Sustainable Forest Management for Implementers

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Introduction

After more than 40 years of practical forest management and coming to the end of my service, I came to the decision to write a book which incorporates all my experience and knowledge I have gained over all these years. This book is especially focused on the development aid sector, or better called international co-operation, in which I worked all together 15 years but over a time span of more than 30 years.

In many of these countries the forestry sector is characterized by a lack of knowledge and skills, especially when it comes to technically subjects, to the implementation of planned activities inside the forest. This applies not only for professional staff of these countries but alarmingly even to the so called "Forestry Experts" which are working for all these international development agencies and NGOs. Many of these experts have joined these agencies directly after completion of their studies or PHDs and have never worked in a Forestry Department or company in their homelands, have never gained any practical experience. This results very often in halfhearted and precarious decisions and actions, especially when it comes to practical implementation in the field. This situation occurred in most of the development aid projects I worked with. Sometimes the projects ceased before the actual implementation even commenced.

Another problem I experienced that there is not much exchange of experiences, or, to say it in other words: "Each project tries to invent the wheel again".

In many of these countries the responsible Forestry Departments are badly organized and financed. So, politicians often think that by outsourcing the forest management to companies or contractors through issuing of licenses these problems can be solved. This could be a good choice if these companies have employed well trained and educated staff, which is mostly not the case. Furthermore the respective Forestry Department has to be in the position to control and monitor these license holders closely, which can be implemented only with trained staff again.

As representatives of their Governments, Forestry Departments can never give up the responsibility for their forests. They are fully responsible towards the public! Outsourcing of responsibilities is not always a good solution!

In this regard, I have written a chapter showing a possible organization of a Forestry Department including an example for a job description for a respective work flow.

Sometimes politicians are starting their political campaign with the promise to stop cutting trees and forestry at all and to put all forests under protection. They forget that timber cannot be beaten for all kind of use by any other material in terms of positive energy balance and carbon fixation. Thus, a sustainable forest management providing timber for all kind of use and at all times has to be considered the optimal solution for following generations.

This book is supposed to give guidance to all staff involved in all the fields of Sustainable Forest Management with an emphasis on forest operations and implementation of activities inside the forest. The language, procedures and methodologies are kept as simple as possible to serve for all staff involved. It does not claim to be based on scientific studies but on practical knowledge and experience.

At the end we will be valuated and have to evaluate our own performance not by how many publications or guidelines we have written but by the fact what has changed inside the forest, what has been really implemented and to which extend the forest has improved.

Walter Benneckendorf

I. Management Planning Guidelines Overview

Glossary

a.m.	above mentioned
DBH	Diameter in Breast Height
e.g.	Example given
FIS	Forest Information System
FO.	Forest Officer
FSC	Forest Stewardship Council
FW	Forest Worker
GIS	Global Information System
Ha/ha	Hectare
Mgt.	Management
PEFC	Programme for the Endorsement of Forest Certification Schemes
PCT	Potential Crop Tree

1 Management Planning and Mgt. Goal

The first step in Management Planning is the formulation of the management goal, asking the question: what do we want from our forest, to what functions it should serve? This Mgt. Goal has to match, of course always with the respective regulatory requirements (Forest Laws) of the respective country.

As an example the following formulation could serve:

The Mgt. Goal is the sustainable production of high value timber from mixed, autochthonous species stands. This requires sometimes a change of present species composition, primarily from monoculture stands, into multi-storied mixed deciduous stands, which are well in line with mitigating the impacts of- and adapting to the ongoing climate change. Additionally, the production of high value timber has to be considered a pre-condition for the improvement of the country's forestry sector, the generation of income and new jobs and finally even the increase of biodiversity. Additionally, the production of non-timber products has to be encouraged.

The management comprises all forest functions as production, protection, welfare and recreation and education.

For the purpose of safeguarding the sustainability and after fulfilling the respective requirements, the certification of the forests by an internationally recognized institution (FSC, PEFC) is highly recommended.

A more detailed information can be found under the chapter "Silviculture". There an example is given for a "Long Term Ecological Forest Development".

2 Zoning to Forest Functions

As a policy advice for a forest administration the development and application of a sustainable forest management system is recommended, based on integrated multiple-use management planning which incorporates timber production, soil conservation, non-forest produces, community needs and conservation of flora and fauna. Refer to **"Guidelines for Zoning according to Forest Functions".**

3 Opening-Up Systems

3.1 Basic Road Network

For ecological reasons forest road densities should be kept to a minimum. However, a prerequisite for efficient forest management is an adequately established road network which facilitates the use of appropriate technologies for silviculture, tending, harvesting operations, protection and even recreation. In some remote areas, forest roads even may play an important role in rural development. This Basic Road Network gives access to the forest for implementation of the forest inventory and forest protection. Refer to **"Guidelines for Forest Road Construction, chapter 3.7".**

3.2 Opening-Up Road Network

For harvesting operations an Opening-Up Road Network, consisting of Feeder Roads and Skid trails have to be added on a later stage. Refer to chapter **"Guidelines for Forest Road Construction and Harvesting Guidelines, chapter 3.8 and Harvesting Guidelines".**

4 Inventory and Forest Record Book

There are many designs and different inventories. First of all one has to clarify for what purpose this inventory should serve and what data it should produce. At the end, when it comes to sustainable forest management, to activities inside the forest, a management inventory, where data as species, age classes, crown closure, etc. have to be collected and documented in a **Forest Record Book**. Refer to **"Guidelines for Forest Inventory and Forest Record Book".**

5 Silvicultural Guidelines

5.1 Stand Establishment

Here we have to refer to the a.m. Mgt. Goal. To keep broad leaf and mixed stands, one can depend on natural regeneration. To increase the number of those stands, planting or sowing with appropriate species should commence as soon as possible. Most of the gaps inside the forest, except for ecological and recreational reasons, should be treated accordingly. Sometimes, these areas have to be protected by fencing against roaming livestock and wildlife.
Refer to **"Guidelines for Stand Establishment".**

5.2. Tending operations

5.2.1 Pre-commercial Thinning Operations

These are thinnings where no commercial timber can be produced (DBH < 10 cm). Maintenance of young stands might become necessary, even the timber cannot be used.
Refer to **"Thinning Operations and Pruning".**

5.2.2 Thinning Operations

Thinnings have to be carried out to regulate tree distribution, directing the growth to PCT's, eliminate bad quality and weak trees and last but not least stabilizing the stands. The activities differ according to tree species and age classes by harvesting techniques and intensity. Before these activities can commence, the opening-up road network has to be established. For the actual operations refer to **"Thinning Operations and Pruning"**

5.3 Harvesting Operations
Refer to **"Harvesting Guidelines".**

6 Economics
Despite serving for all the other forest functions, forestry aims to make a profit. This is the point where a lot of environmentalists start to complain - and there are good reasons for since in many countries the forestry sector was or still is characterized by corruption and a bad, not sustainable management. It was very often a mere exploitation not taking biodiversity and sustainability into account. Refer to **"Economics"**

7 Forest Protection
Since in each country fauna and flora is different, guidelines for forest protection have to be developed separately incorporating the respective national biodiversity regulations and laws. The following can serve only as an example. Refer to **"Forest Protection Guidelines".**

7.1 Forest Fire Management
Most of wildland fires are man- made. Therefore, the conclusion to emphasis on forest fire prevention becomes obvious. Refer to **"Forest Fire Fighting Guidelines".**

8 Recreation
On most of the countries the access of citizens to the forest is regulated by the respective Forest Law. All people should have the right to enter the forest for recreational purposes. Therefore all attractive sceneries, e.g. springs, waterfalls, nice views, lakes, etc., should be made public for the citizens. Refer to **"Recreation Guidelines"**

9 Education

9.1 Forestry Sector
In most of the developing countries presently Forest Officers (FO) with practical management experience and Qualified Forest Workers (FW) are lacking. The foundation of a "Forestry Training Center" in these countries is highly recommended. Refer to **"Education Guidelines for the Forestry Sector".**

9.2 Citizens and School Students
A forest administration has the duty to inform its citizens about their environment, forest functions, problems in the forest and restrictions. The main goal is creating awareness and sensitization for environmental issues. Refer to **"Education Guidelines for Citizens and School Students".**

10 Pasture Management
Opposite to the number of wildlife, the number of livestock in many countries, roaming through the forest is much too high. This leads to excessive browsing on natural regeneration. Without controlling this roaming livestock, a sustainable forest management is not feasible.
Refer to **"Guidelines for Pasture Management".**

11 Ergonomics and Work Safety
Work in the forestry sector is besides mining and oil drilling the most dangerous operation worldwide. To prevent accidents and to keep forest workers healthy, refer to "**Guidelines for Ergonomics and Work Safety**".

12 Set-Up and Duties of Forestry Departments
There are many different names used, e.g. Forestry Department, Forest Department, Forestry Authority or Forest Agency, for an administration with the task to manage a country's forests. Whatever it is named, these administrations are fully responsible to their governments and the public for the sustainable management of their forests. Refer to "**Set-Up of Forestry Departments and Staff".**

Management Planning for Implementers

To carry out a sustainable management in your forests, just follow the steps of this Management Planning Guidelines in succession. At a later stage all activities should be documented in a Forest Information System (FIS) based on a GIS program.

II. Forest Zoning

Glossary

FD. . . . . Forest Department
FDis . . . . . Forest District
FMP . . . . . Forest Management Plan
FSC . . . . . Forest Stewardship Council
FPIC . . . . . Free, Prior Informed Consent
GIS . . . . . Global Information System
Ha/ha . . . . . Hectare
HCV . . . . . High Conservation Value
HCVF . . . . . High Conservation Value Forest
MCPFE . . . . . Ministerial Conference of Protection of Forest in Europe
Mgt.. . . . . Management
M.R. . . . . Management Regime
NTFP . . . . . Non Timber Forest Products
PD. . . . . Production
PT. . . . . Protection
R. . . . . Recreation
SE. . . . . Socio-Economic
W . . . . . Welfare

This chapter is derived primarily from all the publications listed under 7. References

1. Purpose and Definitions

Forest zoning is one of the first steps in management planning. It assures the delineation of forest land according to its functions. It generates quantitative (ha) and qualitative (protection, production etc.) results which are the basis for following management planning and management options.

1.1 Definition Zoning:

Zoning refers to a landscape approach in which the overarching forest functions are defined and priorities for forest complexes are outlined. Forest categorization is a bottom up process in which individual stands or larger units are classified according to specific values and functions which are intrinsic (biodiversity and soil protection) and extrinsic (cultural and economic) in its nature. All forest can and should serve more than one functions in order to provide the best possible provision of all functions over the country.

1.2 Objective and Scope of the Directive

The objective of this zoning directive is to guide and regulate the quality and intensity of human interaction (i.e. forest use and extractive action) with forest. It applies for all kind of forest land (public and private). Forest land can be set aside permanently or temporarily for specific purposes, e.g. for protection, production, hunting or recreation, following the zoning classification and according rules and regulations listed below.

2. Forest Functions

2.1 Protective Functions

Protective forest functions can be separated according to the “Ministerial Conference on the Protection of Forest in Europe” (MCPFE) criteria and indicators or to the “High Conservation Values (HCV) issued by FSC and the HCV Resource network (HCVF). Both systems are possible, but HCVF has some advantages since it provides a practical method/toolkit which defines and determines high conservation values. They alongside with their respective sub-units are individually developed so that each HCV contains following elements:

- Introduction of each HCV. This includes a general discussion, with examples of what is intended to be included (and excluded) within each HCV. It also identifies the elements that a HCV consists of and explains the importance of each element;
- A rationale is given for each element, which provided the requirements that have to be taken to define each element at the national or regional level;
- Guidance on the preliminary and full assessment required for each element, in order to facilitate the HCVF identification process. The preliminary assessment acts as a coarse filter, to rapidly exclude forests that clearly do not contain a particular value and save time and expenses involved in a detailed analysis. This preliminary assessment is clear and simple and does not require the use of complex data or highly technical information, preventing the process from being an unnecessary burden on forest managers.
- Guidance on how to define the HCV for each element. Defining HCVs requires two steps:
  - The first step is to compile the information necessary to identify important values within the country or region.
  - The second step is to set the threshold levels for each value. On the basis of the above, a value asserts itself as a High Conservation Value;
- A manual-toolkit should provide the guidelines on how to develop a specific, more detailed and clear interpretation with specific reference to the social, economic, and environmental conditions of the respective country. Additionally it can serve as an example for national forest managers, working in areas which have not yet been identified nor approved, on how to interpret the global definitions and apply them to their local environment. Finally the manual-toolkit should provide a detailed explanation and methodology for the definition of the six HCV types defined by the FSC, and provides recommendations in regards to the required management and monitoring methods for each HCV type. For the time being the generic toolkits and guidance of FSC and the HCV resource network are considered to be an acceptable base to work on.

2.3 Productive Function

Productive Function refers to the economic and sustainable production of the raw material “wood”. Productive Forests are forest areas in which a sustainable harvest based on an allowable cut defined in the Mgt. Plan is reasonably possible without jeopardizing the protective and socio-economic functions of the forest ecosystem.

This means in practice, that harvesting is principally possible to the extent defined by the increment and production potential of the forest. Yet the harvesting has to be done within the framework of an approved Mgt. Plan and a necessary documentation is required. This applies for timber, firewood as well as for non-timber forest products (NTFPs).

2.4 Socio-economic Function

The terminology shows that the third category focuses on the socio-economic function and the services that forests provide to the society. Unlike the remunerated products of productive forests the socio-economic functions of forests are often consider to be commons and as such to be provided for free to the users. This applies especially for recreation and tourism, but also for provision of fodder and food if it is consumed by

local animals or collectors. In addition the provision of firewood at nominal rates can be considered to be a social function although the economics of this should be discussed separately from the functional categorization of forests. In any case the envisaged discussion will have to define if carbon sequestration is a part of the productive function as the accumulated carbon may be an environmental service that is provided to the global and country society for free or whether this will be remunerated.

Detail criteria have to be worked out in joint discussions with a working group. Already existing local categories of green zone forests and recreation forests should be integrated in the socio-economic forests with specific management restrictions in urban or rural context as far as necessary.

2.5 Multiple Forest Function Scheme

For every function area, the 3 forest functions, production (PD), protection (PT) or socio-economic (SE) must be evaluated and justified. The SE function is further divided in welfare (W) and recreational (R) functions. One of the 3 functions must be defined as the lead function. The function of highest public interest shall become the lead function. A preliminary assessment may be given from the existing categorization of existing management plans. This category however will have to be crosschecked at latest in the process of the next management planning exercise. In this way a vacuum on the functional classification is avoided.

The productive function is not subject to a multilevel evaluation and shall be the lead function if none of the other 2 functions (PT, SE) is set. In other words, if a forest area is not entitled to protection- or socio-economic function, it belongs automatically to the production function.

The avoidance or reduction of dangers to life, the importance of forest functions for the national economy and the frequency of visitors can serve as criteria for the public interest. In the case of forests with an object protection function, the economic value is a fictitious value that is derived from saving expenses for protective constructions.

The value shall be represented numerically and express the degree of public interest in the respective forest function. One of the following grades shall express the value of the protective, welfare and recreational functions:

Table 1: Degree of Public Interest

Value	Importance	Degree of public interest
0	none	No specific public interest
1	low	Public interest
2	medium	Increased public interest
3	high	Special public interest

If two or even all three functions are assigned the highest value (3), the following order shall apply for determining the lead function: protective function comes before socio-economic function and productive function. In such a case, the lead function of this function area will be the protective function. Functions even with lower importance may result in limitations of the lead function (e.g. a protection function importance 1 in a forest area with lead function production can restrict certain operations or is requiring the prior communication with *or* permission from the supervision authority). This has to be reflected during the Mgt. planning process and in the respective Mgt. Plan. This can apply for any measure as harvesting, hunting, extraction of NTFP products, application of insecticides, forest road construction, etc.

The evaluation of the individual functions (PT, W, R) within one functional area is carried out by assigning a three-digit value number where the digits have the following meaning (see table 2).

For the new assessment a guideline for the definition of public interest in various aspects will have to be elaborated to avoid ambiguity (refer to *MCPFE and HCV criteria and indicators)*.

3. Management Regimes (M.R.)

3.1. The ubiquitously valid principle of Sustainable Forest Management (SFM)

Definition SFM adopted by the MCPFE:
The stewardship and use of forests and forest lands in a way and at a rate that maintains their biodiversity, productivity, regeneration capacity, vitality and

Table 2: Examples of Value Numbers

Value Number (e.g.)	Lead function	Protective function (PT) – hundred's place	Welfare function (W) – ten's place	Recreational function (E) – unit's place
321	PT	3 = special public interest = high importance	2 = increased public interest = medium importance	1 = public interest = low importance
121	P (Production, because none of the other 3 functions has the value 3)	1	2	1

their potential to fulfil, now and in the future, relevant ecological, economic and social functions, at local, national and global levels, and that does not cause damage to other ecosystems.

SFM should be the general rule for all Forestry on all forest land, defined in guidelines still and based on international standards, e.g. below.

3.2. Management Regime principles, rules, limitations and prohibitions with Protection Function as lead function

HCV – 1: Species diversity

Concentration of biological diversity including endemic species, and rare, threatened or endangered species, which are significant at global, regional or national levels.

Recognizing significant values in practical terms:

Significant values are those recognized as being either unique, or outstanding relative to other examples in the same region, because of their size, number, frequency, quality, density or socio-economic importance, on the basis of existing priority frameworks, data or maps, or through field studies and consultations undertaken during the HCV assessment.

Endemic species are those which are only found within a restricted geographical region, which may range from a unique site or a geographical feature (such as an island, a mountain range or river basin), to a political boundary such as a province or country. Endemic and range-restricted species are particularly vulnerable to threats as they have a limited distribution and may have smaller populations than widespread species. Endemism only generally triggers HCV status if the population is also nationally significant. The scale of endemism (e.g. national and regional) needs to be agreed.

Note that for HCV 1, 2, and 3, the values need to be significant at a national or regional scale (or higher).

HCV – 1a: Protected areas

- Strictly protected areas for the purpose of scientific research
- Strictly protected wildlife areas
- Recommended 300 m wide protective forest strips around strict protected areas (Nature Reserves, National Parks);

HCV – 1b: Endangered species and species under threat

- Endangered species of flora and fauna
- Related biotopes and habitats
- Nature monuments
- Over-mature trees;
- Virgin or slightly modified forests;
- High productivity, sample and reference (genetic reservation) value, slightly modified or virgin forests;
- Places of permanent sample areas in the forests for eco-monitoring;

HCV – 1c: Endemic species

- Species listed in the IUCN Red List as vulnerable, endangered or critical endangered.
- Endemic means species that are endemic to the respective eco-region.

HCV – 1d: Important temporary concentrations

- Sites that are used seasonally or temporally by major concentrations of species for feeding, breeding or shelter and refuge from adverse climatic events.
- Migratory sites, migratory corridors and wintering sites

HCV – 2: Landscape-level ecosystems and mosaics

Large landscape-level ecosystems and ecosystem mosaics that are significant at global, regional or national levels and that contain viable populations of the great majority of the naturally occurring species in natural patterns of distribution and abundance.

A literal and scientific interpretation of the HCV 2 definition recognizes that the great majority of species are organisms such as insects, plants and fungi, some of which would be viable within even fairly small areas. It must be recognized that conservation efforts often have a bias towards larger, more charismatic species, particularly mammals and birds – in part because they are more studied.

HCV 2 was designed to give some explicit protection to large and adequately-intact forests (valuable for their own sake since they are in a steady decline), and also for the sake of the species that require very large areas of natural forest to maintain themselves. The intent is that large landscapes need to be protected for their own intrinsic value and for viable populations of the species that depend on them.

The following would qualify as HCV 2:

- Large areas (e.g. could be greater than 50,000 ha, but this is not a rule) that are relatively far from human settlement, roads or other access. Especially if they are among the largest of such areas in a particular country or region.
- Smaller areas that provide key landscape functions such as connectivity and buffering (e.g. protected area buffer zone or a corridor linking protected areas or high quality habitat together). These smaller areas are only considered HCV 2 if they have a role in maintaining larger areas in the wider landscape.

- Large areas which are more natural and intact than most other such areas.

