X	X	As Needed
Deck Attend.		X	X	X	X	As Needed
Loader		X	X	X	X	As Needed
Truck Driver		X	X	X	X	As Needed
Visitor		X	X	X	X	As Needed
Harvester		X	X	X	As Needed	As Needed
Forwarder		X	X	X	As Needed	As Needed
Dozer		X	X	X	X	As Needed
Repair		X	X	X	As Needed	As Needed
Axes		X	X	X		As Needed
Pickaroons		X	X	X		As Needed
Hand Tools		X	X	X		As Needed
Contractor	As Needed	X	X	As Needed	As Needed	As Needed
Supervisor	As Needed	X	X	As Needed	As Needed	As Needed

X-Must be worn while doing activity

EXCELLENT SAFETY IS A COMBINATION OF A GOOD SAFETY RECORD AND AN EXCELLENT SAFETY PROGRAM.

10.3.2 Hard hat

- Approved hard hats shall be worn by all persons present on the logging operation including log truck drivers and anyone on or near the woods or landing areas.

10.3.3 Eye protection

- Safety glasses, face shields, or goggles shall be worn by all workers involved in activities where wood chips, sawdust, flying particles, foreign objects (twigs, limbs, branches) may injure, puncture, scratch, or damage workers' eyes.
- Eye protection shall be required for chainsaw operators and for equipment operators where cab protection or a windshield is not adequate.

10.3.4 Hearing protection

- Hearing protection shall be worn by all workers operating chainsaws or logging equipment.
- All workers in the immediate area of any mechanized equipment shall use hearing protection.

10.3.5 Safety footwear

- Heavy-duty logging boots that are waterproof or water repellent, cover and provide support to the ankle and protect the employee from penetration by chainsaws shall be worn by all workers.
- Chainsaw operators must wear boots that will protect them against contact with a running chainsaw.
- "Slip on" rubber boots are not to be used by workers involved in logging operations due to the lack of adequate ankle support.

10.3.6 Safety chainsaw chaps

Chainsaw cuts to the legs are one of the most frequent injuries reported from logging operations. When leg protection is used by chainsaw operators, the chances for saw cuts are greatly reduced. There are many varieties of leg protection available, which are lightweight, comfortable, and affordable. Protective chaps have proven to be effective in reducing the frequency and severity of chainsaw cuts to the legs.

- Chaps or safety pants should be worn by all fellers and buckers, and any other workers using chainsaws. Leg protection of ballistic nylon or other leg protection providing equivalent protection shall be used and shall cover the full length of the thigh to the top of the boot on each leg.

10.3.7 Hand protection

- Work gloves (gauntlets) or other suitable gloves providing equivalent protection shall be worn by all workers handling wire rope.
- Employees handling cable or wire rope, operating a chainsaw, or performing other work potentially hazardous to hands shall wear hand protection.

10.3.8 Respiratory protection

- Respiratory protection shall be provided and used where workers are exposed to dust, smoke, gas fumes, vapors, sprays, or adverse environmental conditions that may affect breathing.
- Workers shall wear respiratory protection where operator cabs are not properly enclosed and where workers are exposed to such conditions as extreme dust, engine fumes, and engine smoke. Workers shall be trained in the use of respiratory protection.

10.3.9 High-visibility clothing

- Highly visible outer clothing should be worn by a worker in a forestry operation if:
 - a) the worker is involved in felling trees or working close to a felling site,
 - b) the worker may be endangered by any moving equipment or cable, or
 - c) the worker's location must be routinely checked.
- Safety headgear worn by a worker in a forestry operation must be a high visibility colour that contrasts with the background against which the worker is working.

10.3.10 General clothing

- Woods workers shall wear properly fitted clothes, which are appropriate for the job. Floppy cuffs³, dangling shirttails, loose or frayed material that might catch or snag on equipment controls, moving parts, handles, doors, etc. should not be worn. Cuffless pants should be worn.

10.4 Fire prevention and suppression

³Trousers with turn-ups ("cuffs" in American English), after hemming, are rolled outward and sometimes pressed or stitched into place.

10.4.1 Fire suppression equipment

- Proper portable fire suppression equipment shall be located on the jobsite, on each unit of mobile equipment, on each vehicle, and at fuel dispensing and storage areas.
- Fire suppression equipment shall have the proper rating, capacity, and charge to suppress any fire effectively. Fire suppression equipment may be of the following types:
 - a) Fire extinguishers-charged, dry chemical type.
 - b) Water tanks-pressurized tanks filled with water.
 - c) Fire extinguishers-charged, chemical foam extinguishers.
- Maintain the proper sized extinguisher at each location.
- Daily, check each suppression unit for proper charge and operation. Recharge all fire suppression units immediately after use.
- Always have spare fire suppression equipment for each unit of mobile equipment on the jobsite.



Figure 53 — Proper portable fire suppression equipment shall be located on each unit of mobile Equipment

10.4.2 Fuel storage

- Portable bulk fuel storage:
 - a) Bulk fuel shall be stored in approved metal containers, with proper labels for warning and identification.

- b) Fire extinguishers shall be located at the bulk fuel storage area. "No Smoking" signs shall be posted - "No Smoking within 20 Metres (60-Feet)."
 - c) Bulk fuel shall be properly stored for safe transport.
- Portable fuel containers:
 - a) Only approved containers shall be used for flammable liquid and fuel storage.
 - b) Never store fuel or flammable liquids in glass containers.
 - c) Containers shall be properly labelled with warning and identification.
 - d) Only vented containers are to be used.
 - e) Portable containers should be secured for safe transport to avoid turnover and spillage and to avoid contact with workers.

10.4.3 Logging equipment fire prevention

Professional loggers know the value of their logging equipment. The value is not only in terms of investment "dollars and cents", but also in terms of daily production and operations. Do not think "metal won't burn." It will!! Logging equipment fires are both dangerous and expensive, and many are preventable. It only takes 15 to 20 minutes daily to reduce the risk of your investment "going up in smoke". It is time very well spent. Most fire hazards are created by:

- Accumulation of debris inside machine compartments.
- Excessive build-up of oil, grease, and fuel from leaks and spills.
- Faulty or damaged electrical system wiring and components.
- Overheating of brakes when improperly applied or accidentally left engaged.
- Heavy build-up of flammable materials around rotating drive shafts which can ignite due to friction.

Routine fire prevention maintenance guidelines

- Perform routine maintenance and all other manufacturer recommendations for service and maintenance.
- Clean unit often. Drop the belly pan and remove side shields to remove debris and accumulated oil, grease, etc. under the engine and transmission at least one time per week. Steam clean and/or pressure wash each unit of logging equipment at least one time per month. During dry conditions, clean the unit twice daily or stop the unit and clean as frequently as needed.
- Inspect battery cables, connections, wiring, and electrical components weekly. Repair or replace any defects in the electrical system. Engage battery disconnect switch if available at

shutdown for poor connections, frayed wires, abraded insulation cables lying against sharp edges, missing clamps, etc.

- Have an approved, charged fire extinguisher on the machine at all times. Check the extinguisher regularly to be sure it remains charged. As a back up, it may help to keep a gallon jug of water handy on the unit.
- Have the operator observe and check the unit for 15-20 minutes after shutdown to ensure adequate "cool down time". Many fires occur after shutdown.
- Park the unit at a minimum distance of 20-metres (60-feet) from other equipment in an area pushed and cleared of excess debris to minimize fire spread.
- Maintain the engine cooling system to avoid overheating.
- Keep the operator's compartment clean.
- Do not transport flammable liquids on the machine.
- Before refuelling shut off the engine. No smoking within 20 metres (60 feet) of refuelling operation.
- Clean fuel, oil, or grease spills.

10.4.4 Vandalism protection

These guidelines are offered to assist in reducing vandalism:

- Remove all keys from ignition switches and engage electrical system cut off switch when leaving the operation area.
- If not already installed, put keyed locks on cab doors, fuel tanks, hydraulic tanks, engine side shields, machine covers, or doors where possible. Chain cab doors and covers if locks unavailable.
- Hide your equipment from easy view whenever possible.
- A night watchman may be necessary to protect the equipment during shutdown.

10.5 Equipment safety devices

10.5.1 Chainsaws

All chainsaws shall be maintained in good working order and all safety devices shall be operational at all times. Specifically all chainsaws should be equipped with:

- Chainsaws shall be equipped with a chain brake, which is activated manually by the front handle guard
- Do not remove or disable chainsaw kickback devices. Under no circumstances should the chain brake be removed.
- a front handle guard for protection of the left hand from the chain
- an on/off switch which is reachable with the right hand on the throttle
- a throttle control lock-out which prevents the chain-saw from being started unexpectedly, because two levers have to be pressed simultaneously
- a rear handle guard for protection of the right hand in case of chain breakage
- an anti-vibration system, consisting of rubber shock absorbers between the engine block and handles
- a chain catcher
- a spiked bumper (for safe and accurate cross-cutting)
- exhaust which directs fumes away from the operator
- a chain guard for avoiding injuries and protecting the chain during transportation
- Chainsaw toolkit for corrective and preventative maintenance and adjustments.

10.5.2 Heavy equipment (crawler tractors, skidders, front-end loaders)

- Every set-screw, bolt or key on any revolving shaft, spindle, wheel or pinion shall be so sunk, encased or otherwise effectively guarded by situation and design as to prevent danger.
- All spur and other toothed or friction gearing shall be completely encased unless it is so situated, or is of such design, as to be as safe as it would be if completely encased.
- Skidders and all other logging equipment such as bulldozers and front-end loaders should be equipped with a structure that protects the operator against falling overhead hazards, rollover, and projectiles.
- A seat belt shall be provided for each piece of logging equipment:
 - a) Each employee shall use the seatbelt while operating vehicle or machine.
 - b) Each employee shall securely fasten the seat belt to restrain the employee within the vehicle or machine cab.

- c) Seat belts shall not be removed, or if removed, be replaced on any unit so equipped at the time of manufacture.
 - d) Each seat belt shall be maintained in a serviceable condition.
- Exhaust systems shall be in service with no holes or leaks, and must point away from the operator.
 - Each machine shall have two operable exit doors or hatches. Do not block or tie any door shut.
 - All logging equipment should be equipped with back up alarms. Do not alter or disengage back up alarms on the skidder. Ensure they are in proper working condition.
 - Each piece of equipment should have an operator's manual on the job site.

10.5.3 Skidders

- A winch on a skidder shall have a quick-release system to permit the winch line to run out freely and automatically disengage from its drum.
- Screen type guards around the cabin are required to protect operators against flying or intruding objects:
 - a) Back screen guard shall be provided in the area behind the operator;
 - b) Side screen guard shall extend forward from the back screen guard to at least the forward edge of the operator's seat and shall extend vertically to at least the full height of operator's control area (ROPS or canopy). The screen should not obstruct or restrict the operator's egress from his control area.
 - c) Front screen guard shall be provided in front of the operator's control area.
 - d) The supports shall be adequately designed and fabricated to resist all loads that the screen guards would likely impose upon them.
 - e) Screen guards may be attached to parts of the rollover protective structure (ROPS), provided that such attachment does not adversely affect the performance of the ROPS.
 - f) The screen mesh shall be fabricated of steel wire material of 6.35 mm (1/4") diameter minimum, having a maximum clear mesh opening of 4.44 cm x 4.44 cm (1 3/4 inch x 1 3/4 inch) square. Such mesh shall be welded to a bolted framework and should not be welded directly to any ROPS.
 - g) Never alter or weld on the protective structure.

- Skidder should be equipped with (half-)doors on both side entrances to the control area to protect the operator in case of a rollover or where the operator may be exposed to flying or other intruding objects:
- a) The door height shall be a minimum of 60 cm (25 inches) from the floor and having the top of the door at least 25 cm (10 inches) above the cab seat.
- b) A latch, preferably of pressure sensitive type should be used to lock the door.
- c) The hinges, stops, and supports shall be adequately designed and fabricated to resist any loads that the door would likely impose upon them.
- d) All members of the half-door should be fabricated of material with good impact absorbing properties.