HCV – 3: Ecosystems and habitats

Rare, threatened, or endangered ecosystems, habitats or refuges.

The following would qualify as HCV 3:

Ecosystems that are:

- Naturally rare because they depend on highly localized soil types, locations, hydrology or other climatic or physical features, such as some types of limestone karst forests, inselbergs, mountain forest, or riverine forests in arid zones.
- Anthropogenic ally rare, because the extent of the ecosystem has been greatly reduced by human activities compared to their historic extent, such as natural seasonally flooded grasslands on rich soils, or fragments of primary forests in regions where almost all primary forests have been eliminated.
- Threatened or endangered (e.g. rapidly declining) due to current or proposed operations.
- Classified as threatened in national or international systems (such as the IUCN Red List of Ecosystems).

HCV – 4: Ecosystem services

Basic ecosystem services in critical situations including protection of water catchments and control of erosion of vulnerable soils and slopes.

Ecosystem services are the benefits people obtain from ecosystems, including provisioning services such as food and water; regulating services such as regulation of floods, drought, land degradation, and disease; cultural services such as recreational, spiritual, religious and other nonmaterial benefits; and supporting services such as soil formation and nutrient cycling; and cultural services such as recreational, spiritual, religious and other nonmaterial benefits. Such basic services become HCV 4 in critical situations:

Critical situations

An ecosystem service is critical where a disruption of that service poses a threat of severe, catastrophic or cumulative negative impacts on the welfare, health or survival of local communities, on the functioning of important infrastructure (roads, dams, reservoirs, hydroelectric schemes, irrigation systems, buildings, etc.), or on other HCVs.

The concept of critical situations relates to:

- Cases where loss of or major damage to an ecosystem service would cause serious prejudice or suffering to recipients of the service either immediately or periodically (e.g. regulation of water provision during critical drought periods), or
- Cases where there are no viable, readily available or affordable alternatives (e.g. pumps and wells) that can be relied on if the service fails.
- It may be useful to think about HCV 4 as supporting and regulating services in critical situations. Provisioning and cultural ecosystem services overlap more directly with HCV 5 and 6 which are treated in more detail in later sections.

The following situations may indicate the presence of a likely HCV 4:

- Remote and/or poor rural areas where people rely directly on natural resources to supply most of their needs, including water
- Upstream of extensive or important wetlands, fish nurseries and spawning grounds, or sensitive coastal ecosystems (e.g. mangrove forests, coral reefs etc.)
- Upstream of important municipal water sources
- Steep or mountainous areas, or areas of high rainfall, where the risk of catastrophic erosion is high.
- Where there is naturally low soil fertility, especially on sandy, peaty or fragile soils, where land clearance, drainage, use of heavy machinery or other intensive land use might affect soil structure and fertility.
- Arid or dryland areas particularly susceptible to erosion and desertification.

HCV 4, 5, and 6 are significant to the communities that rely on them

– so they are not relative to any scale but absolute in their irreplaceability to that community.

- Noise protection forests
- Climate protection
  - Air quality and purity
  - Micro forest climate
  - Protection against winds, and the regulation of humidity, rainfall and other climatic elements.

HCV – 4a: Forests important to water courses

- Managing extreme flow events, including vegetated riparian buffer zones or intact floodplains
- Maintaining downstream flow regimes
- Maintaining water quality characteristics
- Provision of clean water, for example where local communities depend on natural rivers and springs for drinking water, or where natural ecosystems play an important role in stabilizing steep slopes. These two values frequently occur together and the area which provides the critical services (water provision and erosion control) may overlap partially or completely.
- Water protection
  - Ground water formation and recharge zones
  - Water quality
  - Water shed
  - Recommended 200 m protecting strips along the rivers, forest strips existing around lakes, water reservoirs and water bodies
  - Forest strips protecting spawning areas with special protective value, along the rivers;

- Forest districts, existing around wetlands, river hears, spring hears and glaciers;
- Forest strips contributing to prevention of formation of mudflows; river bank-protecting strips for prevention of mudflows;
- Floodplain forests;
- Forest strips around existing mineral and thermal waters of healing qualities.

Recommended regulations on Water Protecting Strip:

- 1. Length up to 25 km – 10 meters.
- 2. Length up to 50 km – 20 meters.
- 3 Length up to 75 km – 30 meters.
- 4. Length over 75 km – 50 meters.

HCV – 4b: Forests important for erosion control

- Protection of vulnerable soils, aquifers and fisheries
- Erosion risks
  - Soil sensitivity
  - Rock formation
  - Geological formations
  - Grasslands providing buffering against flooding or desertification
  - *Steepness, no harvesting operations above 35° slope*
  - *Forest strips existing around avalanche formation and downstream;*
  - *Anti-erosion forest strips of particular importance;*
  - *Protecting forest strips against landslides;*
  - *Forest district, existing around landslides, rock fall- and exposed areas;*
  - *Recommended 300 m protecting strips of subalpine forests;*
  - *Recommended 50 m protecting strips of forest edges;*
  - *Recommended 100 m protecting forest strips existing on limestone and cave formations and around them; protecting strips of forests, existing around natural hollows;*
  - *Forests, represented on the cliffs, cliff projections and rock piles;*
  - *Forest areas on the grounds sensible towards the impact of wind and water;*
  - *Forest districts, existing around deep ravines, canyons, precipices;*
  - *Forest districts, existing around rehabilitated or abandoned quarries;*
  - *Protective forest strips existing around snowdrifts and windy areas;*
  - *Forest strips intruded into areas without forest cover;*
  - Forest areas up to 100 ha represented on bare areas;
  - Forest areas existing around travertine and beginnings of natural springs;
  - Forest areas existing on inversion slopes.

HCV – 4c: Forests presenting important fire barriers

- Forests, wetlands and other ecosystems which provide a protective barrier against destructive fires that could threaten communities, infrastructure or other HCVs.
- Fire prevention and protection
- Forest areas with anti-fire purpose;
- Forest areas existing around burnt areas.

HCV – 5: Community needs

Sites and resources fundamental for satisfying the basic needs of local communities or indigenous peoples (for example for livelihoods, health, nutrition, water), identified through engagement with these communities or indigenous peoples.

It is important to ensure that HCV 5 resources are not abruptly restricted without a transition plan with suitable alternatives identified using participative methods, and ideally with a full Free, Prior Informed Consent (FPIC) process.

The following indicate a high likelihood of HCV 5 in the area:

- Access to health centers or hospitals is difficult,
- Most houses are built from, and household tools made from, locally available traditional / natural materials,
- There is little or no water and electricity infrastructure
- People have a low capacity to accumulate wealth (living “day to day”)
- Farming and livestock raising are done on a small or subsistence scale
- Indigenous hunter-gatherers are present
- There is presence of permanent or nomadic pastoralists
- Hunting and/or fishing is an important source of protein and income
- A wild food resource constitutes a significant part of the diet, either throughout the year or only during critical seasons

The following can qualify as HCV 5:

- Water sources necessary for drinking water and sanitation
- Items which are bartered in exchange for other essential goods, or sold for cash which is then used to buy essentials including medicine or clothes, or to pay for school fees.
- Areas for collection of non-wood forest resources;
- Areas for collection of wild fruit and berries by local community;
- Areas for collection of leaf vegetables, plants for pickling, seasoning-flavoring- dressing plants and edible mushrooms;
- Forest areas with high concentration of the best honey plants;
- Forest areas for nesting of Georgian endemic bees;

- Traditional tree-based bee-keeping forests;
  - Pollination services, for example exclusive pollination of subsistence crops provided by native bees where the pollinators are dependent on the presence of suitable forest habitat and do not survive in purely agricultural landscapes.
- Forest areas rich of medicinal herbs;
- Fishing areas;
- Forests with wild plants, used in production of traditional garments, household items, decoration of living environment;
- Forests with plants containing coloring and astringent (tannin-based) matters;
- Forest areas represented by plants for baskets, wicker-work, tying up, fencing, making pillows, mats, brooms;
- Forests important for the use of wood resources:
  - Forest areas intended for special fire-wood use for the part of the village community which doesn't have any other means of alternative heating;
  - Forest areas intended for reserve fire-wood use, where use of resources shall be permitted if, in extreme situation, local community doesn't have other energy resources;
  - Forest areas to be used for utilization of timber and fire-wood for agricultural and ritual purposes, for constructing roves, including coppiced forest stands.
  - Forest areas intended for obtaining timber for the purpose of construction of houses or other personal use.
- Forests with recreational, climate regulating, sanitary-hygienic and other properties having particular value for population;
- Forests of significance for balneology(forests existing around resort areas of various kinds);
- Forest strips, existing around holiday homes, children's camps and medicinal and recreational establishments;
- Forest strips existing around tourist tracks of national and regional importance;
- Forests existing around suburban areas, summer cottages and settlements;
- Green zone forests.
- *Forest areas located around special purpose objects:*
  - Protective forest areas existing around communication facilities;
  - Protective forest areas existing around railroads and motor roads;
  - Protective forest areas existing around water head-facilities;
  - Protective forest areas existing around hydronods and canals;
  - Protective forest areas existing around pipelines;
  - Protective forest zones of power transmission communications;
  - Protective forest strips existing around cableways and skiing routes;
  - Cattle routes and forest strips existing around them.

HCV – 6: Cultural values

Sites, resources, habitats and landscapes of global or national cultural, archaeological or historical significance, and/or of critical cultural, ecological, economic or religious/sacred importance for the traditional cultures of local communities or indigenous peoples, identified through engagement with these local communities or indigenous peoples.

HCV 6 Indicators:

- UNESCO World Heritage sites
- Museums, heritage lists, national data sets, authorities and any organizations which specialize in particular geographic areas or cultures
- National directives concerning archaeological sites and resources
- Consultation with anthropologists, historians, archaeologists, museums and databases for identification of "sites of global or national significance".

The following would qualify as HCV 6:

- Sites recognized as having high cultural value within national policy and legislation.
- Sites with official designation by national government and/or an international agency like UNESCO.
- Sites with recognized and important historical or cultural values, even if they remain unprotected by legislation.
- Religious or sacred sites, burial grounds or sites at which traditional ceremonies take place that have importance to local or indigenous people.
- Plant or animal resources with totemic values or used in traditional ceremonies.
- Quiet locations and reproduction areas of game-reserves and recommended 100 m protective forest zones existing around them;
- Shrine forests, sacred and ritual places, old graveyards, tombs and remnants of towns, destroyed or abandoned villages, and forest strips located around the paths leading to ritual places; stations of ancient people, battlefields; places of archeological value, forest stands existing around historical- cultural and archeological monuments; forests located around leisure and feasting places around the springs and their sources; places of religious purpose (places where sacred trees grow, spiritual places, springs with sacred water, sacred stones, hills of honor, places of sacrifice, myth-related places);

3.3 Management Regime principles, rules, limitations and prohibitions with Production Function as lead Function

Sustainable forest management has to follow international standards set in the respective guidelines listed below (refer to "Improved Pan-European Indicators for Sustainable Forest Management"). Adherence to set standards should become compulsory for everybody involved in any forest operations.

1. Manageent Planning and Management Goals
2. Zoning to Forest Functions
3. Opening-Up Systems
   3.1 Basic Road Network
   3.2 Opening-Up Road Network
4. Inventory and Forest Record Book
5. Silvicultural Guidelines
   Forest seed plantations, seed areas and places of concentration of mother trees;
   Experimental, sample or model areas for forestry activities;
   Geographical and experimental forest plantation areas;
   5.1 Stand Establishment
      Guidelines for Stand establishment
      Forest-gardens and forest areas allocated for designed forest-gardens.
   5.2 Tending operations
      5.2.1 Pre-commercial Thinning Operations
      5.2.2 Thinning Operations
   5.3 Harvesting Operations
6. Protection
   6.1 Forest Fire Management
7. Recreation
8. Education
   8.1 Forestry Sector
   8.2 Citizens and School Students
9. Wildlife Management
10. Livestock / Pasture Management
11. Ergonomics and Work Safety in Forestry
12. Monitoring & Evaluation

3.4 Management Regime principles, rules, limitations and prohibitions with Socio-Economic Functions as lead Function

Definition of areas with social rights and needs during the zoning process:

E.g. for firewood production, NTFPs as Christmas trees, mushrooms and truffles, fruits, game products, snails, ornamental plants, honey, cork, medicinal or colorant products, seeds of forest tree species and fodder and grazing for livestock. (Refer to Guidelines for Pasture Management and HCV-5)

4. Identification

4.1 Strategic ('Top Down') Identification of Forest Functions

4.1.1 By Law or Directive or through otherwise existing rights

Using the precautionary approach:

The Precautionary Approach means that when there is a threat of severe or irreversible damage to the environment or a threat to human welfare, responsible parties (Governments, Ministries, FDs) need to take explicit and effective measures to prevent the damage and risks, even when the scientific information is incomplete or inconclusive, and when the vulnerability and sensitivity of values are uncertain.

- Forest Code (Law) of the respective country
- Environmental Protection Law of the respective country
- Soil Protection Law of the respective country.
- Water Protection Law of the respective country
- National Biodiversity Strategies
- Respective Management Guidelines
- Corresponding edicts

This top-down / strategic identification is usually carried out by GIS-referenced mapping, should be registered and made available to the public in an online 'Forest Portal". The identification process of HCVFs should be implemented by the Inventory Unit of respective FD during the Management Planning process for all forest land.

4.1.2 Forest Areas

The manual – toolkit for HCVFs is designed to be used in any landscape or forested area including private or institutional ownership or management, church- and municipality forests, areas under license and other areas.

The first thing to do is select a forest area that is being managed, and then, secondly, via the utilization of this manual evaluate the threshold value presence of the HCVs. The third task is to delineate a management regime required which will enable the maintenance and improvement of the identified HCVs. The last step is the implementation and adherence to the HCV monitoring protection program.

In order to summarize the process for establishing HCVF presence consists of four straightforward steps:

4.1.3 Identification of HCVF:

The lead assessor or manager needs to collect enough information to make a preliminary judgement on the likely HCVs to be found and the likely impact of operations – this will guide decisions on assessment team composition and data gaps to be addressed, and the scale of consultation required for the assess-

ment. The initial data gathering should aim to cover the following:

a. Location and size of the project area (e.g. management unit, concession, plantation).
b. Land use and land cover classification
c. Land tenure and ownership
d. Landscape context, including land and resource use – both small scale or industrial
e. scale (e.g. settlements, forestry, agriculture, infrastructure) surrounding the project area
f. Presence and status of a regional land and resource use plan
g. Presence and condition of protected areas in the landscape.
h. Distribution and connectivity of ecosystems across the landscape and barriers affecting
i. movement into and out of the assessment area
j. Soils and geology
k. Watershed maps and criticality of area for maintaining water supply and quality.

Decide if the forest under management contains some HCVs. It is worth noting that valuable information for practitioners in the identification of HCVF value presence is included in this manual. Any type of forest, high or coppice, natural or artificial, can be potentially considered as a HCVF. An example of a HCV is: Plantations of introduced conifers set up for the purpose of wood supply for wood pulp industry can become high conservation value forests if their recreational or other sociological values become primary ones. Similarly, cultivated forest areas or low degraded forests, which preserve soil from washing out and erosion, can also be considered as a HCVF. HCV are those structural elements and functions of forests (rare, endemic and relic species; endangered plants, animals and fungi; endangered habitats and ecosystems; upper vegetation belt etc.) whose values deserve special concern in order these values to be permanently conserved and improved.

4.1.4 Consultation:

Stakeholder consultation is valuable to:

1. Help the assessor evaluate whether a certain value is present.
2. Help the manager (or consultant) design a proper management regime for maintaining the value.
3. Inform local stakeholders that a value is present and that certain measures may be necessary to maintain that value, e.g. set-asides or no-hunting zones.
4. Identify stakeholders, who will be directly affected by or bear the cost of a potential activity (e.g. forestry, agriculture, etc.)
5. Common examples include:
   a. Local communities who use ecosystem products or services
   b. Organisations and institutions that represent these communities (above)
   c. Those whose legitimate commercial use of the natural resources will be altered by development activities
   d. Environmental and social organisations, academics and researchers that represent the wider public and/or have an interest in the way the ecosystems are managed
   e. Government bodies will always need to be kept informed of discussions even if they are not directly affected

According to the FSC criteria 9.2, the identification and management of HCVF needs to be conducted in agreement with all vested parties. The consultation process is useful for any forest owner, since they can count on stakeholders' wide knowledge and experience which will ensure better informed decisions on HCVF identification and the subsequent management.

4.1.5 Management of HCVF:

The most frequent question regards the management technique which needs to be applied in order protect the HCVF. The answer to this question is not unilateral as it much depends on which HCV element is present. It must be taken into consideration that forests and the values that they each contain are unique and very unpredictable. In light of this it is important to evaluate each case singularly bearing in mind their specific area characteristics as it is impossible to provide general management principles for each and every forest environment. As a result of this, this manual includes essential generalized management recommendations which can assist practitioners on managing HCVFs adequately. This also signifies that Forest Departments / forest companies are expected to employ the forest management regimes that will maintain each identified HCV, by taking into consideration local conditions, resources and existing knowledge.

4.1.6 Monitoring

(s. Chapter III)

4.2. Identified by rule of law, to be applied on all forest land, and to be locally specified (registered ('Bottom-Up') in the FMP or corresponding documents)

4.2.1 By Ubiquitously Applying Rules in order to regulate human forest use, interference, extraction of forest products under specific geographical/natural conditions:

All human forest use has to follow rules and regulations under the respective Forest Management Plans, where zoning and management standards are incorporated, for each Forest District, compartment and sub-compartment, the smallest management entity.

These rules come into force from the day of approval and publication of this directive. An additional specific mapping, registration and publication (on the Forest Portal) of those forest areas which fall under these rules have to be implemented particularly through decadal Forest Management Plans. The establishment or any change of the zoning (i.e. change of lead to secondary function) has to be in accordance with the principle of SFM and HCV criteria. Their establishment and any corrections have to be approved by the Inventory Unit of respective Forest Department and the Forest District Offices, or the environmental protection authority, as far as zoning of the protection function is involved. For each sub-compartment all activities, e.g. allowable cut, harvesting system, protected areas (according to HCV), set timeframe for uses, obligations and restrictions, are clearly defined in these FMPs.

Examples:

1. Forest-Area Slopes > 35°
   Defined in the respective guidelines and FMPs.

2. Forest Space (forest lots or forest extensions) near springs, creeks, rivers (running waters), ponds and lakes and standing freshwaters
   Defined in the respective guidelines and FMPs.

3. Forest Space above and near natural monuments, geological specific formations such as caves, karst, at and near areas of specific biodiversity value (for reproduction, rest, and/or nourishment of endangered wildlife incl. plants)
   Defined in the respective guidelines and FMPs.

4. Forest Spaces whose removal, destruction or management may cause dangerous impact and hazard to human populations or objects
   Defined in the respective guidelines and FMPs.

5. Traditional hunting rights
   Defined in the respective guidelines and FMPs.

6. Others

5. Implementation and Control

5.1 Implementation

Implementation, enforcement and supervision is to be guaranteed by the local forest authority (FDis) according to rule of law, ensuring identification of functions in FMPs and their registration in the data-base (incl. Forest Portal Publication, GIS).

5.1.1 by law and GIS-based 'Strategic (Top-Down) Identification'

Management according to the existing Forest Code (Law) of the respective country, its degrees and regulations, including even this zoning directive.

5.1.2 by GIS-based identification of areas subject to rules (e.g. > 35° rule)

All information which can be identified via GIS has to be registered in the respective data-base and on maps for the entire country, region and Forest District.

5.1.3 through in-situ identification and mapping via Forest Management Planning or corresponding plans

All this GIS information together with ground surveillance data (Inventory) are the basis for the FMP which has to be developed for each sub-compartment and where all protected areas, nature monuments, restriction etc. are described and localized in a map.

5.2 Enforcement, Supervision and Control

5.2.1 During Forest and Forest Use Surveillance

Permanent monitoring and control by FD staff on all levels and reflection of findings in the next FMP.

5.2.2 Integrated part of Forest Management Planning

Monitoring HCVF: This is the essential part of any SFM system since it enables the FD / forest companies and forest owners to evaluate if the forest management goals are met and whether the applied system needs to be amended. As the HCVF element can be affected by the forest management applied, it is essential that it be constantly be monitored with special attention in order to identify any changes. Once more, it is not possible to provide detailed generalized instructions on how to monitoring each HCV, but within this toolkit, essential principles are provided to aid practitioners on how to implement a monitoring program.

5.2.3 During Forestry Operations

Assuring of any kind of operation according to approved FMP following SFM principles by FD staff on all levels according their respective job descriptions.

6. Zoning for Implementers

To get an overview about all the regulations mentioned above just follow the few steps listed below and zone your forest accordingly:

Zone 1: Protection forest (no or restricted management, refer to HCV-classes I-VI)

1.1 Steepness
Above 35° slope (70%)
1.2 Endangered species of flora and fauna
Related habitats
1.3 Erosion risks
Soil sensitivity
Rock formation
1.4 Water protection
Ground water formation
Water quality
Water shed
1.5 Noise protection
1.6 Climate protection
Air quality and purity
Micro forest climate
1.7 Nature protection
Habitats, biodiversity

Zone 2: Production forest

All other forest land which does not fit to the zones 1 and 4 can be considered Production Forest.

Zone 2.1: Close to nature forest management
Zone 2.2: Plantation forests, mixed plantations and forests considered to be converted into natural forest management.

Zone 3: Forests for community needs, welfare and recreation

3.1: Recreation forest

- Easily accessible (vehicle, hiking trail)
- Beautiful scenery and views
- Parking areas
- Recreational facilities (refer to related guidelines)
- Sports
- Recreation forests can be used commercially as long it still serves it purpose!

3.2 Education Forest

- Educational trails (refer to related guidelines)
- Forest Camps

All boundaries should be shown in a Mgt. Map, scale 1:25000 (min. 1:50000). A detailed zoning will be achieved during the final tree marking or planting operation, where the entire area will be assessed and all rare species of fauna and flora can be found and finally protected.
If necessary, for each sub-compartment a special Mgt.-Plan can be produced in which all necessary regulations for the protection and functions of a HCV can be described in detail.

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Forest Road Construction Planning in Hanui Province, China (Foto: P. Hess)

III. Opening-Up Systems

Guidelines for Forest Road Construction

Glossary

Camber	The gradient from the center of the road to the shoulders
FDis	Forest District
ft	Feet
GIS	Geographic Information System
GPS	Global Positioning System
GSS	Ground Skidding System
h	Hour
ha	Hectare
hp	Horsepower
km	Kilometer
LDCCS	Long distance cable crane system
m	Meter
Mgt.	Management
MOH	Machine Operating Hour
m^3	Cubic Meter
Right-of-way	Total width of the cleared corridor for the road construction

1. Introduction

For ecological reasons road densities should be kept to a minimum. However, a prerequisite for efficient forest management is an adequately established road network which facilitates the use of appropriate technologies for silviculture, tending and harvesting operations. In some remote areas, forest roads even may play an important role in rural development.

In many countries, forests in mountainous terrain are characterized by a very low density or a complete absence of forest roads.

In steep terrain with difficult topographic and soil conditions and especially in areas with high intensity rainfall, careful planning, surveying and construction of forest roads needs to be exercised. Established technical road specifications such as maximum gradients, road widths and drainage structures should be adhered to strictly. Full compliance to such standards and constructions methods is not possible in some countries since forest engineers, who can design, oversee and monitor forest road engineering activities are lacking.

Badly located and poorly constructed and maintained roads and skid trails lead to landslides, siltation, and local flooding thus greatly degrading the environment. Severe erosion can be avoided alone by preventing road construction in steep terrain with ground slopes above 50%.

Up to 90 % (this figure refers for Tropical Moist Forests only) of erosion in managed forests originates from the construction of roads and skid trails. (Hodgson, 1986)

24 % of the total erosion caused by logging roads could be prevented by conventional engineering methods (Mc Cashion and Rice, 1983).

These guidelines are intended to provide practical guidance to personnel involved in forest road construction. They describe the particular road classifications and the according standards, the planning procedure and finally the actual road construction.

2. Road Classification and Standards

2.1 Structural Parts of a Road

Forest roads, like major hard-surfaced highways, are engineering structures. All consist of two parts: the subgrade and the pavement, which is subdivided into the subbase-, base- and surface-layer. Some terms commonly used for various parts of the structure are shown in figure 1.

2.2 Road Classification

Generally, four types of forest roads can be classified:

Main Roads

Generally, main logging roads with the intention of integrating them into the public road network are planned and designed for facilitating the overall access to and through forest areas. They are the main artery of the road network, surfaced and designed for high travel speed and to absorb heavy traffic density. They are usually constructed as two-lane roads with a bearing capacity corresponding to two logging trucks, one loaded and one light to meet without reducing speed.

Main roads also serve for long-distance timber transport. They are part of the Basic Road Network and, hence, should be maintained permanently.

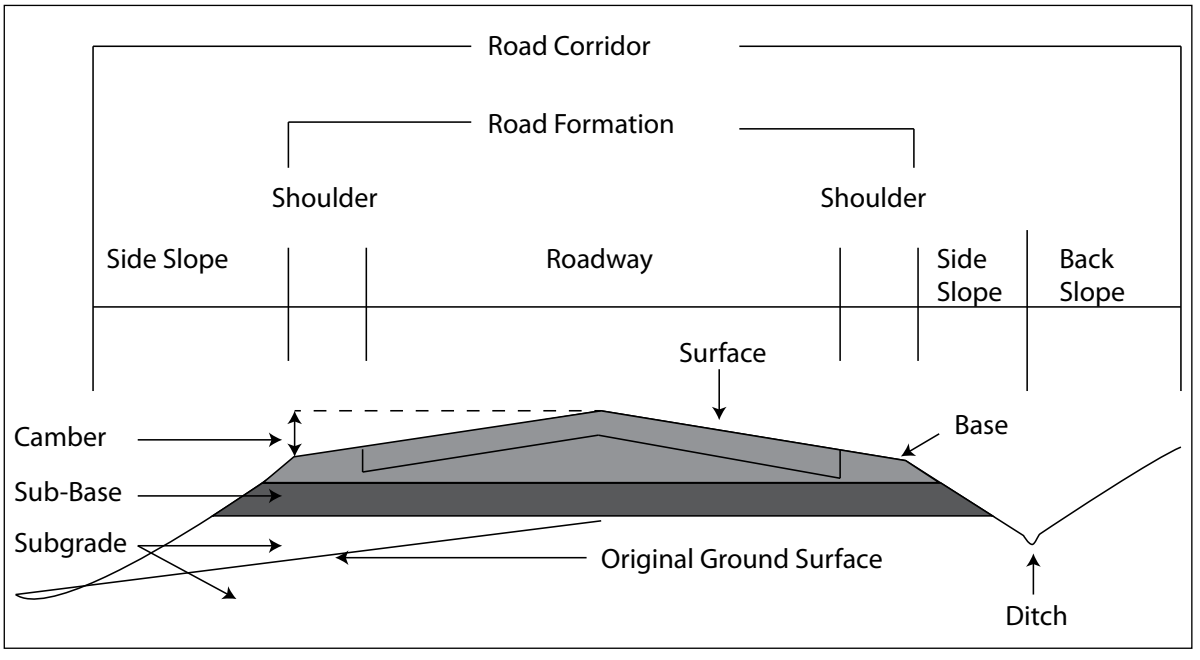


Figure 1 Typical Road Cross Section (Source: FAO, 1977)

Secondary Roads

Secondary roads are narrower than main roads. Vehicles can meet but loaded traffic has right of way and light vehicles must stop to allow loaded trucks to pass. They are one-lane roads, surfaced and connecting the feeder roads to the main road. They serve for timber extraction, general access, tending and forest protection purposes and are therefore part of the Basic Road Network. They should be maintained permanently.

Feeder Roads

Feeder roads are un-surfaced and built for temporary use only. They form the extremity of the entire Forest Road Network and are considered as part of the Opening -Up Network. The width of a feeder road is one lane with a sufficient number of meeting points to facilitate safe passing of loaded traffic.

Skid Trails

Unlike air-borne yarding systems, ground extraction relies on skid trails. The procedure for their planning, survey and construction is the same as for roads.

Their density varies according to the respective road density and logging equipment used. The distance between two skid trails has to be limited to 100 m, in extreme situations max. 200 m.

2.3 Road Standards

(see Table 1)

3. Planning

In general, all already existing roads should be integrated into the particular road networks to minimize the loss of forest land and erosion. Only in a few cases, where the road alignments are too steep and cannot be maintained economically, the construction

Table 1: Road Standards (* = adverse gradient for loaded truck (As far as possible never exceed 8% slope)

	Road Classes							
	Main Road		**Sec. Road**		**Feed. Road**		**Skid trail**	
Lanes	Dual lane		Single lane		Single lane		-	
Truck loads per day	> 50		up to 50		up to 6		-	
Designed speed (km/h)	50 - 60		25 - 40		15 - 25		-	
Width of road corridor (m)	20 - 25		15 - 20		12 - 15		8 - 12	
Tot. width of road formation (m)	9 - 12		8 - 10		6 - 8		4 - 5	
Width of road way (m)	7 - 10		6 - 8		5 - 6		4 - 5	
Width of road shoulders (m)	2 x 1 = 2		2 x 1 = 2		2 x 0.5 = 1		-	
Min. radius of curvature (m)	50		30		20		-	
Curve widening (m)	0.5		0.5		1		-	
Super elevation (ratio)	1 : 10		1 : 12		1 : 15		-	
Max. gradient (%)	6 (8)*		8 (10)*		10 (12)*		27 (18)*	
Min. gradient (%)	2		2		2		2	
Road camber - from center to the ditches % - to the hill-side only %	2 - 6		2 - 6		2 - 6		5	
Embankments (height to width) - hill-side - valley-side - rocky terrain	1 : 1 1 : 2 1 : 0.2 - 0.5		1 : 1 1 : 2 1 : 0.2 - 0.5		1 : 1 1 : 2 1 : 0.2 - 0.5		1 : 0.5 1 : 1 1 : 0.2 - 0.5	
Drainage - culverts - min. diameter (cm)	concrete 40		concrete 40		concrete 40		Surface cross drain	
Wooden bridges - min. width (m)	4		4		4		-	
Stabilization - sub-base (0/150) m^3/ 1 m of road - base (0/50) m^3/ 1 m of road - surface (0/30) m^3/ 1 m of road	1.0 - 4.0 0.6 - 2.0 0.6 - 1.0		0.5 - 2.0 0.3 - 1.0 0.3 - 0.5		-			
- Species	Pine, Norway Spruce, Larch, tropical hardwoods							
- Span (m)	10	11	12	13	14	15	16	17
- Bridge capacity (t)	Min. Diameter (cm)							
Truck with 3 axles cross-weight 32 t	59	63	67	71	75	79	83	86
Truck with 4 axles cross-weight 40 t	61	65	69	71	75	79	83	87
Truck with 2 axles cross-weight 43.5 t	65	68	71	75	78	84	86	90
Truck with 5 axles cross-weight 51 t	63	67	71	75	79	84	86	90

of a new road, or parts of it, can be considered more appropriate.

Planning of road networks comprises the following steps in succession:

- Timing
- Calculation of the optimal road density
- Forest Road Inventory
- Preparation of road maps
- Preparation of the Forest Road Record Book
- Determination of road and skid trail densities
- Determination of the Basic Road Network
- Determination of the Opening-Up Network
- Road Survey

3.1 Timing

Efficient logging operations as well as carrying out of inventories and silvicultural treatments require exact and proper planning and time scheduling. Road construction should be carried out well in advance (1 - 2 years) before logging or any other operations start. At least 6 months are required to give the subbase sufficient time to settle and the road surface to dry. Costs can be reduced by 15 - 20 %, when road construction is carried out during the dry months. Furthermore, planning of the road network ahead of logging operations can lower the road density by up to 11 % and steep grades by up to 73 % as compared to normal ad hoc construction methods (Satterlund, 1972). Especially the steep gradient sections of a road cause most of the wear and tear of haulage vehicles and produce delays in haulage time.

3.2 Calculation of the Optimal Road Density

The calculation of the arithmetic optimal road density for a particular License Area or FDis is an important step in planning the forest road network. The results, calculated on financial conditions only, show beside the optimal (theoretical) road density and the total transportation costs per m^3, the highest profit respectively the lowest loss for the entire harvesting operation in a certain time frame (depreciation of the road network) and for a certain area (License Area).

With the help of appropriate computer software (e.g. Excel) this calculation can be done easily.

The software is available with the author.

The next step then is to study alternatives within the range of the optimal road density.

(s. Table 2)

The table shows clearly that the lowest total transportation costs (TTC) per year and ha correspond with a road density of 5 m/ha. Therefore this density can be considered optimal.

The calculation is based on an AAC of 1 m^3/ha/a, interest rates of 8% and a depreciation time of 40 years. For further assumptions see appendix 1.

Table 2: Arithmetic optimal road density and total transportation costs for Deramakot Forest Reserve, Malaysia

RD (m/ha)	IC ($/ha/a)	MC ($/ha/a)	YC ($/ha/a)	AC ($/ha/a)	Yd ($/ha/a)	TTC ($/ha/a)
1	4.19	9.73	350.40	0.93	0.10	365.35
2	8.39	19.46	175.20	0.46	0.20	203.71
3	12.58	29.19	116.67	1.64	0.30	160.38
4	16.77	38.92	87.50	1.23	0.40	144.82
5	20.97	48.65	70.00	0.99	0.50	141.11
6	25.16	58.38	58.33	0.82	0.60	143.29
7	29.35	68.11	50.00	0.70	0.70	148.86
8	33.54	77.84	43.75	0.62	0.80	156.55
9	37.74	87.57	38.89	0.55	0.90	165.65
10	41.93	97.30	35.00	0.49	1.00	175.72
15	62.90	145.95	23.33	0.33	1.50	234.01
20	83.86	194.60	17.50	0.27	2.00	298.23
25	104.83	243.25	14.00	0.20	2.50	364.78
30	125.79	291.90	11.67	0.16	3.00	432.52

RD = road density (m/ha)
IC = investment costs ($/ha/a)
MC = maintenance costs for roads ($/ha/a)
YC = distance depending yarding costs ($/ha/a)
AC = additional costs ($/ha/a)
Yd = yield losses due to road construction ($/ha/a)
TTC = total transportation costs

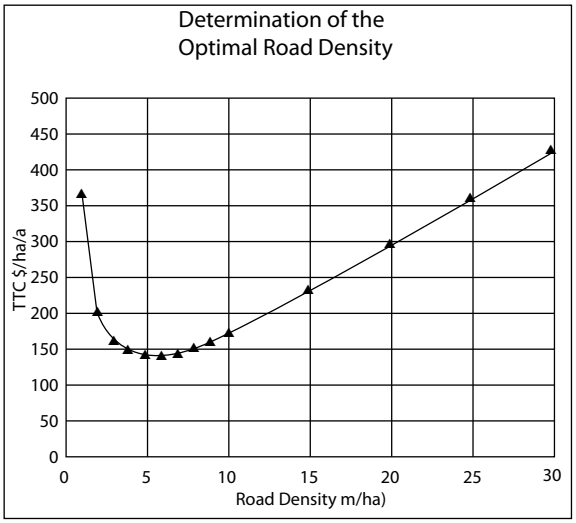


Figure 2: Determination of the Optimal Road Density

3.3 Forest Road Inventory

One of the first steps in the preparation of the Management Plan for a particular License Area or FDis is the road inventory. The purpose is to obtain a complete overview of the existing road network, its condition, the operation area and coupe boundaries, as well as the drainage structures. Before the field work commences, existing information like already existing road maps, reports, logging plans, aerial photos, satellite images etc. should be screened first.

The actual road survey is carried out with a GPS (Global Positioning System), while driving with an off-road vehicle on all accessible roads. (for GPS information see producer's manual).

At the same time other features i.e. road classification, name, location, road condition and the road length can be assessed using the "Forest Road Network Form" (Appendix 2). If a GPS is not available, the "Road Survey Form" can be used. (Appendix 3). Usually the existing road network becomes part of the Basic Road Network.

After tracking with the GPS is completed, the collected data are processed on a PC, transferred to a GIS (Geographic Information System) and edited (e.g. corrections, description of way-points etc.), before a first edition of a "Road Map" is produced with a GIS-plotter.

3.4 Road Maps

The road map is produced at a scale of 1:50,000. It comprises the entire FDis area and shows the following features:

- FDis area
- Main roads (tracked with GPS or planned)
- Secondary roads (tracked with GPS or planned)
- Feeder roads (tracked with GPS or planned)
- Impracticable roads 8digitized from aerial photos)
- Road numbers
- Road junction numbers
- Road length
- All Water courses
- Compartment boundaries

Table 3: Road, skid trail and cable corridor densities according to extraction system.

Inclination %	Harvesting System	Required Road Densities			
		Classification	**Density m/ha**	**Distances between roads/trails m**	**Average forwarding distance m**
0 – 30 (skid trails, not formed)	Motor manually / Tractor	Sec. Road Feeder Road Skid trail	3 8 500	3300 1250 20	825 313 5
30 – 55 (skid trails formed)	Motor manually / Tractor	Sec. Road Feeder Road Skid trail	3 8 100	3300 1250 100	825 313 25
55 – 70 (cable corridors)	Motor manually / cable crane	Sec. Road Cable Corrid.	3 100	3300 100	825 25
55 – 70 (Log lines)	Motor manually / hand work	Sec. Road Feeder Road Skid trail	3 8 500	3300 1250 20	825 313 5
55 – 70	Motor manually / Helicopter	Sec. Road	3	3300	825
> 70	Protection Forest	Sec. Road	3	0	0

- Bridges
- Contour lines

For the actual planning procedure, the road map should be enlarged to a scale of 1:10,000.

3.5 Forest Road Record Book

All the present information and future engineering works (maintenance, repairs) as well as costs will be entered into the "Forest Road Record Book", which gives an overview of the actual standard, planned operations and costs involved of a particular road at all times. The work sequence numbers correspond with chapter 4.2.

3.6 Road and Skid Trail Densities

The road- and skid trail densities according to the particular harvesting systems are shown in table 3:

3.7 Basic Road Network

Independent of any future management options a Basic Road Network is required. A road density of 3 m/ha has proven to be sufficient for general management and operations. A road density of 3 m/ha is equivalent to a road distance of approximately 3300 m (10,000/3m/ha). That means the average walking distance from the roadside into the stand is approximately 825 m (3300/4).

To facilitate the Inventory, this Basic Road Network has to be made accessible first for 4-wheel drive vehicles only. At a later stage it will be rebuilt to a main- and/or secondary road standard in accordance with the progress of operations. This will keep the initial costs at a minimum.

The planning area for the Basic Road Network is the entire FDis area.

3.8 Opening- Up Network

All further planning of the denser Opening-Up Network depends on the selected harvesting system for a particular sub-compartment (see table 3).The decision which harvesting system has to be applied is based on soil condition, inclination and the related erosion risks.

Survey and layout of the Opening-Up Network are carried out after the Basic Road Network has been finally located.

The layout of skid trails can be pre-laid on the Management Map (refer to chapter 3.9), based on optimum road density and average skidding distance calculations.

A copy of the Management Map, showing the pre-laid skid trails and landings as well as growing stock can be used as Harvesting Map.

Log landings should be kept as small as possible. Therefore a proper calculation of the expected harvestable volume is necessary. To avoid log landing at all, decking of logs alongside the road and loading with a crane is highly recommended.

3.9 Road Survey

The survey of roads comprises the following steps in succession:

- Reconnaissance of the planning area to study possible alternate routes, by locating control points such as boundaries, stream crossings, slopes, erosion hazards, rock formations etc.
- Determination of the optimal route by running preliminary grade lines (a few grade breaks only, slope grades can be maintained according to standards, min. erosion hazards)
- Final location by means of a grade line
- Designing the road according set road standards (see chapter 2.3)
- Staking out curves (s. below)
- Recording of soil conditions (texture, porosity and depth, parent material (source for stabilization materials and ground surface obstacles to logging).

Reconnaissance of the Planning Area

Road Maps, enlarged to a scale of 1:10,000, and additional features like contour intervals of 15 m or 20 m, stand type and growing stock can be used for planning road networks.