10.5.4 Trucks, trailers and semitrailers

- For the protection of the driver, each logging truck shall have a substantial barrier (bulkhead bull-board/headache rack) installed at the rear of the cab to help prevent logs from entering the cab from behind that:
 - a) is at least 15 cm (6 in) higher than the cab, and
 - b) is at least as wide as the cab.
- The barrier shall be capable of withstanding a horizontal forward static load equal to 40% of the weight of the cargo being transported that may shift and contact the barrier, with this load uniformly distributed over the entire barrier.
- The barrier of the logging truck must be designed, constructed, and maintained so that it has no aperture large enough to permit any item of cargo to pass through it.
- Trucks, pole trailers, and semitrailers used for transporting logs shall be equipped with adequate metal stakes, bolsters, bunks, or similar devices. Do not use wood extensions. Extensions should be metal and welded or bolted in place.
- Bunks must be able to rotate freely upon their pivots, if designed to do so.
- Stakes must be constructed so that:
 - a) they can be released only from the opposite end of the bunk,
 - b) keeper pins are secured against unintended release.
- Stake extensions should be secured against inadvertent detachment from the stakes.
- A log transporter should be equipped with a horn which, under normal conditions:

- a) is distinctly audible at a distance of 300 m (1,000 ft), and
 - b) has a tone distinct from the horns/alarms used by skidders or loaders in the vicinity.
-
- Each truck shall be equipped with a dry chemical fire extinguisher. The extinguisher must be maintained full, in operating condition, mounted securely, and readily accessible.
 - Each truck should be equipped with flares or reflectors (one set of either), first aid kit, and operable flashlight if used on public roads.
 - Each truck and each trailer shall be equipped with service and parking brakes that will safely hold the maximum load on the maximum grade. Brakes shall be maintained in good condition.
 - Cab doors must open easily from inside and outside. Doors must latch properly.
 - Lighting systems shall be present and maintained in proper operating condition.
 - Trailer poles shall be equipped with stops at the rear end to prevent the pole from pulling out of the trailer socket.
 - Trailer pole or tongue couplings shall be securely locked or connected with a keyed pin.
 - Cab entry steps shall be secure; in good condition; and free of grease, dirt, mud, or debris.
 - All objects shall be secured inside the cab so as not to present a hazard to the driver in the event of an accident or overturn.
 - Safety equipment may include, but is not limited to:
 - a) First aid kit
 - b) Fire extinguisher
 - c) Flares or emergency reflectors
 - d) Seat belts
 - e) Hand tools
 - f) Appropriate load securing devices
 - g) Hydraulic jack
 - h) Legal warning flags
 - i) Load tail light

10.5.5 Boat equipment

- A boat must be equipped with:

- a) effective machinery guarding;
 - b) effective guards or insulation on hot exhaust pipes or stacks;
 - c) suitable cabins, screens or guards to protect operators against injury from towline breakage if the boats are regularly required to pull logs, rafts or barges;
 - d) suitable cabins, screens, or guards if operators are subject to injury from logs or limbs intruding into the control area;
 - e) suitable hydraulic or other steering systems that will not transmit forces that could cause injury to the operator through feedback of rudder reaction; and
 - f) deck matting or other surface cover which provides an effective grip for caulked footwear.
- A boat operated in navigable waters during the period from sunset to sunrise, or in conditions of restricted visibility, shall:
 - a) have deck and cabin lighting, where necessary to provide safe levels of illumination aboard the craft, and
 - b) have searchlights or floodlights, where necessary to facilitate safe navigation and to illuminate working or boarding areas adjacent to the craft.
 - Buoyancy equipment (life jackets) should be worn by each worker on a tug or in an open boat.

10.5.6 Safety with maintenance of skidders and other logging equipment

When maintenance is required on a skidder or other piece of equipment, lockout-tagout⁴ will help ensure the safety of the mechanic and others nearby. The purpose of lockout-tagout is to prevent unexpected movement or start-up of the machine during service or maintenance. Accidents can be avoided by following a step-by-step lockout-tagout plan:

1. Fully lower the blade or lifting devices to the ground. If they must be elevated for repairs, chain or block the blade or lifting devices to prevent injuries.
2. Release hydraulic pressure by moving the controls.
3. Set parking brakes and chock the wheels.
4. Allow all moving parts to come to a complete rest before performing any repairs.
5. Turn the ignition switch to the “off” position and remove the key. Put it in your pocket to prevent accidental start up.

⁴Lockout-tagout (LOTO) or lock and tag is a safety procedure which is used in industry and research settings to ensure that dangerous machines are properly shut off and not started up again prior to the completion of maintenance or servicing work.

6. Turn off the master disconnect if your skidder has one.
7. If you have them available, place a tag on the door to let others know the machine is out of service. This is the “tagout” part of lockout-tagout.
8. Allow heat to dissipate before maintenance or repairs are performed on or near engine, hydraulic systems, and fluids.
9. Disconnect the battery before performing repairs on electrical systems or welding on the machine.
10. At this point, the machine is locked out and at a zero energy state.

Once maintenance or service is complete, replace any guards or panels, remove blocks and chains, and follow start up procedures. These are the reverse steps of the shutdown procedure.

10.6 Chainsaw operations safety

10.6.1 General chainsaw safety

Chainsaws are an integral part of many logging operations. Chainsaw related injuries are still reported frequently. Most chainsaw injuries are the results of saw "kickback". Kickback occurs when the saw bar tip or the top of the saw bar strikes an object and throws the saw in the direction of the operator. Severe injuries are reported to the legs, hands, arms, and face. Proper training, techniques, equipment, and personal protective equipment can reduce the potential of kickback and chainsaw related injuries.

1. Proper personal protective equipment shall be used by all saw operators.
2. Transporting the chainsaw:

By Hand: Stop the chainsaw engine. Grip the saw handle and place the muffler at the side away from the body with the guide bar to the rear.

By Vehicle: Keep the chain and bar covered with a chain guard. Properly secure the saw to prevent turnover, fuel and oil spillage, and damage to the saw.

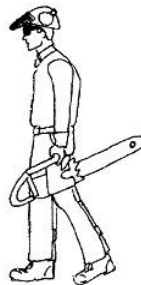


Figure 54 — Grip the saw handle and place the muffler at the side away from the body with the guide bar to the rear

3. Maintain handles, chain brakes, chain, and covers for safe operation. Use low kickback chain (safety saw chain).

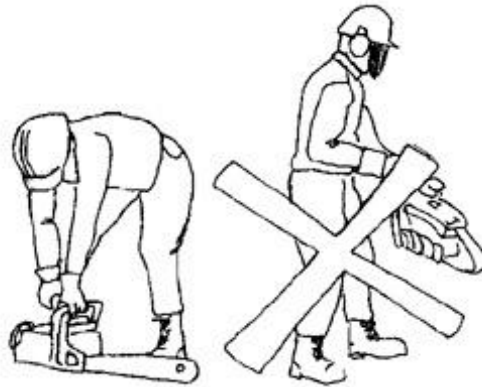


Figure 55 — Always start the saw on the ground

4. Start the chainsaw with the chain brake engaged.
5. Always start the saw on the ground. Engage the chain brake, place one foot through the handle, hold the top handle firmly, and make an even pull on the starter rope. Do not drop start a saw or start a saw on your knee.
6. Adjust the engine idle speed so the chain is not moving when the engine is idling.
7. When moving from tree to tree or when moving to another work area within 20 metres (60 feet) where hazardous conditions exist or when moving farther than 20 metres (60 feet), stop the chainsaw or engage the chain brake.
8. Always maintain a firm grip with both hands on the saw for control. Position the thumb and fingers around the top handle grip for best and safest control.
9. Never use the saw above shoulder height and never over reach. The chainsaw shall not be used to cut directly overhead.
10. Always keep the bar nose clear of other objects during cutting to prevent kickback. Avoid cutting with the upper part of the bar or use extreme caution when this technique cannot be avoided.
11. Before refuelling, if possible allow the saw to cool. Refuel in a clean area on bare soil. Chainsaws shall be fuelled at a distance not less than 5 metres (15 feet) from an open flame or potential source of ignition. Wipe fuel and oil spills from the saw. Move at least 5 metres (15 feet) from the fuelling spot before starting the engine.
12. Do not operate a chainsaw when tired. Overtired operators have less control and are more accident-prone.

13. Keep a first aid kit and fire extinguisher within a reasonable distance of chainsaw operations.

10.6.2 Felling

Felling timber is recognized as the most hazardous job in logging. Safety in felling must be the most important goal of the job. More workers are severely injured, maimed, or killed while felling timber than in any other phase of the logging operation. Proper training, planning, felling techniques, safety, and common sense will not only ensure safe operation, but will increase the quality of the cut log.

1. Use proper personal protective equipment.
2. Clear the area around the tree of brush and other obstructions before cutting.
3. Each tree shall be checked for lean, limbs, shape, crook, wind direction, butt defects, and dead, lodged limbs. Plan the tree's direction of fall. Observe and allow for hazards in surrounding trees, which may be "triggered" by the tree being felled.

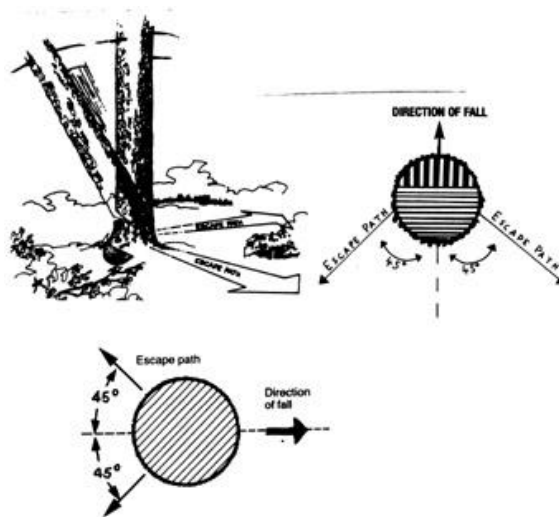


Figure 56 — clear an escape path at a 45-degree angle

4. Plan and clear an escape path at a 45-degree angle in the opposite direction to the planned direction of tree fall.
5. Employees shall be spaced and duties organized such that the actions of one employee will not create hazards for other personnel.
6. All workers shall be clear of the area within at least a 2 tree-length radius of the tree being felled.



Figure 57 —Workers shall be at least a 2 tree-length away from the tree being felled.

7. Make the proper undercut on all trees regardless of size. Never cut a standing tree completely through in one continuous cut. Leave a sufficient hinge of wood between the undercut and felling cut. This helps reduce tree kickback and maintain control of the direction of tree fall.
8. Use wedges when necessary to aid the direction of the fall.
9. Back cuts shall be above the level of the horizontal cut of the undercut.
10. Always keep to the side of the tree being felled. When the tree starts to fall, stop the engine or engage the chain brake, withdraw the bar, and walk away on the pre-planned escape path. Never turn your back on the falling tree. Beware of falling limbs.
11. Do not approach a chainsaw tree feller closer than twice the height of trees being felled until the feller has acknowledged that it is safe to do so. As an additional precaution, fallers should warn fellow workers of a falling tree with a shout such as "timber".
12. Never leave a lodged tree, also called a "danger tree", because it may fall unexpectedly. Never work in the area of a lodged tree. Each danger tree shall be felled using mechanical or other techniques that minimize employee exposure before work is commenced in the area of the danger tree. Always have lodged trees safely pulled or pushed down with the aid of a skidder, tractor, or other heavy equipment.



Figure 58 — Lodged trees should be pulled or pushed down with the aid of a skidder

13. If the danger tree is not felled, it shall be marked and no work shall be conducted within two tree lengths of it unless the employer demonstrates that a shorter distance will not create a hazard to employees. Safely mark the lodged tree, preferably with high visibility coloured vinyl tape, and move two tree lengths away from the tree before resuming work.
14. Domino falling of trees is prohibited. Felling a single danger tree by felling another single tree into it is not recommended. Never climb lodged trees or attempt to cut sections out of a lodged tree. Never cut the tree supporting a lodged tree.
15. Use extreme caution when felling timber on windy days.
16. Fell trees into clear areas when possible to reduce the chances of lodging a tree.
17. If, in any type of felling activity, a tree being felled may create a hazard to a user of a road, effective traffic control must be used to stop or control approaching traffic.

10.6.3 Bucking

The most common injuries received while bucking are saw cuts to the feet and legs. Many injuries are also caused by logs rolling onto workers' legs and feet. Bucking should be done in as clear an area as possible to avoid saw tip contact with other logs, which may result in kickback.