The main purpose of the reconnaissance is to determine control points. A control point is a point, or an area, through which the road should pass. These points have to be marked in the field with flag-tape. Subsequently they are marked on above mentioned road maps. With the help of a pair of compasses (divider) all alternate routes can be selected.

The width of the pair of compasses can be calculated as follows:

$$w = \frac{100 \times h}{p}$$

where: w = width of the pair of compasses
h = difference between contour lines in m
p = desired slope in %

Example:
h = 15 m
p = 6 %

$$w = \frac{100 \times 15}{6} = 250$$

250 m at a scale 1:12,500 = 2 cm (1 : 12,500 x 100 x 250m = 2 cm)

Connecting the contour intervals with a pair of compasses (width = 2 cm), one climbs or descends on that route with a gradient of 6%

A route can be considered optimal, where crossing of steep terrain or rock formations can be avoided, steep gradients and road lengths reduced and construction costs be kept to a minimum. (see Figure 3)

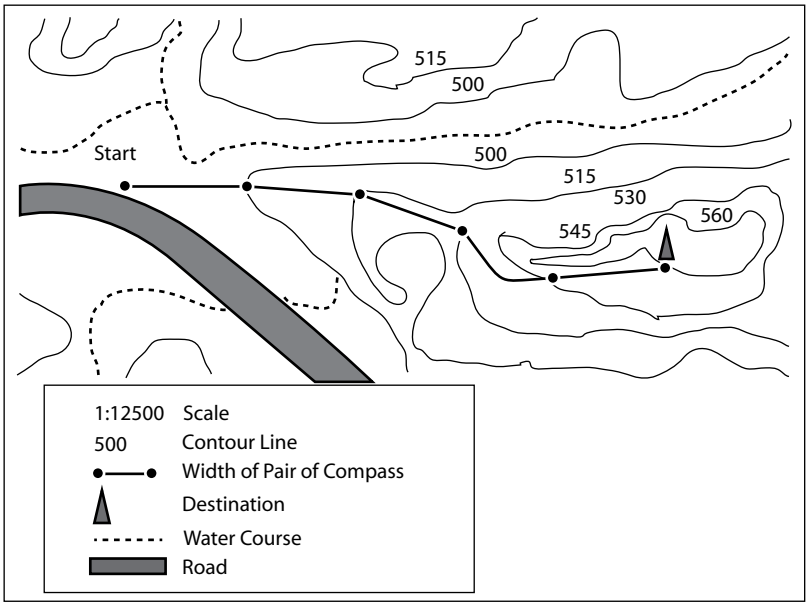


Figure 3: Selection of alternate routes

Grade lines

After the optimal route is identified, the location of the grade line can be selected. A Field Supervisor with the help of 2 laborers can survey a grade line of 0,6 to 1,0 km per day. With the help of a clinometer and a compass, the team joins one control point to the other, maintaining the set road standards. The route is marked with ranging poles first to allow adjustments and straightening, and finally with flag-tape on trees. Never mark grade lines by blazing trees, since these grade lines are often adjusted or even totally abandoned.

Material and Instruments

The following materials and instruments are used for road surveys:

- clinometer,
- compasses,
- flag-tape,
- ranging poles,
- measuring tape
- angle mirror.

Staking out Curves (s. Fig. 4)

A) Beginning and end of curve

1. For constructing a curve it is necessary first to determine the beginning (BA) and the end (BE) of the curvature:
2. The point TS, is where both tangents meet.
3. From this point the distance x (x should be larger than r) is chosen to get the points A and E.
4. In a right angle from these points the distance of the appropriate radius r is measured (s.2.3) to get the points A' and E'.
5. In a right angle from these points the point M is reached.
6. The measured distance y from point M to points A' or E' is laid out from point A and E in direction to TS to get BA and BE.

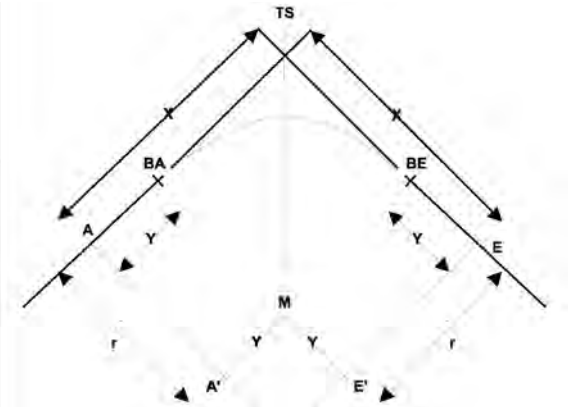


Figure 4: Determination of beginning and end of curve.

B) Open and flat terrain (s. Fig. 5)

To stake out a curvature in open and flat terrain the following method is used to get the required points:

1. Measure an appropriate distance x, according to table no. 5, from the points BA and BE in direction to TS to get the points 1, 2 , 3 etc.
2. Measure from these points at a right angle the corresponding distances (y1, y2, y3 etc.), to get the required points on the curvature according to table No.5.

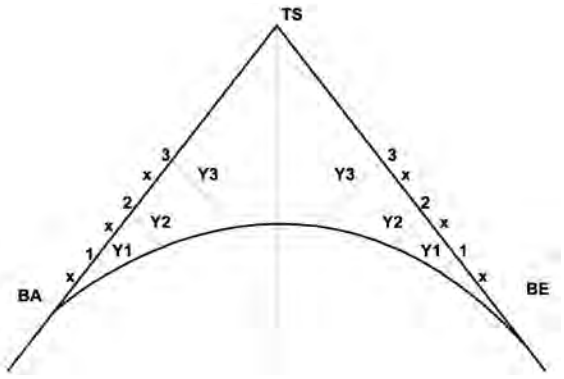


Figure 5: Curve construction in open and flat terrain.

C) Hilly and grown over terrain

In hilly and grown over terrain it is more suitable to use the following method for staking out of curvatures:

1. Measure an appropriate distance X, according to table no.5, from point BA in direction to TS to get the point A.
2. From this point measure at a right angle the appropriate distance y according to the chosen radius from table no. 5 to get point 1.
3. From point BA measure a straight line by connecting point 1.This line extended by the distance X to reach point B.
4. From point B measure at a right angle the appropriate distance of 2 y according to the chosen radius from table no. 5 to get point 2.
5. Continue now according to item 3).Start from point 1 to get point C. From point C according to item 4) to get point 3. Continue until one reach point BE.

Table 4: Coordinates for staking out curves

x-Dist.	y-Distance for a radius of (m)								
m	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**60**	**70**
2.5	0.16	0.13	0.11	0.09	0.08	0.07	0.06	0.05	0.05
5.0	0.64	0.51	0.42	0.36	0.31	0.28	0.25	0.21	0.18
7.5	1.46	1.15	0.95	0.81	0.73	0.71	0.57	0.47	0.40
10.0	2.68	2.09	1.72	1.46	1.27	1.13	1.01	0.84	0.72
12.5	4.39	3.35	2.73	2.30	2.00	1.77	1.59	1.32	1.13
15.0	6.77	5.00	4.02	3.38	2.92	2.57	2.30	1.91	1.63
20.0	20.00	10.00	7.64	6.28	5.36	4.69	4.17	3.43	2.92
25.0		25.00	13.42	10.50	8.78	7.58	6.70	5.46	4.62
30.0			30.00	16.97	13.54	11.46	10.00	8.04	6.75
35.0				35.00	20.64	16.72	14.29	11.27	9.38
40.0					40.00	24.39	20.00	15.28	12.55
45.0						45.00	28.21	20.31	16.38
50.0							50.00	26.83	21.00
60.0								60.00	39.94
x-Dist.	y-Distance for a radius of (m)								
m	**80**	**90**	**100**	**110**	**120**	**130**	**140**		
5.0	0.16	0.14	0.13	0.11	0.10	0.10	0.09		
10.0	0.63	0.56	0.50	0.46	0.42	0.39	0.36		
15.0	1.42	1.26	1.31	1.03	0.94	0.87	0.81		
20.0	2.54	2.25	2.02	1.83	1.68	1.55	1.44		
30.0	5.84	5.15	4.61	4.17	3.81	3.51	3.25		
40.0	10.72	9.38	8.35	7.53	6.86	6.31	5.84		
50.0	17.55	15.14	13.40	12.02	10.91	10.00	9.23		
60.0	27.09	22.92	20.00	17.81	16.08	14.67	13.51		
70.0		35.45	25.59	25.15	22.53	20.46	18.76		
80.0		48.77	40.00	34.50	30.56	27.53	25.11		
90.0		90.00	56.41	46.75	40.63	36.19	32.76		
100.0			100.00	64.16	49.25	46.93	42.02		

To avoid bigger deviations it is better to stake out also from point BE to meet in the middle of the curvature.

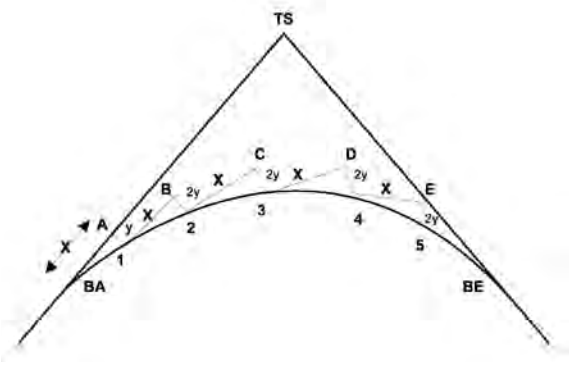


Figure 6: Curve construction in hilly and grown over terrain.

4. Road Construction

The development of road networks involves the construction of main, secondary and feeder roads including the necessary drainage like bridges and culverts. Main and secondary roads are all-weather surfaced roads while feeder roads are un-surfaced or dirt roads.

Before the actual construction, the following activities should be considered:

- Employment of contractors
- Ordering of machinery and materials
- Calculation of expenses
- Information of other authorities
- Reconnaissance to check the area for pipelines and cables etc.

After road construction is completed km-posts should be established at intervals of 1 km. This is very helpful to facilitate the location of road sections for repair and maintenance at a later stage. Additionally the road junctions and the bridges have to be marked permanently and entered into the “Road Map”.

For technical support on machine operator`s level, the “Operator`s Manual for Forest Road Construction” can serve.

4.1 Machinery

The following machinery is involved in forest road construction:

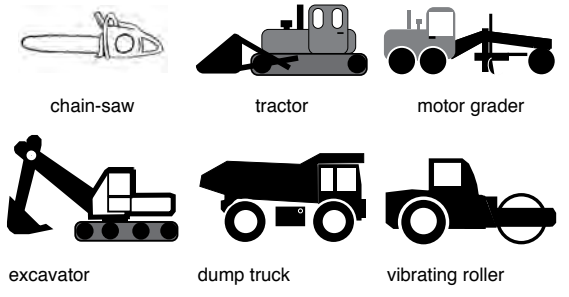


Figure 7: Machinery

4.2 Work Sequences

4.2.1. New Construction

- Survey
- Clearing of corridor by chain-saw
- Forming of the roadbed by tractor or excavator
- Construction of bridges and culverts
- Reshaping the camber with a motor grader (if required)
- Compacting with a vibrating roller (if required)
- Stabilization of Sub-base, Base and Surface (if required)
  - Loading of gravel by excavator
  - transport of gravel by trucks
  - distribution of gravel by motor grader
  - compaction with a vibrating roller

4.2.2. Repair of Roads

- Reshaping by tractor
- Repair of bridges and culverts
- Reshaping the camber with a motor grader
- Compacting with a vibrating roller
- Stabilization of Sub-base, Base and Surface (if required)
  - Loading of gravel by excavator
  - transport of gravel by trucks
  - distribution of gravel by motor grader
  - compaction with a vibrating roller

or

  - Reshaping and compacting (s. 4.2.3.2)

4.2.3 Maintenance

4.2.3.1 Renewal of Surface Layer (for main-and sec. roads only)

- frequency: every 6 years
- cleaning ditches & reshaping the camber with a motor grader
- compacting with a vibrating roller
- Loading of gravel by excavator
- transport of gravel by trucks
- distribution of gravel by motor grader
- compaction with a vibrating roller

4.2.3.2 Reshaping and compacting

- frequency: every 3 years
- cleaning ditches & reshaping the camber with a motor grader or
- cleaning ditches by excavator
- compacting with a vibrating roller

4.2.3.3 Reshaping

- frequency: annually
- cleaning ditches & reshaping the camber with a motor grader or
- cleaning ditches by excavator

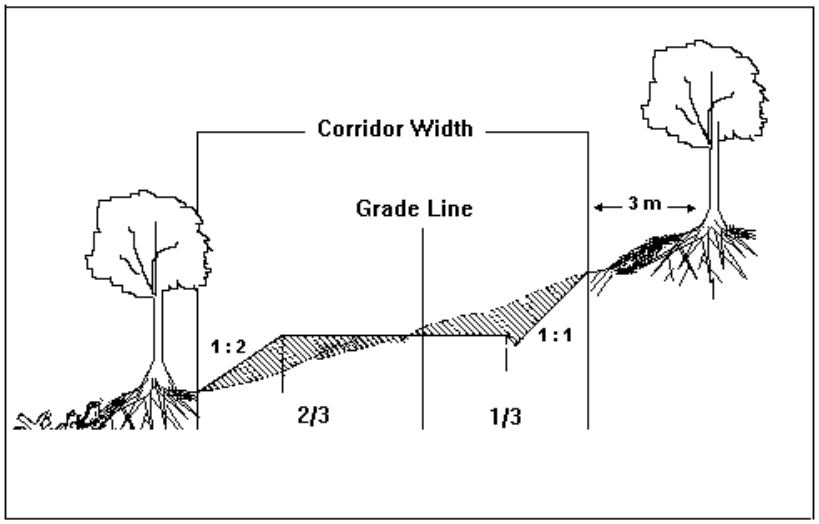


Figure 8: Clearing width of road corridor

4.3 Clearing of the Road Corridor

The right-of-way clearing should be wide enough to prevent damages of main roots of the remaining border trees at the hillside as well as covering the buttresses at the valley side with soil when constructing the road. For corridor widths refer to chapter 2.3. In hilly terrain the corridor should be cleared one third uphill and two third downhill of the grade line. With increasing slope the corridor width is increasing proportionately. To avoid damage to the neighboring stands, the trees on the corridor have to be felled with a chainsaw instead of pushing them down with a tractor. Furthermore, the trees have to be felled along the corridor and not into the remaining stand. (see Figure 8)

4.4 Forming, Grading and Compacting

Road- and skid trail construction should be avoided on terrain with slopes > 55%.

The major work in constructing a forest road is forming and grading the roadbed, as well as the drainage ditches and embankments. To achieve a proper camber of the road surface, already the subgrade should be sloped with an angle dozer or excavator due to the hardness of the material.

For the ratio of height to width of the embankments see chapter 2.3.

To avoid heavy erosion it is recommended to cover the embankments with cover crops or any other organic material as soon as possible. In some cases, where the compactness of the soil is very low, brushwood fascines might be necessary.

After forming the road with the tractor or excavator, grading with a motor grader is necessary to give the road a proper camber of 2% to 6 % slope. Later on, the road is compacted with a vibration roller.

Excavator versus Bulldozer

Well skilled operators are able to perform the alignment of the sub-grade well suited to the surface and depositing cut material downhill in a safe manner. The dozer's work has caused deep environmental impacts both to the surface as well as the trees alongside the road. Big rocks rolled off into the stands, or even endangered people and public facilities underlying the roads. In best cases dispensable material was transported longitudinal, which is a very expensive operation and was therefore mostly neglected. By working with an excavator it is easily possible to separate organic soil from mineral soil and to prevent organic material from entering into the road formation. The excavator, furthermore, is able to depose material from one side of the formation to the other, perform a suitable slope of the embankments and finally cover it with humus material for re-cultivation, previously pulled off and stored beside. Even embedded plants can be 'transplanted' with this humus material.

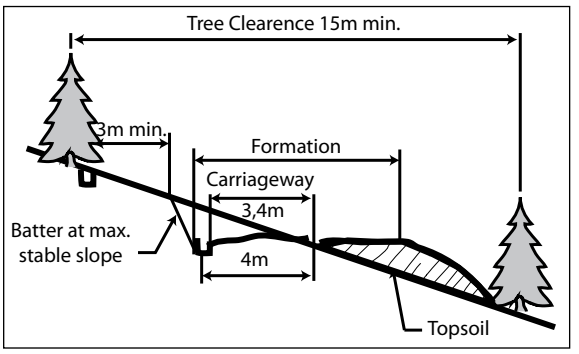
Nowadays forest road construction in step terrain by bulldozer is not an option. It is suggested that a balanced road design provided by excavator construction results in approximately 25 to 35 percent less excavated material compared to the traditional side cast technique by bulldozer where most of the road width is cut into the stable hill side (FAO, 1989).
(derived from: Best Practice Guidelines, Forest Road Planning and Construction, Adaptive Sustainable Forestry Management in Borjomi, Georgia)

(see Picture 1, 2, Figure 9)

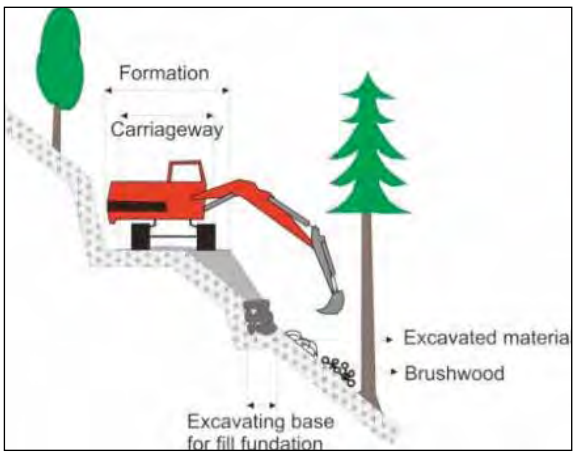
Log yarding

Once the trees have been felled within the corridor limits, road construction activities will start by log yarding out of the construction area by excavator. Trees should preferably remain in full length in order to minimize work delays of the excavator and ensure maximum performance.

After several trees have been attached by means of chain to the excavator's bucket or sometimes just by balancing stems on the bucket, the excavator pulls or carries logs out of the construction area by mov-



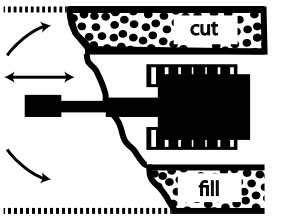
Picture 1: Typical Cross section of a road opened by bulldozer (Ryan)



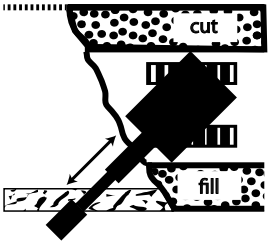
Picture 2: Typical Cross section of a road opened by excavator

(Hagauer, D. and Zöscher, H.: 2013; Best Practice Guidelines, Forest Road Planning and Construction, Adaptive Sustainable Forestry Management in Borjomi, Georgia)

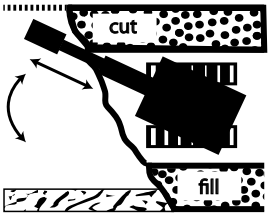
(1) Organic top soil is removed in front of the machine and spread on the rear fill slope in correct positional arrangement in order to facilitate vegetative treatment.



(2) A trench is excavated along the lower fill edge for better foundation.



(3) Cut material is excavated and deposited into the trench and fill, rocks are deposited just below the trench as support.



(4) Cut slope and subgrade are finally shaped.

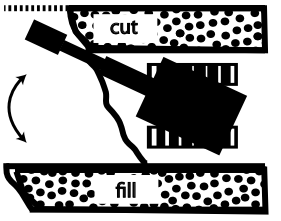


Figure 9: Working technique with excavator

(Hagauer, D. and Zöscher, H.: 2013; Best Practice Guidelines, Forest Road Planning and Construction, Adaptive Sustainable Forestry Management in Borjomi, Georgia)

ing backwards to a roadside storage. Logs should be stored at roadside in several places rather than transported over long distances to landings due to the low driving speed of excavators. Such frequent storage will reduce extraction cost and facilitate any further processing.
(derived from: (Best Practice Guidelines, Forest Road Planning and Construction, Adaptive Sustainable Forestry Management in Borjomi, Georgia)
(see Picture 3)

Top soil removal

The log removal phase will be followed by clearing the construction area from wood residues and organic topsoil. Bigger branches are piled up by moving them with the bucket's shanks. They will be spread out on the fill slope later. Deposition of branches on the fill slope:

- Helps to keep exposure of unprotected surfaces as short as possible,
- Provides immediate erosion control of the fill slope
- Facilitates an earlier natural or man-made revegetation.

Stumps, tree tops and other vegetative debris are removed by the excavator's bucket from the construction area in front of the excavator and placed by the operator with accuracy and care along the base of the fill slope in order to form a barrier. The additional width between the construction area and remaining forest ensures that sufficient space is available to deposit debris outside the construction area and prevent organic material being mixed into the base of the fill.

This barrier will drastically reduce damage to forest stands below the road from excavated materials, especially rocks escaping downhill.

Picture 3: Log removal by excavator and storage alongside the road
(Hagauer, D. and Zöscher, H.: 2013; Best Practice Guidelines, Forest Road Planning and Construction, Adaptive Sustainable Forestry Management in Borjomi, Georgia)

Picture 4: Cleaning the constructing area from branches
(Hagauer, D. and Zöscher, H.: 2013; Best Practice Guidelines, Forest Road Planning and Construction, Adaptive Sustainable Forestry Management in Borjomi, Georgia)

Picture 5: Remove the humus soil layer from the construction area. Covering the completed fill side with the humus soil
(Hagauer, D. and Zöscher, H.: 2013; Best Practice Guidelines, Forest Road Planning and Construction, Adaptive Sustainable Forestry Management in Borjomi, Georgia)

Picture 6: Removal of stumps and storage to the base of the fill

Picture 7: Excavator deposits topsoil directly into the final position on the fill side

After stump removal is completed, the organic topsoil which is unsuitable to be used in the fill will be removed from the construction area and ideally placed directly on the embankment. If working in areas where grass covers the forest floor the operator should be advised to separate and deposit these turfs carefully and install them later in a correct arrangement on the embankments.
(derived from: (Best Practice Guidelines, Forest Road Planning and Construction, Adaptive Sustainable Forestry Management in Borjomi, Georgia)
(see Picture 4, 5, 6, 7))

(see Pictures 8, 9, 10)

Preparation of fill foundation

At the lower end of the downhill embankment a foundation has to be constructed by digging first a trench about 1 m wide and to build it up to 0.5-1.5 m in height. If the excavator cannot reach this site with its bucket the fill side has to be constructed in two stages. Never refrain from the construction of a foundation. The establishment of a fill foundation reduces the length of fill slopes considerably and makes road construction in steep terrain feasible. This foundation is of great importance when side slopes exceed 40 percent of slope since these road sections can be constructed with considerably less excavation (FAO, 1989).

The foundation is filled with mineral soil and compacted (Picture 10. Ideally, the foundation is constructed of rocky material. In general, there should be no organic material in the entire road formation.

In steep terrain where slopes with rock formation near or above surface level have to be crossed, the base of the foundation should be filled with broken rock material, produced either by rock hammering or rock blasting.
(derived from: ((Hagauer, D. and Zöscher, H.: 2013; Best Practice Guidelines, Forest Road Planning and Construction, Adaptive Sustainable Forestry Management in Borjomi, Georgia)

Fill construction

One of the main advantages of road construction techniques by hydraulic excavators is the balance between cut and fill material on short road sections. Material that is excavated on the uphill side is immediately used to build up the downhill fill side (Picture 11).

In general, the fill needs to be built up in well compacted layers in order to have a formation suitable for heavy duty traffic. The excavated material is installed in layers of 30 to 50 cm; these layers are compacted by several excavator passes before being covered by the next layer (Picture 12).

To build up the fill foundation and the fill itself, requires highly skilled and experienced operators, since fill failures, due to improper construction techniques, may not only destroy parts of the roads but may also trigger landslides in steep terrain making large areas unproductive. Since organic material such as stumps, tree tops and humus will decompose and shrink, only mineral soil should be used in fill construction. Depending on its size, surplus of material will either be incorporated in the road subgrade of already established road sections or temporarily stored aside for use in the next work cycle. If surplus material cannot be used, it can be removed with a dump truck.
(derived from: (Best Practice Guidelines, Forest Road Planning and Construction, Adaptive Sustainable Forestry Management in Borjomi, Georgia)
(see Picture 11, 12)

Forming subgrade and cut

The next exercise to be accomplished by using a hydraulic excavator will be the finishing of the subgrade, establishment of the hillside ditch and the final shaping of the hillside embankment.

Smaller holes in the upper fill layer will be filled up while the layer gets continuously compacted through excavator passes. Thus, a firm subgrade can be achieved. Finally smoothing and compacting of the subgrade surface with the help of the excavator's

Picture 8: Excavator arranging the topsoil in correct positional arrangement

(Hagauer, D. and Zöscher, H.: 2013; Best Practice Guidelines, Forest Road Planning and Construction, Adaptive Sustainable Forestry Management in Borjomi, Georgia)

Picture 9: Forming the foundation for the forest road

Picture 10: Compacting the foundation very well with the bucket of the excavator

(Hagauer, D. and Zöscher, H.: 2013; Best Practice Guidelines, Forest Road Planning and Construction, Adaptive Sustainable Forestry Management in Borjomi, Georgia)

Picture 11: Building up the fill in layers with the material coming from the cutting side

Picture 12: Continuous compacting of the layers by the tracks of the excavator or compactor

(Hagauer, D. and Zöscher, H.: 2013; Best Practice Guidelines, Forest Road Planning and Construction, Adaptive Sustainable Forestry Management in Borjomi, Georgia)

bucket, a coarse sub-grade can be achieved (Picture 13).

Depending on the specific material at the construction site and the availability of material suitable for gravelling, a surface- layer of gravel or similar material should be applied to the coarse subgrade, shaped and smoothed and finally compacted in order to provide a cambered road. All these activities can be carried out by the excavator but better later on with a grader.

While the final finishing work is being done to the road surface, the hillside ditch can be formed. This allows for immediate draining of the road structure preventing damage to road structure and erosion during the construction phase.

The edge at the top of the cut has to be rounded in order to avoid overhanging ground vegetation and downhill drifting of loose material. Material eroded and escaped into the ditch does not only increases the maintenance costs since it has to be removed, but also obstructs the water flow.

After the road construction work by excavator is completed, the forest road is in a condition that will allow hauling trucks and off-road vehicles to pass.
(derived from: (Best Practice Guidelines, Forest Road Planning and Construction, Adaptive Sustainable Forestry Management in Borjomi, Georgia)

Picture 13: Preparation of the of the cut side in the right angle and arranging of the final layer of the subgrade without extra gravel

Picture 14: Finished subgrade

(Hagauer, D. and Zöscher, H.: 2013; Best Practice Guidelines, Forest Road Planning and Construction, Adaptive Sustainable Forestry Management in Borjomi, Georgia)

Rock works

Rocks can be

- ripped by excavator equipped with a special bucket or hook
- ripped by a bulldozer
- carved with hydraulic hammers
- blasted by explosives

Hydraulic hammers:

Where the rocks cannot be ripped by the excavator's bucket, the use of hydraulic hammers attached to excavators is considered the optimal solution. Avoiding rock blasting and breaking rocks by hydraulic hammers meet the demand to reduce the environmental impact.

Picture 15: Hydraulic hammer in action

(Hagauer, D. and Zöscher, H.: 2013; Best Practice Guidelines, Forest Road Planning and Construction, Adaptive Sustainable Forestry Management in Borjomi, Georgia)

The main advantages of hydraulic hammers in comparison to blasting are:

- Rock hammers are enlarging the application range of excavators;
- Less non-productive time of the excavator since there is no interference by blasting operations;
- Desired cut slope gradient and shaping can easily be performed by the skilled excavator operator;
- Size of broken rock material can be controlled by a skilled and experienced operator;
- Accurate construction of hillside ditch for water drainage;
- Less surplus material to be removed;
- The hydraulic hammer is the only equipment needed in addition to the excavator already employed at construction site;
- Danger of blasting can be avoided.

Blasting

In case all other options mentioned above have failed, rock blasting may be specified by the road engineer.

Although more sophisticated blasting techniques have been developed, rock blasting is best avoided as the use of rock drilling equipment and explosives increases road construction costs and there are substantial risks in using explosives.

The blasting technique can be adjusted to rock condition and the use of an excavator as carrier vehicle ensures that the road width can be kept to the absolute minimum as excavators do not require additional road width.

(derived from: ((Hagauer, D. and Zöscher, H.: 2013; Best Practice Guidelines, Forest Road Planning and Construction, Adaptive Sustainable Forestry Management in Borjomi, Georgia)

Picture 16: Preparation for Blasting

Picture 17: Blasting on forest road constructing site

(Hagauer, D. and Zöscher, H.: 2013; Best Practice Guidelines, Forest Road Planning and Construction, Adaptive Sustainable Forestry Management in Borjomi, Georgia)

4.5 Drainage

Constructing of Bridges

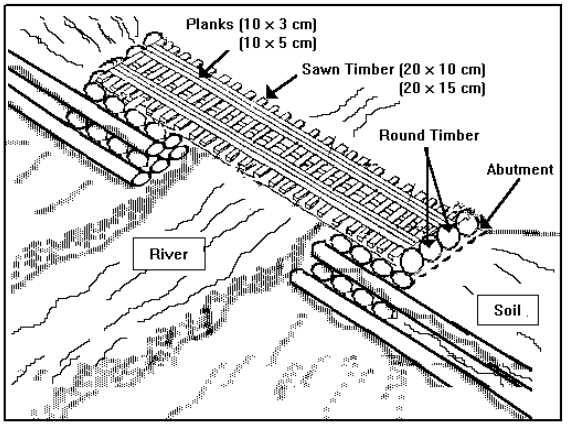


Figure 10: Log bridge construction

Bridges have to be constructed where a river exceeds a certain width and a certain depth. They are usually built for one-lane traffic only. The use of local round timber can be recommended. Logs should not be covered with soil to prevent fast decay of the timber. Therefore, instead of the common soil-layer on bridges, sawn timber (e.g. 20 cm x 10 cm) placed crosswise on the logs is more appropriate. On top of this, planks (e.g. 10 cm x 5 cm) are placed for the two ruts, each 1 m wide. The abutments are made of treated round timber as well. If the distance from bank to bank is too wide, the construction of an iron- or concrete bridge could become necessary. Constructions of such structures should only be carried out by a civil and / or structural engineer. However, in these cases the abutments should be constructed of concrete and not of round timber.

Three types of bridges with different abutments can be recommended. Two constructed with timber and one made of concrete. To minimize the timber consumption, the one shown in Figure 11 is more appropriate and should be used for new construction in the future.

For the selection of species as well as minimum diameter see chapter 2.3

The following design of a concrete bridge was thankfully made available by “Plus Engineering Service PLC”, Ethiopia and should serve as an example only. It serves for traffic up to 30 t.

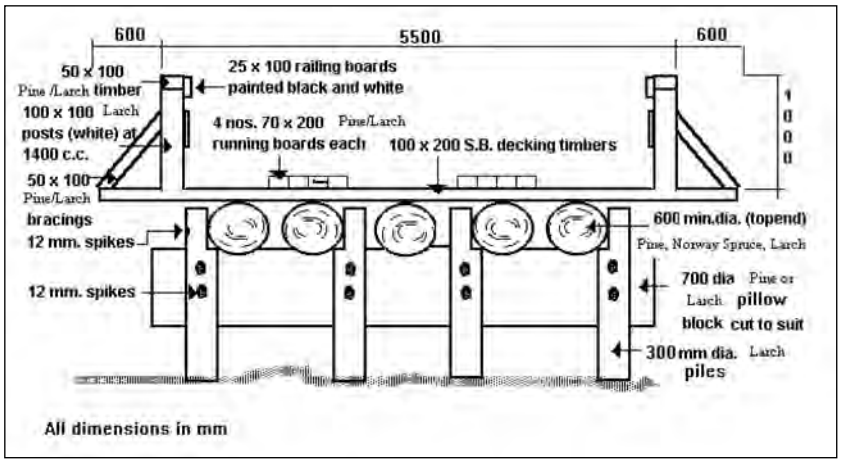


Figure 11: Log bridge construction

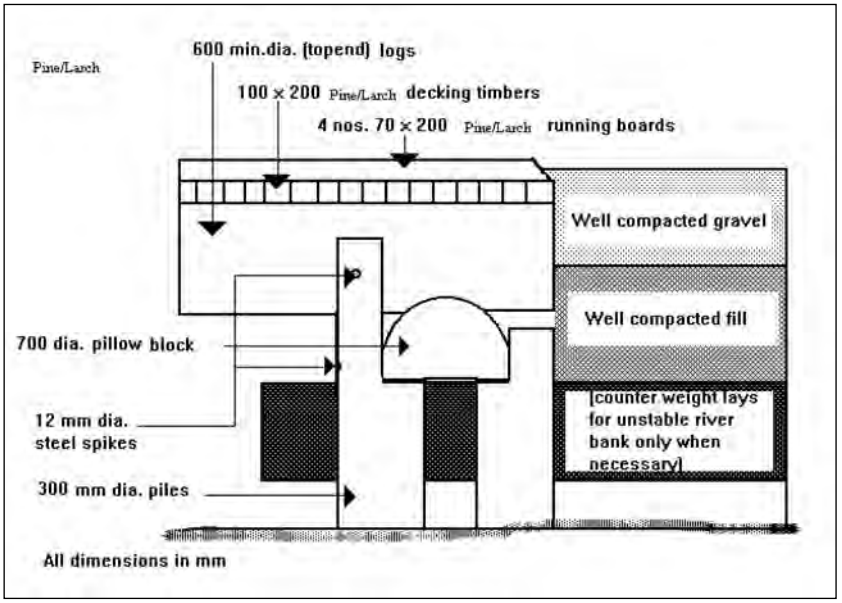


Figure 12: Abutment Details of Log Bridge

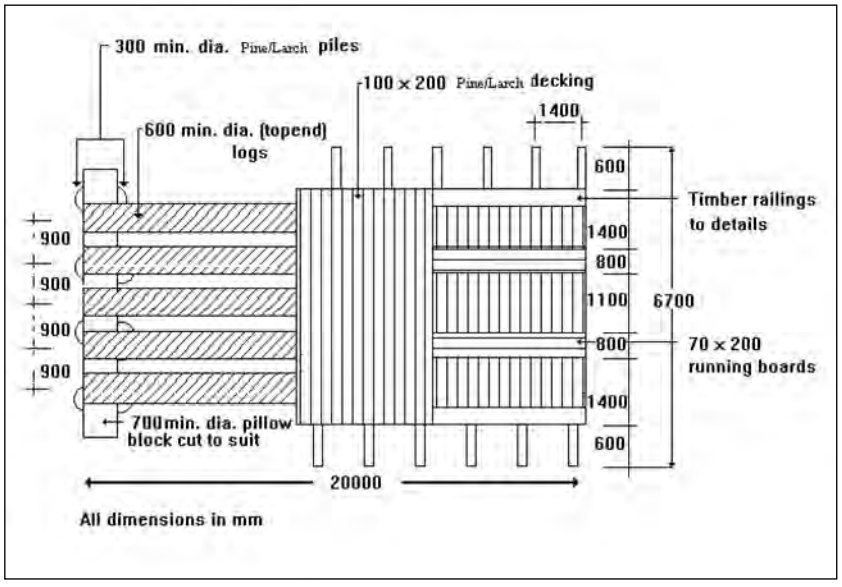


Figure 13: Log bridge construction

Table 5 Bridge specifications

Bridge Specifications		Plus Engineering PLC, 011-4393917, Ethiopia			
Structure: H-Beam & Concrete		Size: L: 6 m, W: 4 m		**Load Capacity: 30 t**	
No	**Description**	**Unit**	**Quantity**	**Specifications(mm)**	**Remarks**
1	H-Beam	No.	4	600x350x6000	
2	L-Beam	m	50	70x70	Fixed crosswise with bolt & nut to No.5
3	Iron-Bars, 20 mm	TON	6		For stabilization of concrete
4	Steel Plate	No.	2	900x1800x20	600x700, laid under No.1 on abutment
5	Steel Plate	No.	2	1200x2400x10	300x300, to stabilize hand-rail and welded on No1. to fix No.2
6	Steel Plate	No.	8	900x1800x3,2	Welded underneath No.1 to support concrete
7	Pipe 2”	m	30		For hand-rail
8	Concrete	M^3	70		
9	Others				Bolt &nuts, wires

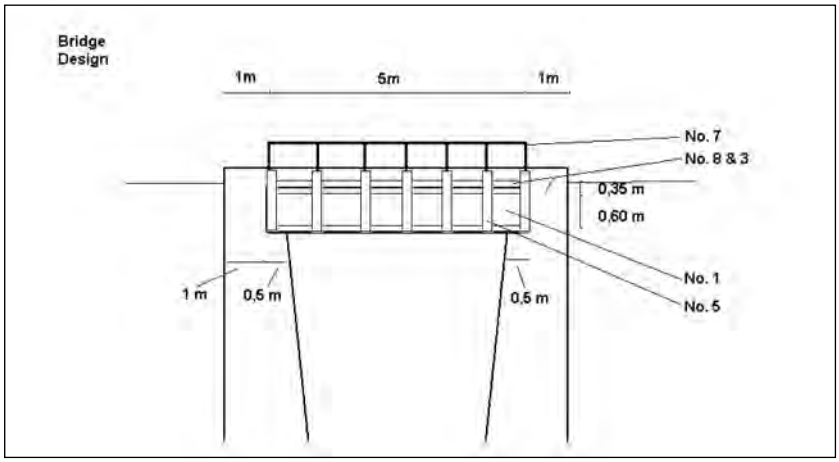


Figure 14: Bridge design

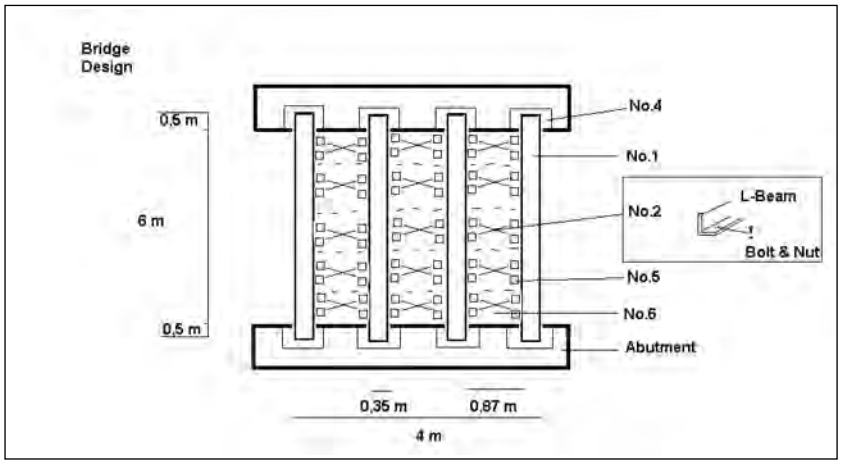


Figure 15: Bridge design

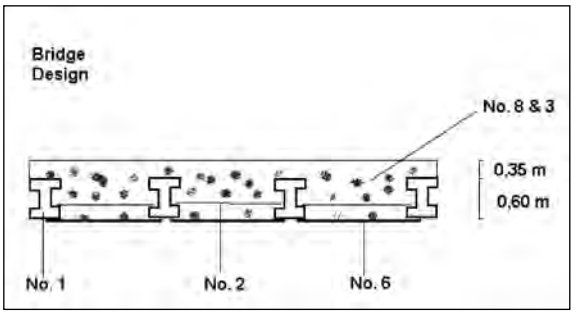


Figure 16: Bridge design

Installation of Culverts

In many cases the poor drainage facilities of forest roads, such as culverts and ditches, are a major source of erosion.