1. Use proper personal protective equipment.
2. Plan cuts before starting the saw.
3. Stand with legs well apart, braced, and with secure footing. Do not get in an off balance position. Do not stand directly behind the saw while bucking to avoid injury in the event of kickback.

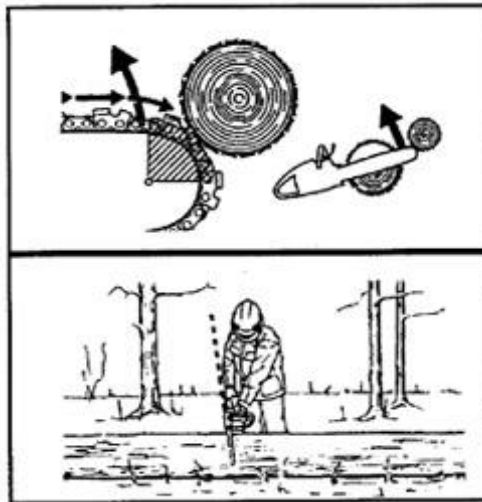


Figure 59 — avoid saw tip contact with other logs, which may result in kickback

4. Keep legs and feet from under the saw.

5. On steep slopes work on the uphill side; if a tree is in a dangerous position, have a skidder or other proper equipment move it into a safe position.
6. Keep the saw bar tip clear and avoid using the extreme tip of the saw for bucking, as this may result in a kickback.
7. Keep the chain out of contact with rocks, gravel, and the ground.
8. Never leave a log partially cut.
9. Make sure the chain is not turning and keep your finger off the throttle trigger when walking between cuts.
10. Maintain a safe operating distance between you and other fellers, buckers, and logging operations.

10.7 Skidding Safety

10.7.1 Before commencing the skidding operation

Personal Protection Equipment

Both the operator and hooker or choker setter should wear hard hats and foot protection. The operator should wear hearing protection. Hookers or choker setters shall wear high visibility vests and safety gloves when handling cable, attaching chokers or handling logs. Frayed or broken cable strands, splinters, and slivers can cause severe hand injuries.

Daily walk around inspection

A walk around inspection of the unit should be performed at least twice a day. Caution should be used when checking any pressurized system such as hydraulic or fuel systems as a fluid injection injury can occur. Check fluid levels, tires, attachments, and fire suppression equipment. Check to make sure the equipment guards are in place and free of chips, limbs, and other debris. Remove rocks, wood chunks, and other debris from between tires and tread. Inspect the engine compartment daily and clean as needed. Debris such as leaves and twigs can be drawn into the compartment and be a fire hazard. Repair any defects such as leaking or loose hoses, guards, handholds, and so forth before operating any equipment.

Mounting and dismounting

Skidder operators can protect themselves against slip-and-fall accidents by using the three-point mount and dismount technique. This means that two feet and one hand – or two hands and one foot – are touching the machine at all times. Exit the skidder the same way you entered it, facing the machine. Never jump out of the skidder cab onto the ground. Do not mount or

dismount a moving machine, and no outside riders allowed. All skidders are equipped with either a step or strap as the bottom step. This should always be in place on the machine. If it is broken or torn off, it should be repaired immediately.



Figure 60 — Nearly one-half of the injuries suffered by equipment operators result from slipping and falling while getting on or off the machine or while working on the machine.

Wear seat belt

Once inside the skidder cab, always wear your seat belt. Keep your head, hands, arms, and legs inside the operator's compartment. Skidder operation should be performed only from the operator's seat. Secure loose items in cab. Always have a first-aid kit and a charged fire extinguisher in the skidder cab with you.

Pay attention to ground personnel

The operator shall make sure the area is clear before starting or operating the skidder. Line-of-sight is very limited on skidders, and you may have difficulty in seeing ground personnel due to blind spots on the equipment. The cabin structure, winch, arch or grapple arm assembly and front blade impede the direct line-of-sight if ground personnel are too close to the front or back of the skidder. Therefore, everyone on the logging job should wear some sort of high-visibility clothing.

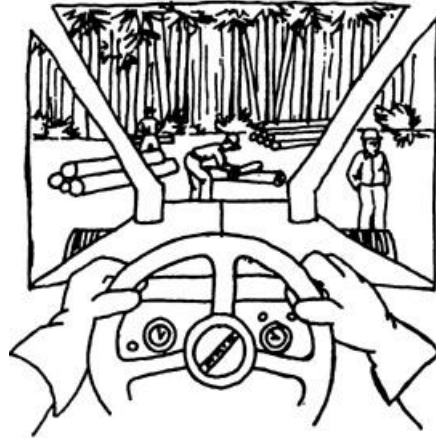


Figure 61 — The cabin structure, winch, arch or grapple arm assembly and front blade impede the direct line-of-sight on skidders

10.7.2 Operation of rubber tired skidders

1. Wear the seat belt while operating the unit.
2. Operate the skidder at proper speeds for the load, weather, and ground condition.
3. Keep blade, grapple, and rigging clear of the ground and obstructions while skidding or moving.
4. Keep head, arms, and legs inside operator's compartment.
5. Never mount or dismount a moving machine.
6. Maintain regularly used skid trails by removing hazardous obstacles (dead snags, spring poles, felled trees, logs).
7. Maintain safe operating distances— at least two tree lengths – from other machines, workers, and operations.
8. Always look behind before backing the skidder. Watch for people, stumps, and other obstructions.
9. When hooking logs or setting chokers for cable skidders:
 - a) Inspect cables and chokers frequently for damage. Replace as needed.
 - b) Always wear proper safety gloves when handling wire, ropes, or cables.



Figure 62 — Hookers shall wear safety gloves when handling cable

- c) If using a hooker or choker setter, always have the worker use signals to indicate safe skidder movement, winching, or stopping.
- d) Stop the skidder, ground the blade, and set the brakes before dismounting.
- e) Set chokers at butt end of log.
- f) When hooking or releasing hooks or chokers, be careful of hands, fingers, feet, and legs. Do not unhook a tight choker.
- g) Stand to the side of the hook or chokers when hooking or releasing. Do not straddle the cable or log.
- h) If possible, keep your body on the uphill side of the tree while hooking or setting the choker.
- i) Use the winch to pull hung hooks or chokers loose, or to relieve a cable under tension.
- j) Always be alert to sudden, unexpected log movements.
- k) The hooker or choker setter should stand a safe distance to the rear and side of the moving load. Stand behind a tree or other barrier if one is available.

10. When winching a load, try to maintain a reasonably level position.

- a) Keep the fairlead in a straight line with the mainline when winching.
- b) Do not winch at severe angles, but winch load in straight line to avoid rollover
- c) Ease the skidder forward during the final winching phase to allow proper bunching of the logs and prevent binding to the rear of the skidder.
- d) On sloping ground, winch the logs uphill. Never winch the logs across the slope.



Figure 63 — Do not winch at severe angles to avoid rollover

11. If using a grapple skidder:

- a) Maintain as level a position as possible.
- b) Grapple logs behind the machine and not at an angle.
- c) Raise the grapple before moving.

12. Operate the winch or grapple controls only while seated in the machine; never from the ground.

13. Never overload a machine. Carry a load that is safe, within the capacity of the machine, and suitable for forest type, ground, and terrain conditions.

14. Position the load safely to permit clearance of ground obstructions and prevent swaying or bumping against the skidder butt plate.

15. Select the safest route. Avoid brush piles, tops, limbs, rocks, stumps, and adverse ground conditions when possible.

16. To avoid rollover, skid up or down the slope. Never skid across the slope.



Figure 64 — Never skid across the slope to avoid rollover

17. On steep terrain, avoid any abrupt turns uphill. Back down the slope and go straight uphill.

18. When travelling downhill, maintain a low gear and maximum engine revs to reduce overspeed and possible brake wear.
19. Reduce skidder speed when turning. Avoid tight turns under load.
20. In case of steep adverse slope or boggy terrain conditions, if cable skidding, drop the load, proceed through the adverse condition, and winch the load to the skidder.
21. Be cautious of load hang ups. Hang ups can damage cable, chokers, grapple, skidder and injure an unsuspecting operator.
22. Drive defensively. Think ahead and anticipate hazards. Adjust speed to allow for any needed defensive action. Watch for snags, limbs, tops, saplings, and lodged trees that may fall on or enter the operator's compartment.
23. Maintain skid trails by removing hung trees, spring poles, logs, and other obstacles. Flag hazardous trees to alert others. Assess each tree individually. Some trees will need to be pulled down, and others pushed.
24. Know where crewmembers are at all times. Be alert to unexpected workers or operations in the immediate skidding area.
25. Immediately push or pull all lodged trees to the ground.
26. Always look behind when backing the skidder.
27. At the landing area:
 - a) Be cautious of and courteous to other workers.
 - b) Approach the landing at a safe speed.
 - c) If necessary, wait for landing workers to move a safe distance from the landing area, and then proceed with load.

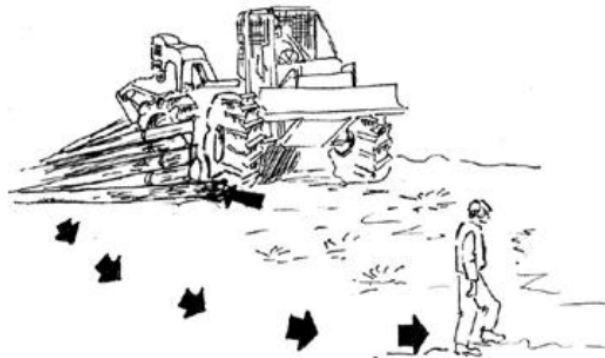


Figure 65 — wait for landing workers to move a safe distance from the landing area

- d) Keep track of your load when turning on the landing.
- e) Winch or release the load only when all workers are clear of the area.
- f) If log-loading operations are in progress, wait for the loader to clear forks, grapple, and moving logs before entering the landing area.
- g) Use the blade to clear debris from the landing area in order to permit safe worker movements. Never attempt to clear the landing area while pulling a load.
- h) Keep the skidder on the ground. Use extreme caution when the skidder is used for pushing logs onto the pile on the landing. The skidder blade can be used for this purpose, but the operator should not ride up onto the log pile.

28. Do not operate skidders during adverse weather conditions.

29. Always lower the blade, release cable, set brake, and lower grapple and other attachments to the ground when stopped. Remain near the unit and allow for proper cool down time at the end of the day.

10.8 Landing area

Many accidents are reported each year in which workers are injured while on and around the landing area. Many injuries can be prevented when proper safety guidelines coupled with proper training are used. Injuries received while working on the landing have resulted from improper chainsaw use, working too closely to loading or skidder operations, improper or lack of use of proper personal protective equipment, trashy landing areas, and poor ground conditions.

Severe and sometimes fatal injuries have resulted when workers are struck by log loaders, approaching skidders, or rolling logs. Proper landing layout and proper planning and coordination of equipment and worker movements can greatly enhance the safety of the landing area.

1. Construct the landing area size to fit the operations size.
2. Keep debris cleared from the landing to provide safe worker and equipment movements.
3. All landing personnel shall wear proper personal protective equipment.
4. Never store flammable liquids, gas, and oils in the immediate landing area where there is a risk of accidental contact by logs, machines, or workers.
5. Remove all standing tree hazards in and around the landing area.
6. Appropriate fire suppression equipment shall be available near the landing area.
7. The landing area should be located away from public roads and power lines.
8. Park all service and passenger vehicles a safe distance from the operating area.