The durability of culverts depending on the type of material and the care applied in constructing them. In case feeder roads are used for not more than one season, normally require culverts only where there is an abundance of surface water or a stream to be drained across the road. Roads to be used more than one season (Main-and Sec. Roads) should be ditched and culverted. In this case the culverts can be built either with local round timber (duration 5-7 years), galvanized, steel, polyethylene pipes or concrete culverts. Galvanized culverts should not be used if the water is acidic. For laying concrete culverts, the manufacturer's installation requirements have to be followed strictly. The proper size of culverts to be used depends on several factors, such as topography, soil, forest cover, size of water catchments, frequency and magnitude of sudden rain storms and, last not least, culvert spacing.

The runoff from logged-over or burned-over land is heavier and more severe than from forested land. The cross-section of a culvert should not be less than 40 cm diameter or 35 x 35 cm for box culverts. The gradient should be 2-5 %. In steep terrain a culvert is needed approximately every 100 m. Whenever possible, culverts have to be placed into the subgrade due to its higher stability and not into the fill. It is very important that they are placed on the same level or even deeper than the bottom of a creek. In case culverts are placed on a higher level, flooded areas, sometimes to a big extent, will be created resulting in the die-off of all affected trees.

In areas where the topography is changing very frequently, the construction of outlets or Fords can minimize the number of culverts. An outlet is just a short ditch connecting the road-ditch with the lower surrounding area.

For installing culverts the use of an excavator is more useful and economical than a tractor.

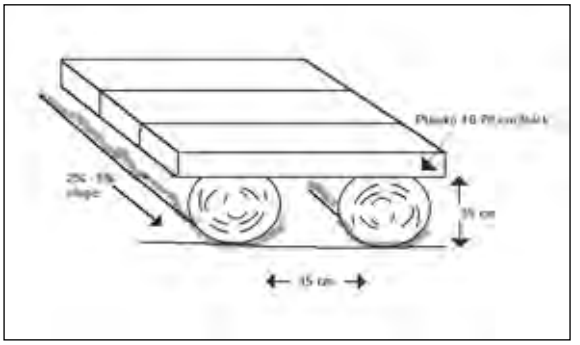


Figure 17: Round timber culvert

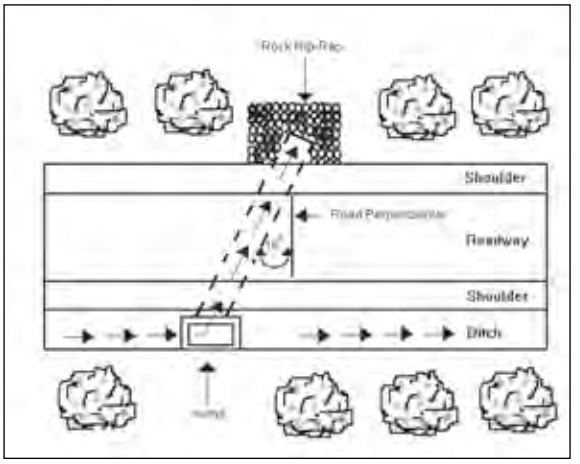


Figure 18: Plan view of a concrete culvert

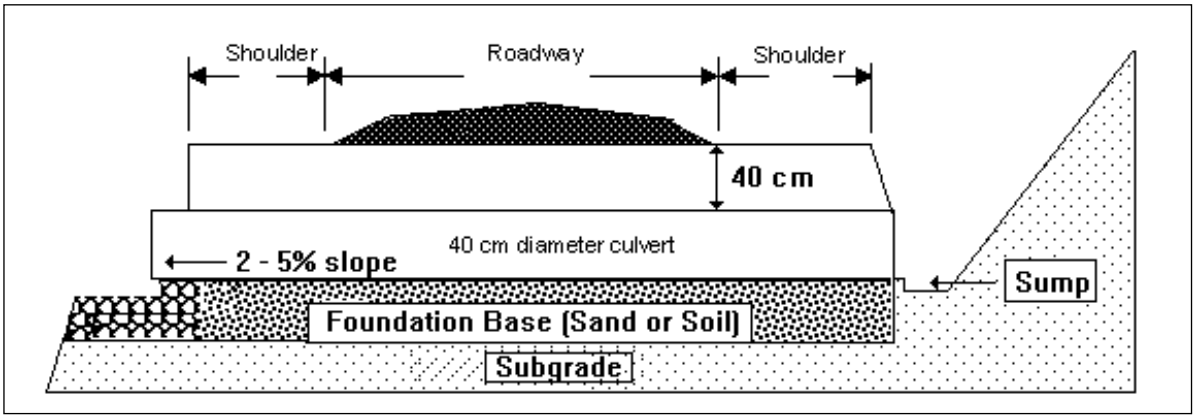


Figure 19: Cross profile of a concrete culvert

Picture 18 A big culvert as an alternative to a bridge

(Hagauer, D. and Zöscher, H.: 2013; Best Practice Guidelines, Forest Road Planning and Construction, Adaptive Sustainable Forestry Management in Borjomi, Georgia)

Picture 19: Installation procedure of a plastic pipe

(Hagauer, D. and Zöscher, H.: 2013; Best Practice Guidelines, Forest Road Planning and Construction, Adaptive Sustainable Forestry Management in Borjomi, Georgia)

Picture 20: Intake of a culvert (not reinforced)

(Hagauer, D. and Zöscher, H.: 2013; Best Practice Guidelines, Forest Road Planning and Construction, Adaptive Sustainable Forestry Management in Borjomi, Georgia)

Picture 21: Other options: Different types of channels for cross drainage
(Hagauer, D. and Zöscher, H.: 2013; Best Practice Guidelines, Forest Road Planning and Construction, Adaptive Sustainable Forestry Management in Borjomi, Georgia)

Fords

The lowest costs engineering structure for water crossings and roads is the ford. Additionally it is very easy to construct and to maintain. There is not much planning needed, the only need is to construct a converse gradient at the downhill side of the ford. The converse gradient (+2-5%) ensures avoidance of the water overflowing the road during periods of heavy rainfall. If concrete is used it should be reinforced with steel.

Fords may be considered as alternative to culverts in crossing perennial streams carrying high loads of sediments. Nowadays fords are very often combined with culverts. The regular amount of water runs off through the culvert; only in case of heavy precipitation the water is also crossing the road on the ford.

A) Big Fords

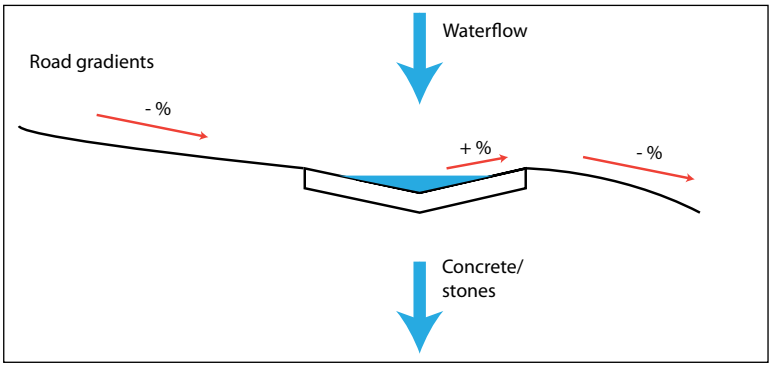


Figure 20: Longitudinal profile of a ford
(Hagauer, D. and Zöscher, H.: 2013; Best Practice Guidelines, Forest Road Planning and Construction, Adaptive Sustainable Forestry Management in Borjomi, Georgia)

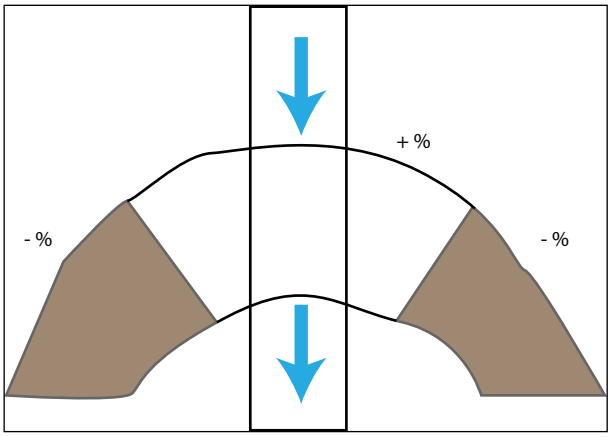


Figure 21: Sketch of the ford
(Hagauer, D. and Zöscher, H.: 2013; Best Practice Guidelines, Forest Road Planning and Construction, Adaptive Sustainable Forestry Management in Borjomi, Georgia)

Picture 22: Different fords

(Hagauer, D. and Zöscher, H.: 2013; Best Practice Guidelines, Forest Road Planning and Construction, Adaptive Sustainable Forestry Management in Borjomi, Georgia)

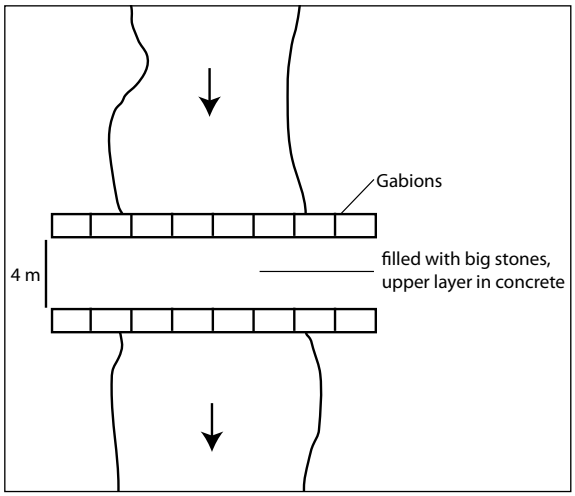


Figure 22: Big ford design

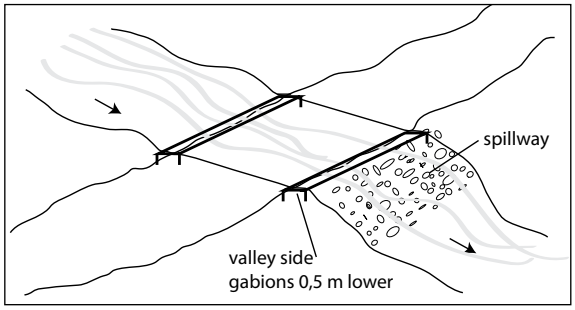


Figure 23: Big ford

B) Small Fords

Small fords can be constructed by hand. One layer of loose stones are well adjusted to achieve a smooth surface, a valley side spill-wall if required, will serve.

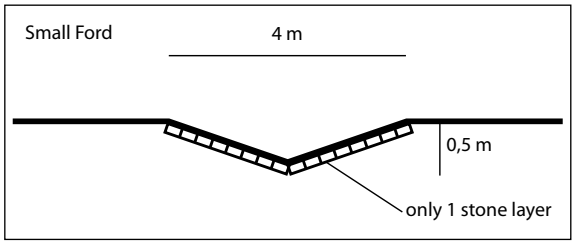


Figure 24: Small ford

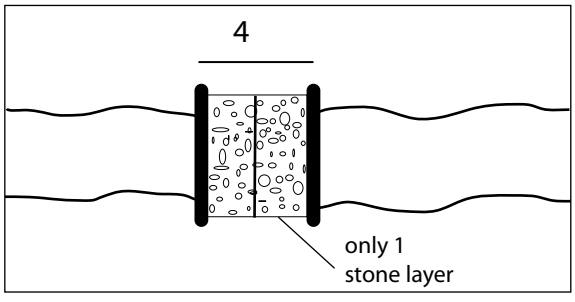


Figure 25: Small ford

4.6 Stabilization

Stabilization is compulsory for main-and secondary roads. Feeder roads are not stabilized, only in case some mud-holes appear, they have to be filled with rocky material.

All earth work mentioned below is done by a motor grader. Afterwards the necessary compaction of each layer is done with a vibrating roller. To achieve a better compaction the material should be moist. However, if the moisture content exceeds field capacity, compaction should not be carried out to avoid puddling of the material.

Correct timing is necessary!

Subgrade, sub-base and base

Stabilization of the subgrade might be necessary if the ground is muddy or the road is passing a swampy area. To stabilize the subgrade a sub-base layer has to be formed. For the appropriate particle sizes and quantities see chapter 2.3. The thickness of a layer should be 2.5 times bigger than the size of the biggest particle. A loss of thickness up to 60 % has to be taken into account, namely by compacting (30 %), in case the subgrade is very muddy (25 %) and if some material is rolling away from the road way (5 %).

Only in case that the particle size of the sub-base is too coarse (> 150 mm) an additional base-layer could be necessary to avoid uncomfortable driving. Therefore a particle size of 0 to 50 mm (0/50) at a rate of 0.3 to 1 m^3 per 1 m roadway is recommended (see chapter 2.3)

Chemical stabilization is definitely a good choice, but it needs experienced staff for implementation.

Surface

If the stability of the subgrade is sufficient, only a surface-layer has to be applied. Sub-base or base-layer have to be covered with a surface-layer. This makes driving more comfortable, safer and keeps the road practicable during the rainy season. The particle size is up to 30 mm (0/30) (see chapter 2.3)

4.7 Maintenance

Maintenance of forest roads comprises cleaning of ditches, re-shaping and compaction as well as graveling.

Additional repair work may occur after heavy rainfalls or intensive utilization of a particular road and can be carried out simultaneously. The prophylactic maintenance has to be carried out according to the schedule under chapter 4.2.

4.8 Skid Trails

4.8.1 Opening-Up Network

Before the first thinning operation commences, the final opening-up network has to be established.

4.8.2 Drivable Area (0 – 30% inclination)

With the help of a compass and measurement tape every 20 m a skid-trail with a width of 4 m has to be laid. These skid-trails have to be as straight as possible to allow skidding by a tractor with trailer or logs up to 10 m length without damage to the remaining stand. The skid-trails hit the forest road in an angle of 45°. Cutting the trees on these skid-trails should be carried out approximately 3 years before the actual thinning operation starts. This helps to stabilize the stand structure.

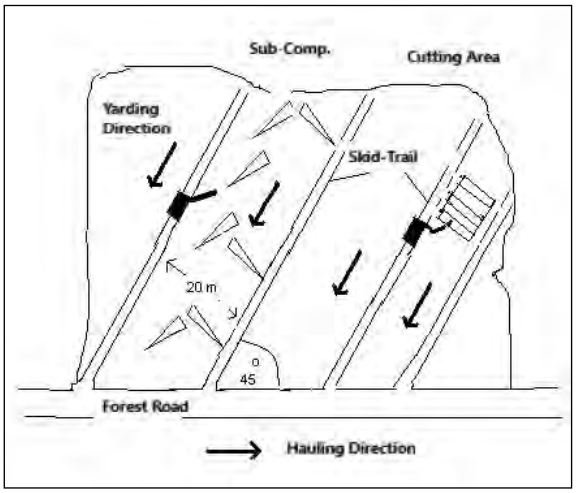


Figure 26: Establishment of skid-trails

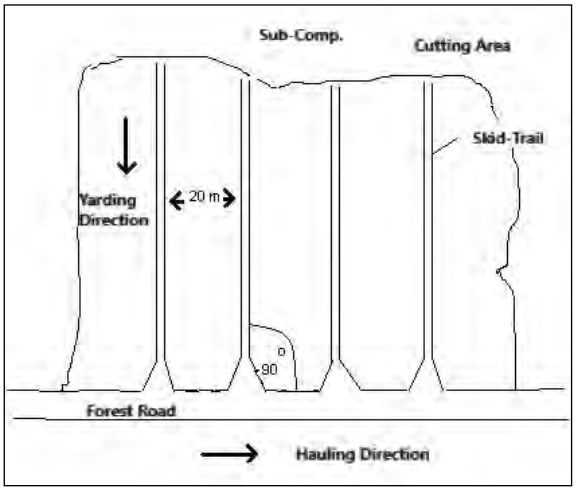


Figure 27: Establishment of skid-trails

4.8.3 Impassable Area (30 – 55% inclination)

If the inclination exceeds 30%, the construction of skid-trails by crawler tractors or excavators becomes indispensable. These skid-trails have to be 4 m wide and in curves even 4,50 m.

Skid-trails are necessary for ground extraction only. The maximum length of a skid-trail should not exceed 500 m. If the skidding distance exceeds this length, it is more economical to construct a feeder road. The spacing depends upon the type of machinery applied.

Example: Assuming a tractor is equipped with a cable 80 m long, the skid-trail distance can be 100 m. (70 m yarding uphill, 30 m yarding downhill). Thus, the skid-trail density is theoretically 100 m/ha (10,000/100). The maximum slope of skid-trails for yarding downhill should not exceed 30 % and for yarding uphill 15 % slope, due to the increase of soil erosion and the decrease of tractor performance. As opposed to roads, a skid-trail should have a camber of 5 % to the hill-side only. On steep skid-trails (gradient above 10 %) at least every 50 m a cross ditch should be built to avoid gully erosion. These drainage facilities should have a slope of 5 % to the valley side. Each skid trail should be drained accordingly before reaching a road. On flat terrain and gentle slopes (below 30% slope), where cut and fill are not necessary, the top soil should not be removed to minimize soil erosion. For the clearing of the skid trail corridor, chain-saws only should be used (no bulldozing).The width of skid trails should not exceed 5 m.

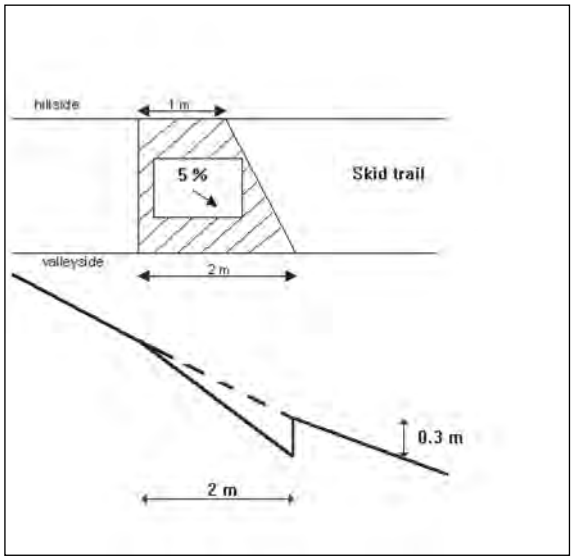


Figure 28: Cross ditch

5. Quarry Pits

The location of quarry pits should be marked on the Road Map and further described in the Forest Road Record Book as to quality characteristics, e.g. laterites, weathered rock formations and limestone formation.

When blocked and surveyed, the volume should be recorded.

6. Annual Road Report

An annual report should be prepared for the entire FDis, giving detailed information about personnel, expenditure and performance data. The “Forest Road Network Form”, the “Forest Road Record Book” and

the “Performance Summary” (s. appendix No. 2, 4 and 5) can serve for the preparation of this report. For the calculation of machine operating costs, the forms attached in appendix no. 6 or computer software (e.g. Excell, refer to chapter Economics.) is very helpful.

7. Forest Road Construction for Implementers

Planning and construction of forest roads is a task for Forest Engineers, a task for specialists. They have to undergo a special training in all the subjects mentioned above. Only after planning and constructing several roads under supervision they can gain practical experience which has to be considered most compulsory.

Since the environmental impact of Forest Road Construction is very intense, one has to follow all the steps a.m. as close as possible.

Forest Road Construction in Sarawak, Malaysia (Foto: M. Prüller)

8. Appendix

Forest Road Network Form

Forest District: Compartment: Date:

Inventory, Planning, Clearing, Construction, Maintenance, Report

	Remarks	Tot. h	Tot. m	Tot. $
1.Road Classification				
2.Road Name/No				
3.Location (Block)				
4.Road good 1 Condition mod. 2 bad 3				
5.Clearing				
5.5.1 Corridor width m				
5.5.2 Est. Timber cum.				
6.Constr./Maintenance				
6.1 Material needed				
6.1.1 Bridges/pc				
Location				
Costs $				
6.1.2 Culverts/pc				
Location				
Costs $				
6.1.3 Gravel t				
Location				
Costs $				
6.1.4 Total Mater.cost $				
6.2 Activities				
6.2.1 Grad./Ang.Doz.m				
Location				
Costs $				
6.2.2 Excavating m				
Location				
Costs $				
6.2.3 Stabil/SubBase m				
Location				
Costs $				
6.2.4 Stabil./ Base m				
Location				
Costs $				
6.2.5 Graveling/Surf.m				
Location				
Costs $				
6.2.6 Grad./Gr.Base.m				
Location				
Costs $				

1) good: no (few) pot-holes, well graded, ditches clean.