9. All open fires used - e.g. for cooking - should be contained within metal barrels or other fire resistant containers to prevent the risk of wildfire.
10. Never allow workers with oily, greasy, or flammable liquid stained or soaked clothes to stand near an open flame, or work near an ignition source.
11. When using a cutting torch or welding machines:
 - a) Have fire suppression equipment available.
 - b) Wear proper personal protective equipment.
 - c) Secure acetylene and oxygen tanks in upright position for storage.
 - d) Perform work at a safe distance from other workers and operations.
 - e) Frequently check lines, fittings, and equipment for safety and proper operation.
12. Daily, clean the deck and woods area of trash. Have a trash container available on the job site.
13. Post warning signs on public roads at hazardous junctions to warn motorists of entering or exiting vehicles or equipment.
14. Never allow visitors, spectators, or unauthorized persons to be on or near any operation unless they are supervised. All visitors shall wear proper personal protective equipment.
15. Use extreme caution with battery jumper cable.
 - a) Wear eye and hand protection.
 - b) Be cautious of explosive fumes.
 - c) Before connecting jumper cables check the equipment batteries to verify if they are positive or negative grounds.
 - d) Ensure the jumper cables are correctly connected to the proper battery poles.
 - e) Warning: batteries produce explosive gases
 - f) Keep sparks, flames, and cigarettes away from batteries at all times.
 - g) Wear eye protection. Do not lean over batteries during jump-starting. See owner's manual for instructions.

10.9 Loading

10.9.1 Log storage on the log market (landing) area

1. Work on a log market (landing) area should be planned and the work area should be located, constructed, maintained and operated to ensure the following:

- a) logs can be moved safely in the area;
 - b) log piles and equipment used to handle the logs do not become unstable or otherwise create a hazard;
 - c) workers are able to work in locations clear of moving logs and equipment;
 - d) workers are not exposed to incoming or runaway logs or other debris;
 - e) the area is kept free from build-up of bark and other debris to the extent that it would pose a risk to workers;
 - f) an effective method of dust control is used and maintained.
2. Log piles should, to the extent practicable, be located on stable and relatively level ground.
 3. Log piles should not be higher than the safe operating reach of equipment being used to handle the logs.

10.9.2 Loading with a rubber-tired loader

1. Follow general prestart and starting guidelines for machines as pertaining to rubber-tired loaders.
2. Keep the sub-frame, steps, and cabin clean of oil, grease, and mud to prevent a fall when mounting or dismounting.
3. Have a large enough landing area to accommodate full movement of the loader with logs. Maintain safe distances from other ground workers and equipment units.
4. Keep the landing clear of debris.
5. Do not allow any workers within the loading area.
6. Know where your fellow workers are located.
7. Know and understand the loader's rated lifting capacity.
8. Never attempt to overload the machine.
9. Carry the load at a safe height when moving.
10. Keep the landing and loading area as level as possible.
11. When piling logs around the loader, maintain the log pile to prevent logs from rolling onto the deck area or into a transport vehicle.
12. Be cautious of rolling logs when removing logs from the log pile.
13. Always use the hold down clamp, if available on the forks, when moving under a load.
14. Always look behind when backing.

15. Back up alarms should be used. They should not be altered or disengaged and should be in proper working condition.
16. Never allow workers to stand near or under the loader while in operation.
17. Never allow any worker to trim a log while suspended by a loader. Place the log on the ground in a safe, clear area.
18. Be cautious of blind spots around the loader where the operator's visibility is limited.
19. Do not attempt to load a truck or trailer when anyone is near the transport unit. Truck drivers shall not remain in the cab unless this is a necessary part of the process and the design and structure of the truck cab and associated guards provide adequate protection.
20. Never attempt to overload a truck or trailer. Keep the load uniform and maintain the legal height, weight, and length limits for the state. Properly balance and saddle loads to prevent shifting.
21. Move the loader slowly and cautiously when moving a log to free a worker's pinched chainsaw. Chainsaw operator should maintain a firm grip with both hands (thumb around top handle) on the saw, stable footing, and should be alert to any unexpected saw or log movements.
22. A log must not be passed over any worker or occupied vehicle or equipment.
23. Despite subsection (22), a log may be passed over a vehicle or equipment that is being loaded, if the log :
 - a) does not pass over any portion of the vehicle or equipment that is occupied by a person, and
 - b) does not constitute a hazard for the occupant of the vehicle or equipment.
24. A worker must not stand or pass under a suspended log.

10.9.3 Loading logging trucks

The log market (landing) area is a potentially dangerous area on any harvesting operation. Loading at many harvesting operations is performed at locations with equipment and logs continuously entering and leaving the deck. Safety must be the prime consideration when placing logs or lumber on any vehicle for movement on logging roads and public roads.

1. Trucks shall wait until the loading area is clear of hazards before entering.
2. When it is necessary for trucks to back into a loading or unloading area, they shall do so only upon the signal of the loader operator or other authorized person. It is always advisable to have an individual guide the backing vehicle. The guide should stand to the driver's side of

the vehicle, away from its path. A warning horn should be sounded before any vehicle begins to back up. Extreme caution should be used when raising or lowering the trailer landing gear.

3. Drivers should exit the truck and move to a safe location during loading.
4. Logs shall not be loaded on a logging truck, trailer or semitrailer unless all workers in the vicinity are in a safe location and clear of any moving logs or logs that might move or fall during that operation.
5. All workers should stay clear of any loading or unloading operation by standing in front of and away from the truck. Never go to either side of the truck until all loading or unloading has stopped and it is obviously safe to do so.
6. While a logging truck, pole trailer or semitrailer is being loaded, a worker must not stand on the cab platform of the transporter or between the transporter cab and a log being loaded.
7. Hard hats and other appropriate personal-protection equipment shall be worn at all times when the driver is out of the cab.
8. Logs must be loaded on a log transporter in a manner that meets all of the following requirements:
 - a) all logs shall be well balanced and centered so the load is stable without chains, cables, or straps;
 - b) the transporter and the load must remain stable while in transit;
 - c) the strain on the binder units, bunk stake lines or stakes must not exceed the load that the units, lines or stakes are designed to bear;
 - d) the free and full movement of the transporter must not be impaired.
9. To ensure that stakes remain at a safe angle, the first tier of logs must be laid tight, and arranged to minimize slack in the stake cables.
10. Unless securely restrained by other means to prevent logs from slipping off, the bottom tier and the side rows of the log load must extend beyond the front and rear bunks and stakes.
11. A log whose length is not contained by the stakes must not be loaded above the level of the stakes unless the log is in a secure lay, and does not have excessive crook, sweep or deformity.
12. Place larger and longer logs at the bottom of the load.
13. A worker must not stand on any part of a load of logs on a log transporter.
14. Outer bottom logs shall be in contact with and resting solidly against bunks, stakes or bolsters.

15. Centre of highest log on each side or end shall be below the top of each stake or bunk.
16. Upper logs that form the top of the load shall be crowned and held in place by binders if not held in place by contact with other logs, stakes or bunks.
17. No log in a load should be more than one-half its diameter above the stakes at any point between the tops of the stakes.
18. No load shall be moved until the binders are securely in place.
19. Appropriate warning flags or lights shall be used as required by traffic regulations (figure 8).
20. Loads shall not extend beyond the maximum overhang beyond the rear bolster that obscures the rear trailer.
21. A worker should not go on bunks and trailer assemblies to raise or lower stakes and extensions unless it is impracticable to do otherwise.
22. If a worker must go on a bunk or trailer assembly to collapse stakes or extensions, the worker should be provided a safe means of getting on and off the bunk or trailer assembly.
23. Empty log transporter trailers, when loaded onto tractors, must be adequately secured against dislodgement.

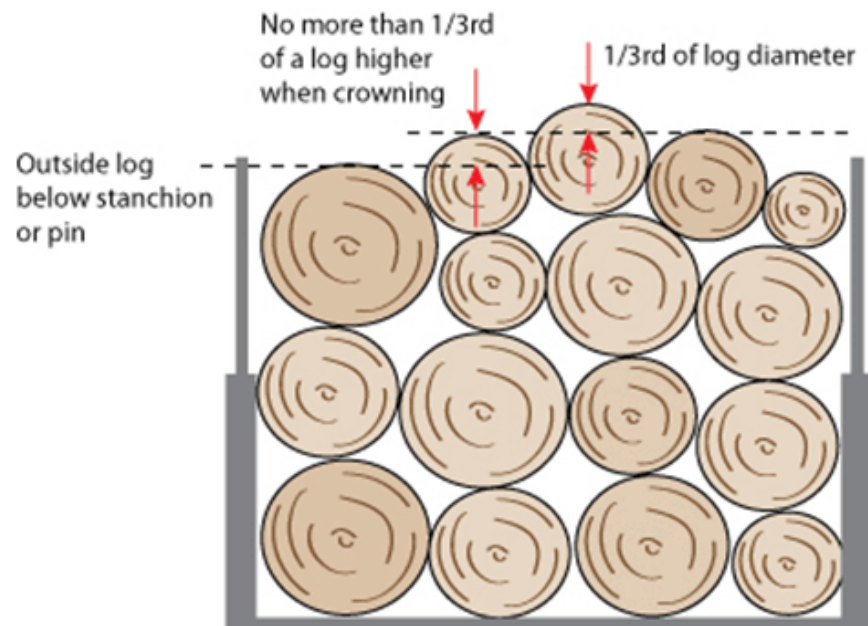


Figure 66 — Upper logs that form the top of the load shall be crowned; no log should be more than one-half its diameter above the stakes

10.9.4 Binding the load

Injuries associated with binding the load can be reduced in a number of ways. It is important to remember that the log deck is the focal point of a harvesting operation and special care should be paid when moving about on the log deck.

1. Unless the centre of all logs lie below the level of the top of the stakes on a log transporter, at least two binders must be installed to restrain the logs before the transporter is moved.
2. Be aware of skidders entering and exiting the log market (landing) area, what the loader is doing, and the presence and actions of other employees around them.
3. Make sure that the area around the truck is clear before throwing binding straps over the load in order to avoid injuring any individual who may be on the other side of the truck.
4. Care should be taken to make sure that the driver does not lose his/her footing. This can range from not wearing boots with excessively high heels to simply paying attention to where one is walking.
5. All binders that should be in place before a load of logs may be transported should be put on:
 - a) as soon as practicable after loading, and
 - b) in a location in close proximity to the loading area.
6. Loads or logs should not be moved or shifted while binders are being applied or adjusted.
7. A binder on a load of logs should be checked and kept tight during transportation of the logs.
8. Bundle straps or banding should not be used as binders to restrain logs during hauling.
9. Binders should be positioned on the load so that they can be safely removed while the load restraining equipment is in position.
10. Binding straps should be checked for cuts or tears before each use. If a cut or tear is found, replace the strap immediately.

10.9.5 Mounting and dismounting trucks

Injuries associated with getting into or out of trucks account for 10 percent of injuries to truck drivers, making this act the third-most likely reason for an accident to occur. The number of injuries due to mounting and dismounting can be reduced by the following actions:

- Mandate that employees wear non-skid footwear.

- Ensure that all handholds are properly attached and in sound condition.
- Use the “three points of contact” climbing method (two hands and one foot, or one hand and two feet in contact at all times).
- Stress that truck drivers keep all steps clear of mud and other debris.

10.9.6 *Pre-trip inspection of logging trucks*

Most accidents associated with heavy trucks are caused by brake failure. Drivers should always perform a pre-trip inspection of the truck and trailer. This "walk around inspection" will identify items in need of repair before they can contribute to an accident. Regular safety inspections of all trucks can help ensure the detection and correction of any problems before they cause an accident.

1. Tires, steering apparatus, horn, bolsters, windshield wipers, air hoses, and all connections on trucks and trailers shall be inspected before and after each trip. Inspect the following periodically: wheel flaps, exhaust system, wheel alignment, floors, bumpers, shocks, power train linkage, and electrical system. All gauges should be functional.
2. If any defect is found, which will prevent the safe operation of the equipment, all necessary repairs, or adjustments shall be made before the equipment is used.
3. Inspection and maintenance records should be maintained to ensure maintenance is performed properly.
4. Bleed compressed air tanks daily to eliminate water in airlines.
5. Brake and air hose lines and couplings shall be replaced or repaired immediately when found to be defective.
6. Excessively worn tires, re-grooved tires (unless designed for re-grooving), and section repaired tires shall not be used on the front wheels of trucks or truck tractors. Re-grooved or section repaired tires should not be used on the drive wheels of trucks or truck tractors.
7. The trailer shall be properly connected. All trailer air lines and electrical connections are to be properly attached.
8. Cracked or broken windshields shall be replaced.
9. Cracked or broken mirrors and mirrors that cannot be adjusted shall be repaired or replaced.
10. Wheels shall be checked for cracks and loose or missing lug bolts. Remove rocks, wood chunks, and other debris from between tires and tread.

10.9.7 *Inspections when entering a public road*

Haul roads are often rough and littered with debris. Loads can settle, wiring can be pulled loose, and undercarriage parts can be damaged or loosened. The following checklist can keep trucks operating safely and should be completed before entering any public road.

1. **Tires:** Make sure that all tires are fully inflated, without wood or rocks jammed between them. Remove debris resting on the trailer frame.
2. **Lights:** Light wires can be pulled loose and light bulbs may be broken or jarred loose. Ensure that all lights are working properly. Clear mud or heavy dust from lenses.
3. **Load binders:** Loads may settle when pulled over haul roads. Binders should be checked for slack and tightened as necessary.
4. **Trailer connections:** Make sure that coupling devices used to connect the service and emergency air lines from the truck or tractor to the trailer (hose couplers/glad hands/palm couplings) and electrical connections are not loose.
5. **Load flag or lights:** Make sure that load flags or lights are still attached and working.
6. **Clear vision:** Make sure that you can clearly see forward, sideways, and behind while in the cab. Adjust mirrors as needed.

10.9.8 Operation and movement of logging trucks

Drive the vehicle in accordance with all traffic laws. Never drive when not fully alert and capable of safe driving. Do not operate a vehicle after consuming any alcohol or drugs, or when fatigued. Never drive a truck if the load is improperly distributed or inadequately secured. The safe condition and operation of the transport vehicle is the driver's responsibility.

Injuries associated with driving trucks may increase costs due to medical expenses from injured drivers, damage to the truck and trailer, and loss of production associated with accidents. This is compounded by the potential of injuries or property damage to other parties who may be involved in these accidents. There are several ways to reduce the likelihood of these incidents occurring. The first is to hire only qualified drivers with safe driving records. Additionally, drivers should be reliable, as well as willing and able to take care of their equipment properly.

1. Comprehensive driver training including defensive-driving techniques and safe loading/unloading methods should be taught periodically as part of a training program.
2. Installing governors or requiring the driver to drive at a lower speed can translate into fewer and less serious accidents.
3. The use of new tires instead of recaps – especially on the steering tires – decreases the likelihood of an accident due to a blowout.
4. It is important to monitor brake wear and adjustment.
5. Be certain air hoses, connectors, and seals are in good condition.

6. Make sure the driver is bleeding the air tank regularly.
7. Check the load to see that it is safely stacked and properly balanced. Trim any limbs, branches, or sticks protruding from the load.
8. Passengers shall not be carried in trucks unless authorized by the truck owner.
9. Riding on any part of a truck except inside the cab is prohibited.
10. Trucks shall not be moved on a landing or other operating location until all persons in the area are in the clear.
11. Seat belts shall be worn at all times by the driver and authorized passenger when the vehicle is in operation.
12. Before entering any public road, drivers shall stop, and tighten all load binders, and inspect loads for stability and security. All lights should be clean.
13. Maintain a safe distance from other vehicles. Pass other vehicles only where road conditions permit.
14. Do not overtake another moving vehicle, except on a signal from the other vehicle operator.
15. Use extreme caution when approaching vehicles coming from the opposite direction.
16. Keep a safe distance when following crew transportation vehicles.
17. Maintain proper clearance when turning with tree length loads. Allow clearance for any part of the load extending beyond the rear of the trailer.

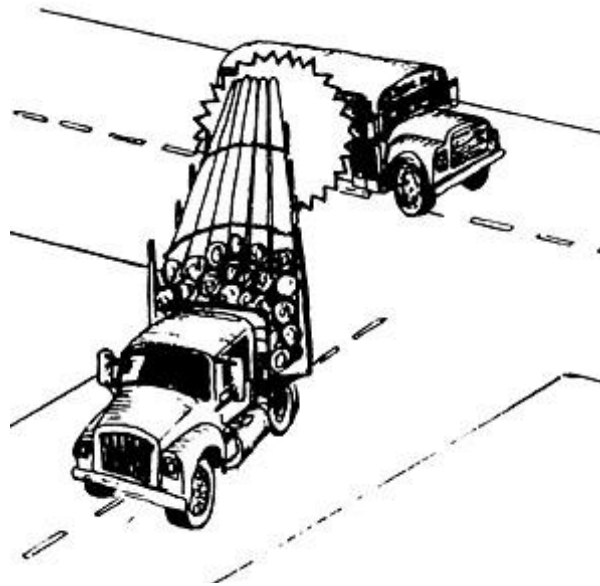


Figure 67 — Maintain proper clearance when turning with tree length loads

10.9.9 Unloading

Unloading at the mill or log pond carries many similar risks as loading in the woods. Unloading occurs in a noisy environment often with multiple trucks and cranes moving in a central area.

1. Drive at a safe speed inside the mill or log pond. Follow any posted speed limits.
2. Follow all mill / log pond policies during unloading.
3. When outside the truck, stay in a safe position at all times.

10.10 Transporting workers

1. A driver of a vehicle transporting workers in a forestry operation on a road must not overtake and pass a moving and loaded log transporter or low bed transport truck, unless:
 - a) that driver receives a signal to proceed from the driver of the loaded log transporter or the operator of the low bed transport truck, and
 - b) the road conditions are suitable for that maneuver.

10.11 Water Operations

10.11.1 Condition of boats

1. A boat used in or about a forestry operation should be maintained in good mechanical and seaworthy condition.
2. A boat should be inspected daily before first use, and thereafter as required, and defects should:
 - a) be reported immediately in writing to the supervisor, and
 - b) if they affect the safe operation of the boat, be remedied before the boat is used.

10.11.2 Boat operations

1. A boat shall not be used to tow log booms/rafts or barges, which, because of weight, wind, current, or sea conditions, are beyond the capacity of the towing craft to safely control.
2. A boat shall not be loaded with personnel or equipment so as to adversely affect its stability or seaworthiness.
3. When a boat is used to push, pull or restrain log bundles, the operator shall remain on the boat unless the boat is firmly secured to the log bundles in a manner that allows the operator to get on and off safely.

4. A boat designed for use in calm waters should not be operated in wind or sea conditions that adversely affect its safe operation.
5. General requirements for booming/rafting
6. Log booms/rafts must be made up and sized with due regard for the size and quality of the available rigging.
7. Booming/rafting grounds must be of sufficient width to accommodate booms/rafts that are being worked on safely.
8. Booming/rafting grounds must be provided with safe access.
9. Booming chains, swifters and related items of rigging used in booming operations should be maintained in safe condition.
10. Rigging which is damaged or deteriorated enough to be a danger to workers should be removed from service.
11. A boat that is used to make up or strip booms/rafts should use a winch appropriate to the task that:
 - a) is capable of withstanding the maximum stress that could be imposed while moving log bundles, and
 - b) has a large enough diameter to hold all of the line that is needed to complete the task.
12. If boom/raft stripping is done manually, a sufficient number of workers should be available to handle the rigging safely.
13. A log or log bundle should not be dumped into water if there is a known or reasonably foreseeable risk to a worker.

11 SOCIAL ISSUES

Sustainable forest management is ultimately about people. Healthy social practices in managing forests promises to foster sound business as well as to improve Guyana's economy. The forests need to be socially beneficial to contribute to the objective of sustainable development. The benefits derived from the existence and management of the forests, and accruing to people living in and around them may be a precondition for the conservation of the forest.

The practices and standards set out in this chapter are based on the land and forest use rights and responsibilities; and community and work place relations, rights and responsibilities.

The rights of Indigenous people of Guyana are entrenched in the Guyana constitution and the Amerindian Act, Cap. 29:01 of Guyana. The Amerindian Act guarantees land rights and sets out a legal process not only for titling of existing villages, but also claims for new lands and extensions to existing lands.

11.1 Land and forest use rights and responsibilities

Respect for legal or customary rights to land

- The concessionaire shall be in possession of a legally valid concession agreement for the area from which all timber is sourced
- If the concessionaire has contracted a third party (includes concession activities relating to harvesting, extracting of forest produce and transporting to another point out of the concession, processing and export, of forest produce), such arrangement shall be formally approved by the GFC using the defined approach and in compliance with the Forest Act, Cap. 67:01.
- There shall be no legal titles by indigenous or other persons in the area from which all timber is sourced unknown to GFC and the concessionaire.
- The GFC should be informed of any illegal forestry activity

Rights of Amerindians

- The legal, social, and ecological integrity of all Amerindian lands shall be respected
- Disputes over Amerindian land tenure and use rights shall be brought to the attention of the Ministry of Amerindian Affairs and Guyana Lands and Surveys commission

Commercial contracts with Amerindian communities

- Any contractual arrangements for logging on Amerindian lands must have been made with free and informed consent of the community and the MOAA and GFC should be aware of the contractual arrangements
- Persons desirous of negotiating commercial forestry contracts with an Amerindian Council should contact the relevant Amerindian Council and the Ministry of Amerindian Affairs
- Amerindian Village Councils that are desirous of entering into commercial forestry contracts should seek advice from the Ministry of Amerindian Affairs, and the Guyana Forestry Commission

Conflict management between forest operations and local communities

- Forest operators and elected or recognized community representatives should use methods of consultation as a first step to resolving any conflict(s) that might arise before exploring other legal options
- A neutral third party should be invited to facilitate negotiated agreements between forest operators and communities

11.2 Community and work place relations, rights and responsibilities

Respect for cultural and traditional values

- Legal and traditional, non-commercial uses and customs of the forest shall not be prevented by the concessionaire.

Building mutually beneficial partnerships

- Forest management operators should adopt a mechanism for engaging the local communities, community base organizations and other interest groups in a dialogue that is aimed at ensuring that socio-economic benefits accrue to the local population
- All parties have copies of a joint plan

- Local representatives are present at meetings and participate in decision making
- Attention is given to such critical areas as health, education, transportation
- Local population is not totally dependent on the forestry operation and the services that they provide

Terms and conditions of employment

- Employers shall inform employees of the terms and conditions of service prior to or at the time they are hired
- Prior to or upon assumption of duties, an employer shall document and inform an employee of his/her wages by task or by day
- The national minimum wage shall be respected by the employer
- Working hours shall be within the labour laws
- Adequate work-related transportation should be provided for workers
- Employment of expatriate workers shall be within agreed limits (e.g. in Foreign Direct Investment agreements)

Contractors and contracted labour

- Contractors are obliged to adhere to conditions applicable to employers/concessionaires
- Employers/concessionaires should develop a contract agreement between the concessionaire/employer and the contractor to include the following:
 - i. The parties agree that a written agreement between the concessionaire/employer and any contractor shall be the basis of any engagement with any such contractor for the purpose of conducting forest operations on the concession area
 - ii. The employer/concessionaire shall provide a copy of any written agreement with any contractor(s) for the consideration of the Commissioner of Forests at least one month prior to the desired date of commencement of work by the contractor(s)
 - iii. The parties agree that any agreement regarding contractual work in which the employer/concessionaire is engaged must include the following:
 - a) an explicit statement that the employer/concessionaire is responsible directly for all actions of the contractor

- b) an explicit statement committing the employer/ concessionaire and the contractor(s) to full compliance with the terms of the concession agreement, the provisions of the most recent Forest Management Plan and the provisions of the most recent Annual Operational Plan
 - c) an explicit statement committing the employer/concessionaire to responsibility for the social welfare of contractors and their families, while such contractors are engaged in the approved contractual operations
 - d) an explicit provision making clear that there shall be no transfer whatsoever of the concession, the concession area or any part thereof
- iv. The contractor agrees that it will maintain registers of all employees, together with employment records (including PAYE and NIS contributions) and that such registers will be available for scrutiny by the Guyana Forestry Commission and concessionaire, and such other agencies approved by the Guyana Forestry Commission

Equal opportunity employment

- Women and men shall be paid equal remuneration for the same work or work of equal value
- There shall be no discrimination on the basis of race, sex, religion, colour, ethnic origin and sexual orientation

Prohibition against forced labour

- Employers shall ensure fair remuneration and humane working conditions in return for all services rendered
- Employers shall observe ILO Convention 182 on forced labour

Employment Opportunities for local and forest-dependent populations

- Opportunities for employment and training are provided to local and forest dependent c within or adjacent to the forestry management operation