2) moderate: rough surface, erosion, practicable for trucks.

3) bad: road practicable for 4 wheel-drive vehicles only

6.2.7 Grading/Gr.Surf.m				
Location				
Costs $				
6.2.8 Compacting m				
Location				
Costs $				
6.2.9 Build/Rep.Brid.pc				
Location				
Costs $				
6.2.10Build/Rep.Cul.pc				
Location				
Costs $				
6.2.11 No. of Junctions				
6.2.12 Km-posts impl.				
6.2.13 Man Power				
6.2.14 Tot.Meas.costs $				
7 Equipment needed				
7.1 Angle Dozer				
Model D7G $/h				
Model D6H $/h				
Model $/h				
7.2Vibr.Roller $/h				
7.3Excavator $/h				
7.4Motorgrader $/h				
7.5Payloader $/h				
7.6Truck $/h				
7.7ManPower $/h				
8.Total Road Length m				
9.Total Area covered ha				
10.Total m/ha cov.Area				
11. Costs $				
11.1 Costs / m $				
11.2 Costs/ha cov.Area $				

Total Road Network Forest District: Forest Range:

Road Class.	**Length m**	**m/ha**	**Total Costs $**	**Total Costs/m**	**Total Costs/ha**
Main Road					
Sec. Road					
Feed.Road					
Tot. Roads					
Skid Trail					
Total					

6.1.1 Bridges, Compartment: Road No.: Date:

Bridge No.	Location (km)	Status	Costs ($)	Remarks

6.1.2 Culverts, Compartment: Road No.: Date:

Culvert No.	Location (km)	Material	Status	Diameter (cm)	Costs ($)	Remarks

6.2.11 Junctions, Compartment Road No.: Date:
Forest District: Forest Range:

Junction No.	Location		Junction pole	Remarks
	km	Compartment		

3. Road Survey Form

Road Survey Form, Compartment: Road No.: Date:

Forest District: Forest Range: Name:

Compass bearing (°)	Variation (+ - °)	Km-reading (m)	Distance (m)	For scale 1: (cm)	Remarks

4. Forest Road Record Book

Forest Road Record Book								
Forest District:			**Forest Range:**				**Road Name/No.:**	
Classification:			**Location: from Comp.:**				**to Comp.**	
Date:			**Planned**		**Carried out**			
Work Sequence	**Year**	**Present Length km**	**km/ No.**	**costs $**	**km**	**Total costs $**	**Costs/m $**	**Remarks**
Total:								

(Example)

Forest Road Record Book								
Forest District: Sandakan			**Forest Range: DFR**				**Road Name/No.: 1**	
Classification: Sec. Road			**Location: from Comp.: 5**				**to Comp. 54**	
Date:			**Planned**		**Carried out**			
Work Sequence	**Year**	**Present Length km**	**km/ No.**	**costs $**	**km**	**Total costs $**	**Costs/m $**	**Remarks**
4.2.3.2	1994	25.2	25.2	11617				Resh.&Co
4.2.2	1994		3	18936				Bridges
4.2.2	1994		15	8430				Culverts
4.2.3.3	1995		25.2	7913				Reshaping
4.2.3.3	1996		25.2	7913				Reshaping
4.2.3.2	1997		25.2	11617				Resh.&Co
4.2.3.3	1998		25.2	7913				Reshaping
4.2.3.1	1999		25.2	172872				Ren.Surf
4.2.3.3	2000		25.2	7913				Reshaping
4.2.3.3	2001		25.2	7913				Reshaping
4.2.3.2	2002		25.2	11617				Resh.&Co
4.2.3.3	2003		25.2	7913				Reshaping
								($/m =
Total:		**25.2**		**282567**				**11.21)**

Forest Road Record Book Summary						Total Road Network							
Tbilisi City Hall:						Forest Reserve:							
Date:		Work Sequences (km) or (No.)							Costs ($)		Density m/ha	Area covered ha	Remarks
Year	Length km	4.2.1	4.2.2	Bridge	Culv.	4.2.3.1	4.2.3.2	4.2.3.3	Total	per m			
													Planning
Total:													
													Achieved
Total:													

Performance Summary

Work-Sequences	Machinery	Perform.	$/	$/km	Remarks
4.2.1 New Construction					
Survey	1 FO,1 F,2 L	0.6-1.0 km/day			(0.8km/day)
Clearing	Chain-saw	100 m/day			Width=14m
Forming	D6 **	25 m/h			
Construction of Bridges	D6** Exc.Cat 320	40 h/pc 40 h/pc			logs not included
Construction of Culverts	Exc.Cat 320	8 h/pc			culv.not incl.
Reshaping	Grad.Cat12 G	6-9 h/km			(8 h/km)
Compacting	Vibr.Rol.	6-7 h/km			(7 h/km)
Stabilisation Sub-Base Loading:(1.25 m^3/1m of road) Transport: Building in: Compacting:	 Exc. Cat 320 Dump Truck Grad.Cat 12G Vibr.Rol.	 120 m^3/h 30 km/h 5-8 h/km 6-11 h/km			 (11 h/km) * (6 h/km) (9 h/km)
Stabilisation Base Loading:(0.65 m^3/1m of road) Transport: Building in: Compaction:	 Exc. Cat 320 Dump Truck Grad.Cat 12G Vibr.Rol.	 180 m^3/h 30 km/h 5-8 h/km 6-11 h/km			 (4 h/km) * (6 h/km) (9 h/km)
Stabilisation Surface Loading:(0.4 m^3/1m of road) Transport: Building in: Compaction:	 Exc. Cat 320 Dump Truck Grad.Cat 12G Vibr.Rol.	 220 m^3/h 30 km/h 3-4 h/km 4-5 h/km			 (2 h/km) * (4 h/km) (5 h/km)
4.2.2 Repair					
Reshaping	D6 **	50 m/h			
Con.bridge	D6 ** Exc.Cat 320	40 h/pc 40 h/pc			logs not included
Con.Culvert	Exc.Cat 320	8 h/pc			culv.not incl.
Reshaping	Grad.Cat12 G	6-9 h/km			(8 h/km)
Compacting	Vibr.Rol.	6-7 h/km			(7 h/km)
Stabilisation s. 4.2.1					
Resh.& Comp. s.4.2.3.2					
4.2.3 Maintenance					
4.2.3.1 Ren. of Surface					
Resh.& Comp. s.4.2.3.2					
Stabilis. Surface s.4.2.1					
4.2.3.2 Resh. & Comp.					
Clean.ditch & reshaping	Grad.Cat 12 G	3-5 h/km			(4 h/km)
Cleaning ditches	Exc.Cat 320	50 m/h			
Compaction	Vibr.Rol.	2-4 h/km			(3 h/km)
4.2.3.3 Reshaping					
Clean.ditch & reshaping	Grad.Cat 12 G	3-5 h/km			(4 h/km)
Cleaning ditches	Exc.Cat 320	50 m/h			

All costs are machine operating costs incl. operator and based on 6.2 working hours/day

* Calculation Example and Assumptions:
Distance between quarry pit and construction site = 25 km.
1 round trip = 50 km ~ 1.7 h.
1 Dump Truck load = 5 m^3
For Sub-base: 1250 m^3 / 5 m^3 = 250 truck loads * 1.7 h = 425 h = $/km
Base:650 m^3 / 5 m^3 = 130 truck loads * 1.7 h = 221 h = $/km
Surface: 400 m^3 / 5 m^3 = 80 truck loads * 1.7 h = 136 h = $/km

** Performance figures for D7 or equivalents: add 25 - 30 %

Machine Operating Cost Estimate

Machine Calculation, New Tractor, 02.04.2017				
No.	**Data**	**Calculation**	**Unit**	**Price**
1	Purchase price		$	400000
2	Operation time in years		years	8
3	Operation time in hours		hours	10000
4	Operation ratio	03:02	Hours/ year	1250
5	Realistically operation time		Hours/year	800
6	Fuel consumption per hour		L/hour	25
	Fuel price		$/L	2,20
7	Repair factor			1,2
8	Grease factor			0,1
9	Interest rates		%	8,00
	Calculation			
10	Depreciation			
	If 5 > 4	01:03		0
	If 5 < 4	1 : (2 x 5),	$	62,50
		400000 : (8 x 800)		
11	Interest rates / year	(1 x 10 %) : 2 : (5), (400000 x 10%) : 2 : 800	$	20,00
12	Repair and maintenance	(1 : 3) x 7, (400000 : 10000) x 1,2	$	48,00
13	Fuel and grease	6 x GEL/L x (1 + 8),	$	60,5
		25 x 2,20x1,1		
14	Transport	3 per month x12 months x 2h/(5)	$	0,09
		3x12x2/800		
15	**Total costs per hour**		$	**191,09**
16	**Total costs per year**	15 x 5	$	152872

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IV. Guidelines for Forest Inventory and Forest Record Book

Glossary

BHD . . . . . Breast Height Diameter
Com . . . . . Compartment
Dia. . . . . Diameter
FD. . . . . Forestry Department
FDis . . . . . Forest District
FRa. . . . . Forest Range
H. . . . . Height
Ha/ha . . . . . Hectare
Incl. . . . . Inclination
M. . . . . Meter
M^3 . . . . . Cubic Meter
Mgt.. . . . . Management
NFI . . . . . National Forest Inventory
No. . . . . Number
Sub-Com . . . Sub-Compartment
Vol. . . . . Volume

1. Introduction

There are many different designs and possibilities for Forest Inventories. First of all one has to decide for which purpose this particular inventory should serve, what kind of data do I need to give the required information about the condition, volumes, species etc. of that forest land and what accuracy is needed. For National Forest Inventories (NFI) satellite or aerial pictures can be used, controlled of course by ground reference. In case of big differences in terms of species, stand structure and age classes, a few strata should be developed, again, of course with ground reference. The design and implementation of those NFIs specialists should be employed who are familiar with the procedure and calculation of accuracy, variables, etc. There are many consultancy companies worldwide who are in the position to carry out such a job. For a Mgt. Inventory one need more detailed and precise information. The Mgt. inventories should proceed step by step, meaning FDis by FDis, completing one FRa after the other. Parallel the number of FD staff can increase in terms of education and practical training in forest management. The design for a Mgt. inventory stated below is rather simple but contains sufficient information to manage the forest sustainable.

2. Mgt. Inventory

Since the smallest Mgt. entity is the sub-compartment, an inventory for an entire Forest District or Forest Range could become rather expensive. Additionally, in most of the cases, implementation later on is executed partly only, meaning not in all sub-compartments where a planning was carried out. All the recorded data for a 10 years Mgt. Plan will be used partly only and a lot of time spend and funds used are in vain.

Therefor I highly recommend carrying out Mgt. Inventories only in these sub-compartments where an activity has to and can be implemented (staff, funds). The advantage is that the costs are kept to a minimum and one can start immediately with operations afterwards. The costs are distributed over the entire planning period (10 years).

For this Mgt. Inventory I highly recommend a simple line-sampling called “Trans-Sect” which is easy to learn and fast to be implemented. Depending on the respective Forest Laws, about 0,3% to 3% of the sub-compartment area has to be assessed. From the author’s point of view, 2% deem to be sufficient.

The following steps have to be carried out in succession:

2.1 Step 1, Selection of Sub-Compartment

Select a sub-compartment with harvestable volume or where a planting or any other silvicultural treatment is necessary.

Draw a small sketch of the present situation of the entire sub-compartment and record all information into the **For.Mgt.Plan- 1** form and later on into the **Compilation Form**, e.g.:

2.2 Step 2, Trans-Sect

Carry out a Trans-Sect diagonal through each sub-compartment. The Trans-Sect corridors are 5 m wide, the length differ according to the size of the sub-compartment and the requested percentage of the area to be assessed.

An Inventory Group consists of 3 people. The group leader is taking the direction with the help of a compass, measuring the distance with a measurement tape or thread measurement tool and is recording all data. The 2 laborers are measuring the BHDs. Each one carries a stick along, 2,5 m in size, to measure the distance from the center line (laying thread). A plastic water pipe has proven to be optimal for this purpose.

Picture 1: Thread measurement tool (Grube Forst Katalog, Bispingen, Germany)

They collect all BHD’s of all trees and the height of an estimated average tree every 10 to 15 m. Do this for each species separately. From those trees standing on the transect boundary, the data of each second one has to be recorded only. Make use of the **Inv-1 form**. Estimate the crown closure. Calculate the average BHD, height and the respective volume. Measure the inclination for each sub-comp., calculate the average. Draw all roads, skid-trails and other information, e.g. storey/layer, altitude and regeneration area (refer to compilation form). Collect all information about the different forest functions, e.g. protected species, options for recreation, etc. which can be used for the zoning operation. For ad hoc calculation make use of the Inv-2 form. All information has to be entered into the digitized maps, the Inv-3 Form (Table: 4) and the Forest Record Book (Table: 1) at a later stage.

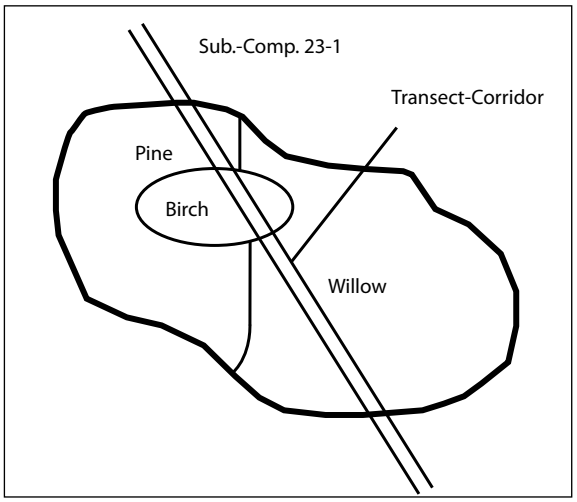


Figure 1: Trans-Sect

Table 1: Inv-1 Form

Inv-1 Form, Forest District:						**Forest Range**					
Comp.:						**Date:**					
BHD	**No.**	**H**	**BHD**	**No.**	**H**	**BHD**	**No.**	**H**	**BHD**	**No.**	**H**
7											
8											
9											
10											
11											
12											
13											
14											
15											
16											
17											

Stand description and planning:

- Inclination/ direction:
- Corridor length:
- Mgt.-Zone:
- Protection:
- Endangered species:
- Altitude:
- Storey / layer:
- Regeneration:
- Crown closure:
- Etc.: Follow all subjects listed in the **Compilation Form.**

Table 2: Inv-2 Form

Inv-2 Form, Com:	**, Sub-Com:**	**Sub-Com Area: Ha**
SUM BHD / No. of trees **= ..... Average BHD**		**Sum H / No. of trees** **= ..... Average Height**
Volume calculation: μ/4 x d1,3² x h x f **f = 0,45 for Needle Trees, 0,5 for Broad Leaf Trees** **Calculation μ/4** x Average BHD (m) x Average BHD (m) x Average Height (m) x f = M³/Average Tree **e.g. BHD = 20 cm, Height = 10 m, Pine Trees** **Calculation: 3,14/4 x 0,2 m x 0,2 m x 10 m x 0,45 = 0,15 M³/ Average tree**		
Calculation: 3,14/4 x ..... m x ..... m x ..... m x (f) = ... M³/ Average tree		
Area Transect Corridor (5 m width x m Length = m²/10000 = Ha **e.g. Corridor width = 5 m, length = 80 m,** **Calculation: 5 m x 75 m = 400 m²/10000 = 0,04 Ha**		
Calculation: 5 m x ..... m = ... m²/10000 = ... Ha		
No. of trees (where BHD was taken) ≈ 0,04 Ha. Question: How many on 1 Ha **e.g. No. of trees = 50** **Calculation: 1 Ha / 0,04 Ha = 25 x 50 trees = 1250 trees/Ha**		
Calculation: 1 Ha / ..... Ha = ... x ..... trees = ... trees/Ha		
Sub-Com. Ha x trees/ Ha **e.g. 12 Ha, 1250 trees** **Calculation: 12 Ha x 1250 trees = 15000 trees**		
Calculation: ..... Ha x ..... trees = ... trees		
Sub-Com. Stand.Vol. = Total No. of trees x Average M³/ tree **e.g. 15000 trees, 0,15 M³/ tree** **Calculation: 15000 trees x 0,15 M³/ tree = 2250 M³ Stand.Vol. = 187,50 M³/ Ha (2250 M³/ 12 Ha)**		
Calculation: ..... trees x ..... M³/ tree = ... M³ Stand.Vol. **= M³/ Ha**		
Standing Vol. – (minus) 15% Needle trees = Harvestable Volume **Standing Vol. – (minus) 20% Broad leaf trees = Harvestable Volume** **e.g. Pine trees, 2250 M³ Stand.Vol.** **Calculation: 2250 M³ – 15% = 1912,5 M³ Harv.Vol.**		
Calculation: ..... M³ – ..... % = ... M³ Harv.Vol.		

The volume calculated with a.m. Inv/2 Form is always a little lower than the volume calculated with the “Basal Area Average Tree” (Grundflächenmittelstamm). Thus, we are always on the save side, meaning not calculating a volume which is higher than in reality.

To achieve much more precise results, enter all BHD and tree heights into the Inv-3 Form, which is an excel sheet and based on “Basal area average tree” calculation. This software is available with the author.

Table 3: Inv-3 Form

Inv-3 Form		**Forest District:**		**V**		Date:	13.05.14
		Forest Range:		Tskene			
Compartment:		**I.7-23**	Ha	2,6			
Pine							
	DBH cm/H m	7	8	9	10	11	12
	Basal area	0,003847	0,005024	0,006359	0,00785	0,009499	0,011304
65	No.:	0	0	0	1	0	0
2,54	T.basal area	0	0	0	0,00785	0	0
0,45	Form factor:	0,45	0,45	0,45	0,45	0,45	0,45
7	Height No:	0	0	0	0	0	0
114	Sum	0	0	0	0	0	0
16,29	H.Average	16,28571	16,28571	16,28571	16,28571	16,28571	16,2857143
0,22	Average BHD m:						
18,64	Volume m^3:	0	0	0	0,057529	0	0
0,29	Avarage vol/tree m^3						
0,056	Corridor ha	Width m	5	length m:	112		
1161	Trees per ha						
332,92	Volume per ha						
865,59	Total Volume m^3:						

2.3 Step 3, Data Processing

Process all collected data and enter all information into the form **"For.Mgt.Plan 1".** Describe the present situation with a few words.

2.4 Step 4, Planning

Make use of the For.Mgt.Plan 2 form. Think, discuss and finally decide what activities have to be carried out during the entire Mgt. Planning period (normally 10 years) in this respective sub-compartment.

2.5 Step 5, Annual Planning

All activities mentioned in the For.Mgt.Plan 2 form have to be broken down to an Annual Plan of Operations (APO), refer to For.Mgt.Plan 4 form. Here one has to decide what should be done in the respective year of the planning period. Since these data are collected for each Sub-Comp., they have to be entered as a summary for all into For.Mgt.Plan form 6, 7 or 8.

2.6 Step 6, Documentation, Monitoring & Control

Always after finalizing an operation, latest at the end of each year all implemented activities have to be recorded on the For.Mgt.Plan 3 form. By comparison of planning For.Mgt.Plan 2 with For.Mgt.Plan 3 form, one can easily monitor the progress of implementation throughout the entire year for the respective sub-compartment. Reasons for deviations from the Mgt. plans should be mentioned and justified.

2.7 Step 7, Final Documentation, Monitoring & Control

Transfer of all information about implemented activities at the end of each year to the For.Mgt.Plan 5 form. Now compare For.Mgt.Plan 4 (APO) with For.Mgt. Plan 5 (AAPO) form to gain information about the total implementation of that year.

So, at the end of each year, the achievements can be evaluated and, if necessary, in the following years be adjusted. At the end of the entire planning period, normally 10 years, achievements should comply with the planning.

From Step 3 onwards all data are entered in a computer and at the end of each year be printed out and filed.