Education and training for workforce and local populations

- Relevant education and training required for the job should be specified and/or provided
- A range of educational and skills training programmes for the purpose of enhancing workers' job performance and promotion within the workplace should be made available on an appropriate basis

- Educational and vocational skills programmes should be made available to communities within or adjacent to the forest management operation
- Wherever possible, certification for educational and skills training programmes should be issued by a recognized institution or body

Social security benefits

- Employers shall provide employees with information on the NIS
- Employers shall meet the requirements of national laws regarding deduction of income tax and payment of National Insurance
- Employers should inform employees about the procedures for recovering damages in respect of personal injury or in respect of death resulting from personal injury

Recreation

- Employees shall have the benefit of adequate rest and recreation time and facilities in keeping with the labour laws of Guyana

Prohibition against child labour

- Employers shall not knowingly employ persons under the age of 14 in keeping with the International Labour Organization Convention 182

Workers right to union representation

Workers are free to organise and/or join a trade union or association of their choice and shall not be prevented from negotiating for wages and conditions with their employers as stipulated under the Trade Union and Recognition Act No: 32 of 1997

Conflict management in the workplace

- In the event of an industrial dispute, the relevant parties should first explore to resolve through management/shop steward discussions. If this step fails then the parties involved should seek to utilise the mechanisms of conciliation and arbitration

APPENDICE

APPENDIX 1: GENERAL TERMS AND CONDITIONS RELATIVE TO LARGE CONCESSION AGREEMENTS

1. The concessionaire is granted exclusive rights for a period of his/her Forest Concession Agreement to occupy his/her concession area for the purposes of cutting and taking or obtaining timber.
2. The concessionaire shall demarcate the boundaries of the concession and shall place and maintain at the corners of the area, and in such other places as the Commissioner of Forests may direct a board, on which shall be painted in plain legible letters and figures the name of the concessionaire and the number of the Forest Concession agreement.
3. The concessionaire shall be responsible for patrolling the boundaries of the concession and reporting any illegal activities to the GFC.
4. The concessionaire has been conveyed the right to cut and remove timber from the concession area on payment of the prescribed management fees, charges and levies, for the period described in the concession agreement and do such things as can reasonably be regarded as necessary for the purpose, but shall convey no other rights whatsoever,
5. The concessionaire shall pay annually to the GFC such management fees, charges and levies as prescribed by the Forest Act, Cap. 67:01 and its Regulations. Where any forest charges are payable in advance, the payment shall be made on or before the 31st day of January of the year in which it is due.
6. The concessionaire shall work the area to the satisfaction of the Commissioner in accordance with the terms of the concession agreement and only in accordance with the Forest Management plan, as approved by the Commissioner, referred to in section 2.3.
7. The concessionaire shall keep true and complete records declaring all timber cut and removed. The concessionaire shall be responsible for ensuring that such records are accurate and that the full charges are paid on all timber taken.
8. The concessionaire shall allow the GFC to monitor the progress of operations and inspect the forest production and forest utilization records of the Concessionaire.

9. The GFC reserves right of way and right of access to all parts of the concession including the right to transport any produce or material across the said area.
10. The GFC shall be entitled to make reasonable use on visits of inspection, of such transport facilities as the concessionaire maintains on the area. Wherever the GFC considers it necessary to have resident Forest Officers the concessionaire shall, if requested by the Commissioner, construct and maintain at his own expenses permanent quarters for the accommodation and use of such Forest Officers.
11. The concessionaire shall not transfer, sublet, mortgage or otherwise dispose of any interest arising under the concession agreement.
12. The concessionaire shall comply with the provisions of the Forest Act, the Forest Regulations and the Environmental Protection Act and with the terms and conditions listed hereunder:
 - a) The Concessionaire shall comply with all laws of the Parliament of Guyana including but not limited to the following:
 - i. Labour Act, Cap. 98:01;
 - ii. Prevention of Discrimination Act, Cap. 99:08;
 - iii. Occupational Safety and Health Act, Cap. 99:06
 - iv. International treaties, conventions and agreements to which Guyana is a signatory.
 - b) The concessionaire shall recognize the right of employees to be members of a trade union of their choice, and the right to education and training opportunities. The concessionaire shall at all times provide employees with comfortable housing, sanitary, medical, and recreational facilities, and safe drinking water.
 - c) The concessionaire is duly bounded to respect the traditional rights of the Amerindian people of Guyana.
 - d) The concessionaire shall submit within six (6) months, a Forest Management Plan and Annual Plan of Operations prepared in accordance with the GFC Code of Practice for Forest Operations, or any other special condition(s) specified by the GFC herein.

The plan shall provide for the systematic harvesting of timber within the concession in contiguous blocks to be determined by the Concessionaire in consultation with the GFC. The plan shall be prepared in accordance with sound forestry practices and, as far as practical, be based on the principle of sustainable management. The Forest Management Plan shall be binding on the concessionaire in respect of all matters therein set out and the concessionaire shall not depart from the approved Plan without the written consent of the GFC. The approved Forest Management Plan shall remain in force and effect for the first five years and shall be revised every five years or more

frequently as shall be agreed between the GFC and concessionaire, or any other special condition(s) specified by the GFC herein.

- e) The Concessionaire shall not hinder or otherwise interfere with the unrestricted right of way or roads and the navigation of creeks and rivers used in connection with the working of the concession. Where the concessionaire uses a road, creek or river jointly with others, the concessionaire agrees to accept the decision of the GFC as to the proportion, which each party shall be required to develop and maintain.
- f) The GFC shall have the right at any time to reserve for silvicultural, environmental or other purposes, any lands within the boundaries of the concession as may be considered suited for purposes other than timber production.
- g) The place where forest produce is to be measured shall be identified and fixed by the GFC from time to time after consultation with the Concessionaire.

No timber shall be removed from the place of measurement, utilized, disposed of, or converted until it has been measured and marked in a manner directed by the GFC.

- h) The concessionaire shall exercise all reasonable care in the felling, extraction, conversion, transporting, and any other activities of his operations, to limit and or prevent the degradation of the environment through excessive felling damage, soil erosion, stream pollution, and fires.
13. No tree shall be felled unless its girth measurement at a point 1.3 meters (4 feet 3 inches) from the ground ("breast height"), or in the case of a buttressed tree at a point immediately above the top of the buttress, is not less than the measurement prescribed in the Third Schedule to the Forest Regulations: i.e. 42 inches girth (= 34.0 cm diameter) for 25 species specified in paragraph 1; 24 inches girth (= 19.4 cm diameter) for all other species.
14. Provided that the Commissioner may, where he is satisfied that under the system of working being practiced in any area adequate provision is being made for the establishment of seedling growth exempt the concessionaire from the provisions of this clause or such conditions as he may think fit.
15. No Bulletwood tree shall be felled without permission in writing of the Commissioner first being obtained.
16. No tree shall be felled at a height of more than 0.5 metres from the ground, or in the case of a buttressed tree at a height of more than 0.1 metres above the top of the buttress except to avoid unmerchantable timber.
17. The concessionaire may be granted permission to construct and use such roadways, tramways, railways, timber and cart paths in any State Forest outside the limits of his/her

concession area, as may be necessary to facilitate the transportation of timber from his/her concession area.

18. The concessionaire may be granted permission to occupy at a convenient point along, at or near the end of any roadway, railway, tramway, timber or cart path, or at or near the entrance of any creek, any State Forest not exceeding four hectares in extent for the purposes of:

- a) depositing or storing timber or any goods appertaining to, or necessary for the operations of felling and extracting timber;
- b) erecting houses, garages, workshops and other buildings and installations necessary for the operation of felling and extracting timber;
- c) cultivating any portion of such land for the support of national agricultural objectives.

If an additional area is required in view of the size of the operations of the concessionaire, permission may be granted upon request in respect of an area exceeding four hectares.

19. The GFC will give consideration to valid requests from concessionaires for the rental of machinery/equipment for harvesting purposes for periods less than the previously stipulated minimum rental time of two (2) years.

Appendix 2: SKID TRAIL DEMARCATION

Demarcation of the skid trail alignment on the ground should take place in three stages; first, the alignment on the map is followed, while observing and recording obstacles; subsequently the alignment is adjusted; finally, the alignment and potential crop trees and protected trees that should be circumvented are marked. The last two stages can take place in one go.

First stage (while entering):

1. Follow the alignment as indicated on the harvest map; using compass, block and strip line distances, by sending crew members ahead to verify location of last (group of) trees at the end of the branch trail; while proceeding:
2. Note gullies and intermittent streams, their courses and the steepness of their banks;
3. Note obstacles (rocks, boulders, large fallen boles);
4. Note buffer zones of watercourses;
5. Note trees with DBH \geq 20 cm diameter at a distance of less than 2 meters from the centre of the alignment;
6. Note potential crop trees, seed trees, trees of protected species at a distance of less than 4 meters from the centre of the alignment;
7. Judge and note slopes (longitudinal and lateral).

Second stage (on the way back):

1. Circumvent obstacles (rocks, gullies, slopes > 20%, large fallen boles) in a smooth curve;
2. Pass trees > 20 cm diameter at a distance of 2 m from the centre of the alignment in a smooth curve;
3. Pass potential crop trees, seed trees and trees of protected species at a distance of 4 m from the centre of the alignment in a smooth curve;
4. Avoid steep longitudinal slopes (> 20%);
5. Avoid lateral (side) slopes > 5%.

Third stage (after adjusting the alignment):

1. The line should be opened up by cutlass and marked with paint or flagged;
2. Potential crop trees along the alignment should be marked with the symbol "Ø" which should be visible from both sides of the trail;
3. Seed trees and other protected trees should be marked with a "P" in the same manner;
4. Paint marks or ribbons should be placed at regular intervals so that the course of the alignment is clearly visible to the bulldozer or skidder operator;
5. Mark the centre of the trail by planting pickets with ribbons attached (or with their heads painted) in the middle of the alignment if necessary;
6. 6. Spacing between pickets should be at least 20 m;
7. All lianas along the width of the skid trail should be cut and, if possible, all large fallen boles should be cut by chainsaw.

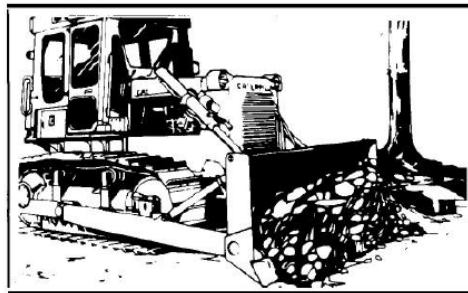
APPENDIX 3: PRACTICAL GUIDELINES FOR ROAD CONSTRUCTION

Clearing and grubbing methods

- In the case of brushwood or small trees, the bulldozer advances pushing the blade along the surface of the soil in order to carry away everything it meets. While it is doing this, the dozer knocks down the vegetation and pushes it along in front. On its second journey it clears the roots from the soil and takes away the greater part of the humus or top soil, thus leaving the site ready for the eventual earthworks. This work is done in first gear.
- To uproot medium-sized trees from 20 to 40 centimetres in diameter, the tractor advances, raising the blade as high as possible to push the trunks over; as soon as the tree has begun to fall the operator must back to free the stump and the large roots which will be coming up - in this way, the fall will not be hampered. On the next movement forward, the operator lowers the blade, puts it under the roots, and pushes the stump, lifting the blade a little to take away the whole thing and to complete the uprooting.

- Circumventing and felling of large trees is preferred over uprooting because of the dips created in the roadbed. If such trees cannot be skirted, a bulldozer should be used. When using a bulldozer for large trees of more than 40 to 50 centimetres in diameter, it is usually more economical to uproot the whole tree before it is felled rather than to fell it first and then pull out the stump; the weight of the crown can thus be used to help pull the tree down after the roots are cut. Generally it is better not to try to knock down the tree by a direct attack, as in the case of medium-sized trees. The best result is obtained by first cutting the roots at the sides:

1. tilt the blade;
2. dig a ditch in front of the tree to cut the roots on the side opposite to where it will fall;
3. dig a ditch on the right and left sides about 50 centimetres deep to cut roots on sides parallel to the direction of fall;
4. build a small ramp at the foot of the tree so that the trunk can be attacked as high as possible with the blade raised;
5. with successive pushes shake the tree which is now not very firm;
6. draw back so that the stump, when it comes up, does not lift the front of the tractor.



Cut roots on sides parallel to the direction of fall (Caterpillar 1999)

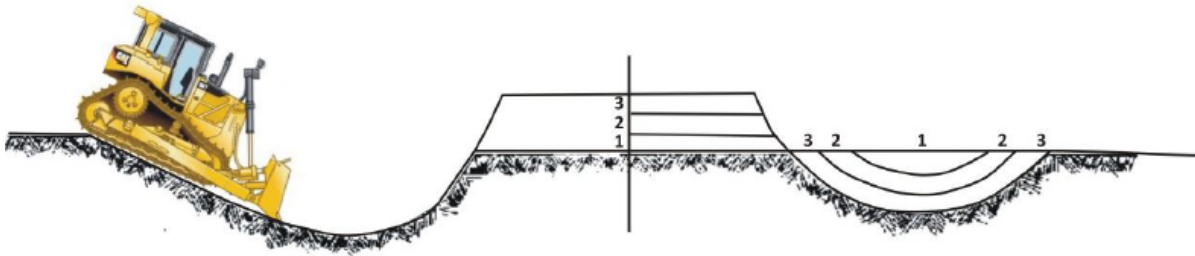
- When the trees have previously been felled, large stumps are uprooted by cutting the roots on all sides and then rocking the stumps and pulling them out with a winch.

Moving material

In earthworks, the preliminary operations are carried out thus: the tractor is started in first gear; the operator lowers the blade a few centimetres; under the action of the weight of the tractor, the blade enters the ground and keeps pushing the material, which piles up in front until it is full. The operator continues in second gear pushing the earth as far as the place where it is to be piled or spread by raising the blade. Wherever the configuration of the ground permits, earthworks should be carried out downhill, so that the slope can help the power of the tractor.

Constructing of fills or embankments

- Embankments or fills should be constructed by spreading a succession of layers about 30 to 40 centimetres (12-18 inches) thick before compaction. The tractor has to make numerous journeys on the embankment, pushing the material in front of it to the end of the embankment. The amount of compaction depends on the type of equipment used, the soil type and moisture, and the number of machine passes.
- Embankments or fills across drainages are especially critical because they may act as dams during severe weather. It is a poor construction practice to build up fills by end dumping instead of layering and compacting. When the depth of the fill is more than 3 metres at centreline, build the earthwork structure carefully to support traffic loads.
- When an embankment is to be made after a cutting, especially crossing a small valley or as an approach to a bridge, it is better to make the embankment the full length in order to make use of the materials from the excavation.
- On slightly uneven ground, the tractor may have to excavate on the lower edges and push the material onto the formation. The carriageway should be constructed as a low embankment above the level of the surrounding ground, so that water can easily run off the road (See diagram below).



Construction of the embankment on level ground (FAO 1963)

Works on the hillside

Steep slopes: work from above (see diagram below)

The bulldozer, with the blade straight, is placed above the edge of the roadway and facing downhill. By lowering the blade to the maximum, the operator digs and pushes the earth down the slope, thus making a platform, which is partly cutting, and partly embankment. This platform must be at least as wide as the blade, say, 4 meters, and at least one and a half times as long as the tractor, say, about 10 meters. Once this platform is constructed, the work continues by following the longitudinal profile of the road to be made.

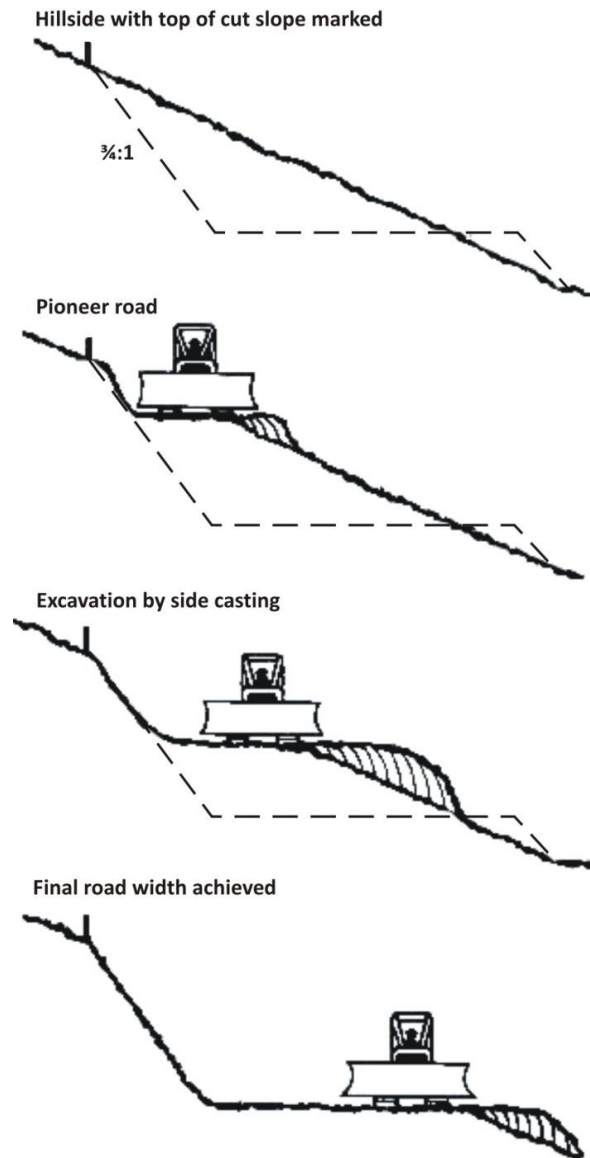


Working on a hillside: direction for steep slopes (FAO 1963)

Easy slopes: work from below

The tractor is placed below the edge of the roadway and facing uphill. The operator lets the blade rest on the ground and makes the machine advance while swinging round on one track. The blade sweeps a level surface and takes more earth from the upper than from the lower side of the turning area. This operation must continue until there is a platform from which to start. The work can be done with the blade as a bulldozer or, better still, as an angle dozer. Once an adequate starting platform of about 4 by 10 meters has been made, the work can be continued by following the longitudinal profile of the road, preferably going downhill. The operator should try to make a cross profile with a slight cross fall toward the batter to prevent a tendency to skid to the outside and to allow a margin for subsidence.

Once the platform has been established, the bulldozer can excavate and side cast material until the desired road width is obtained. The bulldozer then makes successive passes until road width and grade are achieved (see diagram below).



Excavating a road surface out of a hillside (Oregon State University 1983)

APPENDIX 4: PRACTICAL FELLING GUIDELINES

Step 1: Before starting

- Make sure there is enough fuel in the tank before you start felling

Step 2: Starting

- Place your right foot firmly on the rear handle
- Grab the front handle with the left hand
- Pull the starting handle with your right hand

Step 3: Final checks

- Once the saw is running, check the chain brake function by pushing forward on the front hand guard.
- The chain lubrication should be checked by holding the guide bar over a stump and accelerating the engine.

Step 4: Position yourself (see diagram below)

- Stand facing the desired felling direction to aim properly.
- Position yourself firmly with your left shoulder resting against the tree.
- Support your right arm on your right knee, or support your right knee against the tree to take the strain off your back and enable you to guide the saw better



Stand facing the desired felling direction to aim properly (State Forests of New South Wales 2001)

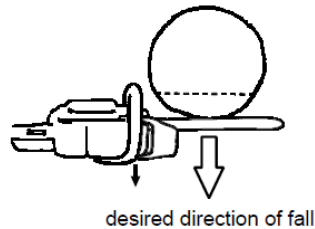
Step 5: Align the saw

- Grip the top edge of the front handle, since this will tilt the saw at the right angle for sawing the top cut (see diagram below).



Tilt the saw at the right angle for sawing the top cut (State Forests of New South Wales 2001)

- Align the saw at right angles to the felling direction. Use a straight edge or a line painted on the saw for aiming (see diagram below).



Align the saw at right angles to the felling direction (Forest Operations Institute of Sweden 1984)

Step 6: Make the top cut

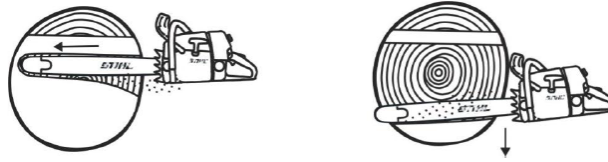
- Always make the top cut first;
- This will enable you to see into the cut to ensure the bottom cut is not made too deep;
- Complete the top cut by sawing horizontally. If the cut is not level, the tree may not fall in the desired direction. Therefore it is better to make the cut again.

Step 7: Make the bottom cut

- Hold the side of the front handle.
- Align the cut carefully so that the top and bottom cuts meet exactly.
- Look through the top cut to check that the bottom cut is not made too deep.
- The angle between the top and bottom cuts should be as close to 70° as possible although never less than 45°.
- The bottom cut should have a depth of about 20-25% of the diameter

Step 7: Make the back cut

- Once the directional notch is complete, the back cut can be made.
- The technique used for making the back cut depends on the diameter of the tree, the length of the guide bar and the lean of the tree
- Whenever possible, use the backward-running part of the chain. The reason for this is that the sawdust will be ejected from the cut, making it easier to insert a wedge.
- Use a felling wedge in order to prevent the tree from settling back and pinching the bar.
- Be careful if there are signs of internal rot. The wood fibres will be weakened when a tree has been attacked by rot, which may affect the direction of the fall.
- The safest and most efficient way to make the back cut is to leave a piece of holding wood by plunging the guide bar directly behind the hinge (see diagram below).



Plunge cut to leave holding wood to control the tree until it starts falling (Forest Operations Institute of Sweden 1984)

Step 8: When the tree begins to fall

- Withdraw saw. Do not continue sawing when fibres start breaking
- Withdraw along intended escape route
- Continuously look back at tree's fall
- Look out for falling limbs
- Do not re-enter felling site until all movement has ceased
- When felling trees uphill, they may slide straight backwards over the stump
- Trees that have lodged into a neighbouring tree must be brought down immediately. If the hung-up tree cannot be brought down, its location should be clearly indicated with suitable signalisation; e.g. flagging tape.

GLOSSARY

Abutment

End support for bridge culvert or similar structure

Adverse gradient

Upslope gradient up which a loaded logging or

	skidder truck must travel
Batter	Inclination or shape of a cutting beside a road or track
Binder	a wire, synthetic rope, chain or other device that is placed around logs on a logging truck or trailer to prevent the logs from falling off
Biodegradable	Capable of being decomposed by bacteria, fungi or other living organisms
Biodiversity	The range of diversity of plants or animals, including the diversity of different species, the variation found within species and the variety of ecosystems
Borrow pit	An area where excavation takes place to produce materials for earthwork, such as fill material for embankments and surfacing material. It is typically a small area outside the roadway for obtaining sand, gravel, laterite, or loam without further processing
Box cut	A road cut through a hill slope or, more commonly a ridge, in which there is a cut slope on both sides of the road. Also called through cut
Bucking	Cross-cutting of a log in shorter sections
Bunk	The bottom section of the cradle assembly on a logging truck or trailer onto which logs are placed
Bridge	A structure that provides for vehicle access over a watercourse
Buffer strip or zone	Strip of vegetation left intact along a watercourse or other sensitive area or site during and after logging.
Buttress	A ridge of wood that develops in the angle between a lateral root and the base of a stem to provide lateral root stability to the stem
Camber	The amount of cross-fall on a road
Catch drain	A drain constructed above a batter to prevent erosion of the batter by surface water

Catchment	An area or basin of land bounded by natural geomorphologic features such as hill crests and ridges from which water drains and flows to a watercourse, lake, wetland or estuary
Chain brake	A safety device on a chain-saw designed to stop the chain in the event of a kick-back
Channel	A waterway that contains flowing water either periodically or continuously. A channel has a defined bed and banks that confine the water
Chaps	Chainsaw chaps are half-trousers which are contain material designed to protect against chain-saw cuts
Choker	A noose of wire rope used to skid logs
Choker setter	Worker who puts the chokers around logs in a yarding or skidding operation
cm	centimetre
Compaction	The process of reducing the apparent volume of the soil, by reducing the empty spaces between particles and increasing the density of the soil under the influence of pressure. Compaction is desirable when a soil is to be used as the base of a road, because it improves stability and reduces infiltration. For the same reasons, compaction is undesirable in the forest, because it has a negative effect on plant growth and survival and soil life
Compartment	A sub-division of a concession frequently of several thousand hectares. It is normally defined along natural boundaries
Corduroy	Cording or matting involving the use of suitable logs to spread the weight of the load and separate machine tyres or tracks from direct soil contact during harvest operations, thus reducing ground pressure and rutting
Coupe	A defined area of forest of variable size, shape and orientation, on which harvesting takes place; usually to be harvested over one year
Crawler tractor	Vehicle with tracks to skid logs; "Cat" (Caterpillar)

Cross-cutting	Cutting through a felled log. Sometimes called bucking
Cross-drain	Surface shaping and devices designed to capture water that collects on and drains down the road and release it in a manner that minimizes effects to adjacent areas and the watershed. They may also be used to relieve hillside ditches and the inside edge of insloped roadways without ditches.
Cross bank or water bar	A ditch and earth bank constructed at approximately right angles to a track, preventing water from building up speed along the track and allowing redirection of running water into surrounding areas
Crown	A crowned road surface has the highest elevation at the centre line (convex) and slopes down on both sides. Crown is used to facilitate draining water off the road surface
Culvert	A conduit, typically of made of metal, concrete, plastic or (hollow) logs, set beneath the road surface, to move water from the inside of the road to the outside of the road. Culverts are used to drain (inside) ditches and watercourses (commonly gullies) that cross the road. Also called koker
Cut-and-fill	A method of road construction in which a road is built by cutting into the hillside and spreading the spoil materials in adjacent low spots and as compacted or side cast fill slope material along the route. A 'balanced cut-and-fill' utilizes all of the 'cut' material to generate the 'fill'. In a balanced cut-and-fill design, there is no excess waste material and there is no need for hauling additional fill material. Thus, cost is minimised.
Cut slope	The artificial face or slope cut into soil or rock along the inside edge of the road
Cutting cycle	In selective (polycyclic) harvesting systems: the planned number of years between successive harvests on an area of forest. It is also referred

	to as felling cycle
Dbh	Diameter at breast height; 130 cm above the ground
Debris	Organic material, rocks and sediment (leaves, brush, wood, stones, rocks, rubble, etc.) often mixed, that is undesirable in a channel or drainage structure. Compare sediment
Directional felling	A concept that focuses on predetermining the final direction of fall of a felled tree. It includes selecting a particular direction of fall based on a predefined set of criteria and the felling techniques and aids involved in felling the tree in the selected direction
Ditch	A channel or shallow canal along the roadbed intended to collect water from the road and adjacent land for transport to suitable point of disposal. Also called table drain or (incorrectly) side drain
Erodibility	See soil erodibility
Erosion	See soil erosion
Favourable gradient	Downhill slope gradient which an unladen logging truck or skidder must travel
Feeder road	A road connecting log markets to a secondary or primary road; also called spur road
Feller (or Faller)	A logger who specializes in felling trees. Also called "saw-man" or "sawyer"
Fill	Excavated material placed on a prepared ground surface to construct the road sub-grade and roadbed template. Also called embankment
Fill slope	The inclined slope extending from the outside edge of the road shoulder to the toe of the fill. Also called embankment slope
Flood plain	A level or gently sloping area on either side of a watercourse contemporary channel that is submerged at times during high water of periods of flooding.
Ford	A rock, other hardened or corduroy structure that is built across the bottom of a watercourse

	channel that is usually dry, to allow improved vehicle passage during periods of low water or no flow and minimises channel disturbance or sediment production
Gradability	A vehicle's gradability is its ability to climb slopes. Gradability is measured either in degrees or in percent. Gradability is dependent on engine power, drive train type, gear ratio, weight, weight distribution, vehicle centre of gravity and traction.
Gradient	The longitudinal slope of a road or skid trail. This slope is expressed in percent – the ratio of elevation change compared to distance travelled.
Grapple	A hydraulically powered pincer-like claw with two or more opposing levers that pinch a log or other materials, usually to lift or drag them
Groundwater	The part of the subsurface water that is in the zone of saturation, including underground streams
Gully	Steep sided drainage channel where water may flow during a wet season or only after a rainfall
Gullying	Scouring of the soil by high velocity water flow resulting in channels where water runs down a slope, embankment or roadbed
ha	hectare
Harvesting debris	Broken logs, branches, twigs, vines, epiphytes and other tree related vegetative material brought down as a result of felling or skidding
Hauling	Transport of forest products, particularly logs, from the log market to the processing facility, commonly by way of logging trucks
Headwall	A concrete, masonry or timber wall built around the inlet or outlet of a culvert to increase inlet flow capacity, reduce risk of debris damage, retain the fill material and minimise scour around the culvert inlet or outlet
Hung-up (trees)	A tree which has not completely reached the ground following cutting

Inlet	The opening of a drainage structure or culvert where the water first enters the structure
In-slope	The inside cross-slope of a road surface, typically measured in percent. In-slope is used to facilitate the draining of water from a road surface to an inside ditch. An in-sloped road has the highest point on the outside edge of the road and slopes downward to the ditch at the toe of the cut slope, along the inside edge of the road
Integral arch	An extension to the body of extraction equipment, which raises the anchor point of the wire rope and thereby lifting the load off the ground, also called logging arch
km	kilometre
Landing	See log market
Logging	Logging is the process of harvesting timber from trees. This includes felling, skidding, loading and transporting forest products, particularly logs. Pre-harvest inventory, tree and skid trail marking can be part of the process
Log deck	See log market
Log market	A cleared area, usually adjacent to the roadbed where logs are assembled after being skidded, awaiting subsequent handling, loading and transport. Also called ramp, log deck or landing
Log transporter	Any of the following vehicles used to transport logs on roads: a) truck, b) trailer, c) truck and trailer assembly.
Logging arch	See integral arch
m	metre
mm	millimetre
m ²	square metres
m ³	cubic metres
Mainline	Cable mounted on e.g. the winch of a skidder to yard logs, usually out of wire rope
Non-harvest area	Area which is excluded from harvesting
Outlet (1)	The opening of a drainage structure or culvert

	where the water leaves the structure. The outlet should be lower than the inlet to ensure that water flows through the structure
Outlet (2)	Excavations designed to divert water away from the ditch and roadway in order to reduce the volume and velocity of roadside ditch water. Also called drain diversion, lead-off, or mitre drain
Out-slope	The outside cross slope of a road surface, typically measure in percent. Out-slope is used to facilitate the draining of water from a road or trail directly off the outside edge of the road or trail. An out-sloped road or trail has the highest point on the uphill or inside of the road or trail and slopes down to the outside edge of the road
Potential crop tree	Stems of commercial species remaining after the cut and forming the basis of subsequent cutting cycles
Retainer log	Log along the outside of a bridge or culvert, above the main stringer logs to prevent fill from slipping off the bridge into a watercourse
Riprap	Layer of large, durable materials (usually stone or rock) used to protect exposed soil to minimise erosion
Roadbed	The formation between the ditches or tops of embankments, including the travel way and shoulders
Roadway	The formation between the extreme limits of the earthworks, from the top of the cut slope to the toe of the fill or graded area. Also called road formation or width of earthworks
Road reserve	The area that corresponds to the limit of the ground affected by the road, usually equals the width of clearing
Rutting	Road or skid trail surface damage in the form of deep tracks made by the passage of wheels or tracks. This typically a result of high wheel pressure on saturated or low load bearing soils.

	These conditions worsen with heavy loads, high traffic volumes and inclement weather conditions
Scour	Erosion or soil movement in a watercourse bed, bank, channel, or behind a drainage structure, typically caused by increased water velocity or lack of protection
Sediment	Fragments of rock, soil, and organic material transported and deposited in bed by water, wind or other natural phenomena
Sedimentation	Deposition of material suspended in water or air, usually when the velocity of the transportation medium drops below the level at which the material can be supported
Sediment trap	See silt trap
SFP	State Forest Permit is a type of State Forest Authorisation (SFA) granted by the GFC allowing the holder to remove a certain quota of timber from an area, and are valid for twoyear. SFPs are classified as small concessions and includes Community Forest Management Agreements (CFMA).
Shoulder	The strip along the edge of the travel way on either side of the road, commonly flush with the travel way for roads on stabilised soil. It is generally only used by passing vehicles but may be used for travel by track machines. Also called verge
Side cast	Road construction material that is not used for fill and is pushed to or placed on the down slope side of the road. Such material may travel long distances down slope before coming to rest
Side drain	See ditch
Silt trap	Hole created to divert sediment laden water, creating enough residence time to allow solid material in suspension to drop out, before it is diverted back into a body of water or drainage structure
Sight distance	The distance along a road or track that a driver

Skidding	<p>can see other objects (usually other vehicles)</p> <p>A method of ground-based extraction in which logs, poles or whole trees are dragged from the felling point to the log market, commonly by means of a tractor equipped with a cable-arch or a grapple known as a skidder, but also by means of farm tractors, crawler tractors, or bulldozers equipped with a winch or chains. Also called yarding</p>
Skid trail	Trail along which a log is dragged by a extraction machine to the log market
Soil erodibility	The inherent susceptibility of a soil to erosion
Soil erosion	The process by which soil particles and aggregates are worn away and moved by the actions of wind or water in the from of raindrops, surface runoffs, and waves
Spoon drain or water bar	A shallow open drain, normally traversable by vehicles designed to carry water to the side of a road or skid trail
Stakeholders	Individuals or groups of individuals who have an interest in, or an impact on, the outcomes of a decision as well as groups or individuals dependent to some degree on the outcome for their personal or institutional goals
Strategic plan	Long term plan, which provides a broad description and broad details of future harvesting and management.
Sustainable forest management	The process of managing forests to achieve one or more clearly specified objectives of management with regard to the production of a continuous flow of desired forest products and services, without undue reduction of its inherent values and future productivity and without undue undesirable effect on the physical and social environment.
Swamp	A generally or permanently waterlogged area which may or may not have associated tree or palm vegetation; or a tract or low, poorly drained ground with patches of open water in

	which reeds, rushes and sedges occur. Swamp sediments are dominated by still water deposits, commonly with high organic content
Swifter	A line run around the ends of capstan bars to prevent their falling out of their sockets
Temporary crossing	A crossing of a watercourse by a skid trail or road construction equipment designed for removal following short term use, having a designated opening to take typical peak flows, e.g. a log culvert, and a cover of slash or small stems for a running surface
Topping	Severing the crown of a felled tree from the usable stem, usually at the first heavy branch. Also called junking
TSA	Timber Sales Agreement is a type of State Forest Authorisation (SFA) granted by the GFC for a duration of ≥ 20 years and a total area $\geq 24,281$ ha. TSAs are classified as a large concession.
Turbid water	Water bearing significant quantities of soil particles
Unstable areas	Sites susceptible to one of the forms of mass soil movement or accelerated soil erosion as a result of the interaction of such factors as steepness, soil properties, parent and surface geology and the position in the land form profile
Verge	See shoulder
Washboard (rills)	A series of ridges and depressions across the road caused by soil and aggregate road surfaces by the lack of surface cohesion. This typically is a result of the loss of fines in the road surface caused by dry conditions or poorly graded material. These conditions worsen with excessive vehicle speeds and high traffic volumes
Water body	Watercourses and surface water such as lake, lagoon, sea or ocean
Watercourse	Defined depression or channel that receives and conducts perennial or intermittent flows of surface water for part or all of the year in most

	years. Watercourses includes rivers, creeks, gullies and waterways
WCL	Wood Cutting Licence is a type of State Forest Authorisation (SFA) granted by the GFC for a duration of 3-10 years and a total area 8,093-24,281 ha. WCLs are classified as a large concession.
Wedge	A high impact plastic, aluminium alloy or hardwood wedge driven into the back-cut to assist felling
Wire rope	Flexible twined metal alloy or steel rope to tie, pull or lift loads; in this context the cable by which logs are winched or attached to the skidder. Also cable
Winch	A rotating powered drum used to haul in or pay out a cable (wire rope)
Wing wall	Masonry, concrete or timber structures built onto the side of culvert inlet and outlet headwalls or bridge abutments, designed to retain the roadway fill and direct water into or out of the drainage structure or underneath the bridge while protecting the road and fill from erosion

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