Table 4: For.Mgt.Plan and Record Book

Forestry Management Plan and Record Book 2015 to 2025

Forest District:				**Com. No.: *I/2-4***		**Total area: *16,0* ha**		
Altitude m	**Area of Regen. %**	**Age**	**Incl.% Dir.**	**Main Species**	**Crown closure**	**Aver. Dia. cm**	**Aver. Height m**	**Cal. Stand. Vol. m³**
700	*20*	*51*	*S 16*	*Pinus silves-tris 99%*	*0,9*	*25*	*19*	*1374*
				Ash 0,5%		*9*	*10*	*5*
				Hornbeam 0,5%		*15*	*15*	*7*
				Total				***1387***

Date: 14.11.2014 Compiled by: Walter Benneckendorf

Map: GPS -Coordinates: W N S E

Present Situation / History:

The total area was logged over by “Timber Eating Logging Company”. The area is therefore characterised by low timber volume. Appr. 80% of the area is covered with a loamy and sandy soil. Total present volume estimated: 15 m³ construction timber, 80 m³ fire wood per ha.

For.Mgt. Plan 2	Planning 2015 - 2025	Sub-Com: I/2-4

Management Goals and Restrictions: Enrichment planting in Sub-Com I.2-4 (low standing volume). Timber production. No grassland in between. Planting areas have to be fenced in the first year against livestock.

Mgt. Plan No.	Activity	Year	Unit/ Quantity kg,m, pc, h,)	HARV. M³	Ha	Costs $				Comments
						Income		Expenditure		
						FD	Others	FD	Others	
1	Planting of pine seedlings from Rustavi, Size 50 cm, Spacing 2x2 m	2013	2000 Pc 8 hours		1,0				1000 80	1 seedling = 0,5$ 10$ per h Planting by GIZ
2										
3										
4										
5	Harvesting of birch firewood	2013		32	1,6	96				20 m³ per ha License fees
22	Harvesting of birch firewood	2016		34	1,7	102				20 m³ per ha License fees
Total				66		198			1080	

For. Mgt. Plan 3	Implementation and Documentation (IaD) from AAPO	2015 - 2025		
Tbilisi City Hall Forest	Compartment: I/2-4	Compiled by:	Date of 1st Entry: 01.07.2014 Date of last Entry	Total Area: 16,0 ha

Mgt Plan No.	Activity	Unit, Qua.	Ha	HarvM³	Year, Date of entry	Costs GEL				Comments
						Income		Expenditure		
						TCH	Others	TCH	Others	
1	Planting of pine seedlings from Rustavi, Size: 50 cm, Spacing 2x2m	1000 pc 5 h	0,5		2013 15.07.2013			50	500	GIZ Bad weather (5 h x 20,00 L)
5	Harvesting of birch firewood		1,0	7,5	2013 15.07.2013	150				Cash to TCH TCH intends to cut the rest next year
Total			1,5	7,5		150		50	500	

For.Mgt. Plan 4	Annual Plan of Operations (APO)				Year *2015*				
Tbilisi City Hall Forest		Compartment: *I/2-4*			Compiled by: *Mr. Charadze*		Date: *01.07.2014*		Forest Area: *16,0 ha*
Mgt Plan No.	Activity	Unit	Ha	Harv. M^3	Costs $				Comments
					Income		Expenditure		
					FD	Others	FD	Others	
1	*Planting of pine seedlings from Rustavi, Size: 50 cm, Spacing 2x2m*	*2000 pc 5 h*	*1,0*				*50*	*1000*	*GIZ (5 h x 10$)*
5	*Harvesting of birch firewood*		*2,0*	*15*	*150*				*Cash to TCH, License fees*
Total			*3,0*	*15*	*150*		*50*	*1000*	

For.Mgt. Plan 5	Annual Achievement of Plan of Operations (AAPO)				Year *2015*				
Tbilisi City Hall Forest		Compartment: I/2-4			Compiled by:		Date:		
Mgt Plan No.	Activity	Unit	Ha	Harv. M^3	Costs $				Comments
					Income		Expenditure		
					FD	Others	FD	Others	
1	*Planting of pine seedlings from Rustavi, Size: 50 cm, Spacing 2x2m*	*1000 pc*	*1,0*				*50*	*500*	*GIZ Bad weather (5 h x 10$)*
5	*Harvesting of birch firewood*		*0,5*	*7,5*	*16.500*	*60.000*		*16.500*	*Cash to TCH, License fees*
Total			*1,5*	*7,5*	*16.500*	*60.000*	*100*	*16.500*	

For.Mgt.Plan,6	Annual Harvesting Plan									Year:
Sub-Com	Species	Ha	Age	Assort-ment	M^3/Ha	Total M^3	Estimated Costs $			Com-ments
							Total income	Exp.	Bal-lance	
Total										

For.Mgt.Plan,7		Annual Plan for other Activities					Year:
					Costs GEL		
Sub-Comp.	Activity	Ha	Unit Quantity	Date/ Month	Income	Expenditure	Comments
Total							

Mgt.Plan,8	Annual Plan for Stand Establishment							Year:	
Sub-Com	Species	Age	Ha	Spacing	No. of Seed-lings	Date/ Month	Costs Seed-lings $	Costs Plant-ing $	Com-ments
Total									

Compilation Sheet

Line	Forest district	ownership	Forest Range	compartment	Mgt. Zone	Total area	year of reference	Planning until	altitude	slope direction	inclination	Substrate	skeletal soil	soil type	Natural age class	crown closure
1	TCH	Com-mu-nity	Kojori	II.7-34	3/4	4,2	2013	2025	1300	9	22				5	0,9
2			Kojori	II.7-36	3/4	3,3	2013	2025	1310	5	16				5	0,9
3			Kojori	II.10-4	3/4	5,6	2013	2025	1360	3	20				5	0,9
4			Kojori	II.50-2	3/4	8	2015	2025	815	5	30				3	0,6

Line	Tending operation	Danger class	Storey/ layer	tree species	tree species group	Target of growing stock	age	age class	yield class	stand density	subarea ha	mixture of trees	quality	number of trees	height m	dbh 1.3 cm
1	3	1	0	pi	pi	ms	52	3			4,2	1	3	4796	15	24
2	3	0	0	pi	pi	ms	51	3			3,2	1	3	3138	19	25
3	3	1	1	pi	pi	ms	46	3			5,6	2	3	6479	14	21
4	0	1	0	pi	pi	ms	55	3			8	1	3	3576	8,3	24

Line	growing stock m^3	Increment m^3 year	tending necessity	tending area ha	AAC m^3	Total allowable cut m^3	Regene-ration ha	reg. natural ha	reg. artificial ha	Fire risk class	Threats
1	1446		2	4,2		126	1,05	1,05		III	
2	1411		2	3,3		100	0,66	0,66	0	III	
3	1454		2	5,6		168	1,1	1,1	0	I	
4	623		3	8		80	0	0	8	III	

Code number/key for Compilation Sheet

Cardinal point	
N	1
NO	2
E	3
SO	4
S	5
SW	6
W	7
NW	8
SE	9
All directions	0

Inclination	
< 10°	1
10 -20°	2
20-30°	3
30-35°	4
> 35°	5

Skeletal soil	
0-25%	1
25-50%	2
50-75%	3
> 75%	4

Natural age classes	
regeneration (natural/artificial)	1
thicket stage	2
young stand	3
pole stand	4
timber	5
old timber	6

Tending necessity	
tending arrears	1
tending urgently	2
tending o.k	3

Mixture of trees	
single	1
small group	2
great group	3
areal	4
rows	5
stripes	6

Age class	
0-19	1
20-39	2
40-59	3
60-79	4
> 80	5

Crown closure
≤ 0,9
1
≥ 1,1

Tending operation	
cleaning in seedling age	1
Pre-commercial thinning	2
thinning	3
final cut	4

Threats	
> 25% of the trees dead	1
10- 25% of the trees dead	2
gaps	3
many top ruptures	4
grow up to weeds	5

Storey/layer	
main layer/storey	0
upper storey	1
second layer/storey	2
regeneration under canopy	3

Quality	
good	1
average	2
poor quality	3
fire wood	4

Stand density		
Thin	0,1-0,2	1
Low	0,3-0,4	2
Average	0,5-0,6	3
High	0,7 and more	4

Fire risk classes	
I	pine trees, young coniferous trees, coniferous bushes on the south exposition slopes
II	oak, hornbeam, chestnut, acacia, oriental hornbeam stands, deciduous bushes on the southern exposition slopes
III	I and II stands on the northern exposition and IV on the southern exposition
IV	fir-tree, spruce, beech and other species stands on the northern exposition slope
V	alder, willow, wing nut, asp, eucalyptus stands, ever green bushes, riparian forests and other stands located on wetlands

Mixed species groups	
Oak: e.g. common oak, sessile oak,	Oak
Beech:	be
Hornbeam	hb
Other broad leaf trees alder, willow, poplar tree, robinia, ash, birch, wild cherry, maple, nut trees, lime trees	Obl
Spruce spruce, fir,	Sp
Pine different species	Pi
Mixed species conifers + deciduous species	ms

Protection Forest
Zone 1:
1.1 Steepness
1.2 Endangered species of flora and fauna
1.3 Erosion risks
1.4 Water protection
1.5 Noise protection
1.6 Climate protection
1.7 Nature protection
Zone 2: Close to nature forest management
Zone 3: Plantation forests, mixed plantations and forests considered to be converted into natural forest management.
Zone 4: Forests for community needs and recreation
4.1 Recreation Forest
4.2 Education Forest

Danger class	
Healthy, no danger	0
light desease	1
sick	2
exposed to wind throw	3
dying	4
dead	5

3. References

Benneckendorf, Walter: 2014; Guidelines for Forest Inventory for Tbilisi City Hall Forests, Project Report, Tbilisi, Georgia

Grüneklee, Wolfram: 2013; Forest Management Planning, Project Report, Tbilisi, Georgia

Staupendahl, Kai: 2014; Forest Inventory, Planning & Monitoring, Project Report, Tbilisi, Georgia

V. Silvicultural Guidelines

Glossary
LÖWE. . . . . Long Term Ecologically Forest Development
Mgt.. . . . . Management

1. Introduction

As already mentioned in chapter Mgt. Planning, the determination of the Mgt. Goal and a strategy for forest development has to be established as a first step.

All following remarks have to be seen as an example and are intended to assist in the formulation of Mgt. Goals and duties of any Forest Department. They should give a direction and outlook for future forest management. They are derived from the Lower Saxony (Germany) Forest Department's silvicultural program.

"The forest deserves our special attention. We are everywhere in the need of a new ecologically oriented silvicultural planning, which is specifically designed for a species-rich forest. Additionally all possibilities of forest management have to be used to improve the resistance of our forest ecosystems."

(Chief Minister of Lower Saxony, Mr. Gerhard Schroeder, 1990)

For the restoration of bare or heavily degraded landscapes I highly recommend to make use of the *"Community based Participatory Watershed Development Guidelines" of the Ministry of Agriculture and Rural Development, Ethiopia (s. References). These Guidelines show a big range of possible technical structures and bio-physical measures including the required person-days and related costs to improve degraded lands. These guidelines are available with the author.*

2. Long Term Ecological Forest Development ("LÖWE Program")

The respective authorities have to manage the forests according the following basic principles:

- Management to the highest benefit for the general public. This incorporates a management that supports the favorable effects of the forest on the environment, especially on the protection and recreation function.
- Management to maintain an appropriate standing volume, to manage the forests sustainable and to utilize the forest products economically. To permanently guaranty the supply of timber and long term yield and the protection and recreation functions to the benefit of present and future generations.
- Management to the best (economical) practice, to achieve goals with the lowest input of money (staff, machinery), or, in case of lack of funds, as far as possible.
- All forest functions as protection, recreation and profit are considered to be equal. The determination is according to the Zoning process (see chapter Zoning). In a long term, they can be optimal realized only, if the silvicultural and ecological goals and techniques are corresponding.
- The forests have to be tended in a sustainable and economical way, to develop the forest ecosystems in such a way, that the productivity will be maintained forever. A natural oriented silvicultural system opens up the possibilities to combine the ecological requirements with the economically goals of sustainable timber production on the entire forest area. Forest operations facilitate the establishment, tending and conservation of healthy and against pollution resistant forests, the protection or re-establishment of their ecological biodiversity, potential for recreation and production of high-value timber.
- Mixed species stands, with a structural variety and according to site conditions have to be established and supported, if possible from natural regeneration.
- Beside the protection of certain biotopes, an ecologically oriented silviculture gives the opportunity to develop the positive natural values of the forest to an ecologically balanced area in a heavily changed cultural landscape.
- The ecologically oriented silvicultural program has to be put into practice through The Forest Management Plan (10 years period), which is part of the Long Term Ecological Planning. The implementation has to be carried out through the annual work plans of the respective Forest Districts.
- Macro planning in the forestry sector can contribute in connections with other programs for all forest owners to the realization of these management plans.
- The development or change into close to nature forests cannot be implemented abruptly, destroying the present forest structure. Thus, the implementation of this program has to be seen as a consistent and long term developing process. It needs the compliance and homogeneous efforts of several generations of foresters.

3. Principles for an Ecological Forest Development

3.1 Soil protection and site-adequate choice of tree species

Maintenance and / or restoration of forest soils are a priority. It is a pre-condition to keep its natural capability (power). Fertile forest soils are the foundation for healthier, varied and productive forests. Beside this, a high quality ground water level will be insured.

The potential of sites should not be changed to a higher quality, due to the need of man. The drainage of wet sites should be stopped. Fertile soils have to be maintained. Damaged soils, due to former missmanagement, e.g. polluted soils, should be restored only, as long it is not interfering with ecological requirements.

Only site-adequate species should be planted. Natural forest ecosystems should be maintained and regenerated. Site mapping is only recommended if soils have to be restored or the establishment of plantations is planned. Its results have to be implemented, structured according to ecological growth zones. In case a natural forest management is just continuing, site mapping is not always essential.

3.2 Propagation of mixed stands

In tropical zones just let nature work, meaning whatever growths is correct. In temperate zones the situation is different. Here, increase and protect the biodiversity of forest stands, mixed stands have to be established as many as possible. Prevent as far as possible mono-cultural stands. Pure stands are naturally very rare and so limited to extreme sites only. Priority has to be given to mixed stands according to their respective ecological conditions. Mixed stands are much more resistant against the negative impacts of climate change.

3.3 Ecological effects

The diversity of tree species in the different growth zones, originating in the course of evolution and natural forest development, should be encouraged. Adding additional tree species is possible, as long as there is no interference with the productivity, stability and flexibility of the forest ecosystem.

3.4 Preference of natural regeneration

As long as the forest is covered with a mixture of site-adequate species, corresponding with natural stocking, natural regeneration should be preferred.

As long as pioneer stockings and stands not suited to the site or genetically unsuited occur, the chance to establish mixed species plantations under shelter should be taken. The use of site-adequate and ecologically suited provenances is compulsory.

3.5 Improvement of the forest structure

Increasing the stability of forests and the number of ecological niches can be achieved through adaptation to site requirements, the choice of different species according to their capacities and through vertical structuring of stands. E.g. species for forest borders with a deep rooting system and different heights. Clear cuts should be avoided as far as possible. They can be implemented only, if a site contains thick pioneer stocking, is genetically undesirable or the species are not site- adequate. The size should not be larger than 1 - 2 Ha for 1 cut.

3.6 Chosen tree system (exploitable size felling)

Forests should grow old. They should be harvested in a single-stem cutting when they have reached their exploitable size (? cm DBH). This refers especially to tropical forests. In temperate zones felling of small trees could become feasible as long the forest floor is covered sufficiently.

3.7 Preservation of old trees and protection of rare and threatened plant- and animal species

By using the forests selectively, old and big trees should be extensively preserved in clusters or small areas, as habitats for animal-and plant species, which need this kind of environment to live (insects, animals living in tree holes, fungus, mosses, etc.) There are many rare and threatened plant and animal species that appear in the forests. They have to be preserved and supported in the framework of an ecologically based forest management system. Rare and threatened native tree species should be regenerated on appropriate sites. Their genetically potential has to be protected.

3.8 Building up of a forest conservation area network

An appropriate amount and a representative choice of forest areas, which are typical for rare ecosystems, should be protected. These forests will not be managed, or under restricted conditions only. Nature protection areas and natural forest reserves are included. In some of these areas harvesting operations are prohibited to insure the maturation- and decay phases of the forest with its specific symbiosis. These processes are valuable for scientific observations. Independent of this, certain biotopes which are under the respective nature conservation law, have to be preserved. Additionally, rare and valuable single biotopes which are not protected by law, should be recognized and to be taken care of.

3.9 Guarantee for special forest functions

In case certain forest functions, as soil-, water-, climate-, visibility-, pollutant-, noise- and biotope protection, are not ensured by an ecologically oriented silviculture already, the locally important function can be separately developed.

The development of Forest Function Maps and biotope mapping by the respective Forest Departments serve as a basis, beside land use programs, landscape plans, construction plans and the biotope mapping of any other Departments.

The forest protection functions are not allowed to be endangered by any other function or activity.

(Refer to chapter Zoning and Protection)

3.10 Establishment and maintenance of forest borders

As a consequence of forest development, forest borders have to be specially maintained. They have to be stocked permanently with a diverse range of native shrubs, bushes and tree species. They have to

be developed in an appropriate width (min. one tree length) and the vegetation should decrease in size towards the barren areas. Tending operations have to secure the less competitive species. Borders inside the forests can be developed similarly, only the width can be smaller.

3.11 Ecological forest conservation

The biological forest conservation has priority over technical operations. This principle complies as a preventive measure with the development and tending of site-adequate mixed forests, with a big variety of species and structural diversity.

The use of substances (Pesticides), providing protection against damages and not originating from the respective ecosystem, is authorized only, in case of existential threats for stands and forests and their respective functions. Their application has to follow the principle of the least environmental impact. Therefore biotechnical measures are preferred. As long these measures are not feasible in all places, or their effects are not sufficient, selective working substances in the lowest possible concentration can be applied. A combination of both, biotechnical measures and selective working substances, can be recommended.

3.12 Ecosystem compatible wildlife and livestock management

Since all wildlife populations are quite limited in number and rarely a threat to the forest, the author has not addressed this subject in a separate chapter. If the need arises, Guidelines have to be elaborated.

In accordance with the respective hunting rights appropriate game populations have to be maintained as part of the forest ecosystem.

The development of an ecological oriented silviculture may not be jeopardized by excessive game and / or livestock populations. Game populations have to be regulated by hunting in such a way, that the biodiversity and ecological forest development is not be endangered. This is guaranteed when the main tree species can regenerate natural without any protection measures. The same refers to livestock. The grazing of livestock inside the forest has to be well planned and regulated by the respective Forest Departments. In many development countries this problem is not sufficiently addressed and respective legal regulations are either missing or not enforced at all.

(Refer to chapter X. Guidelines for Pasture Mgt.)

3.13 Ecologically sound harvesting operations

Tending operations in the forest should control the natural dynamic processes in a cautious way. The “Biological Rationalization” has to be preferred. This means give nature a chance: wait until the differentiation of a stand is completed, do not interfere before. Harvesting technology has to meet ecological requirements. Only those technologies can be applied which take care of the forest soils and stands with its structure and biodiversity.

4. References

Ministry of Agriculture and Rural Development 2005; “Community based Participatory Watershed Development Guidelines”; P.O.Box 62347; Addis Ababa, Ethiopia

Nature Resources Sector, e-mail: moard-nr@telecom.net.et

Nds. Landesforsten 1991, Das Löweprogramm, Langfristige ökologische Waldentwicklung, Husarenstr. 75, 38102 Braunschweig, Germany

Forest Inspection in Thunkel, Mongolia (Foto: K.Schmidt-Corsitto)

V.1 Stand Establishment Guidelines

Glossary

Cm	centimeter
Ha/ha	Hectare
Kg	Kilogram
L	Liter
M.	Meter
Stock.Dens.	Stocking Density

1. Introduction

Modern forest management must have the goal to establish close to nature, site compatible and stabile forests. This means creating forest stands with species of autochthonic origin and provenances of the respective country. As long as an old stand consists of species compositions fulfilling these requirements, natural regeneration should be given priority. If this is not the case, planting or sowing might become necessary. Furthermore, forest management has to support the biodiversity of flora and fauna and to minimize risks. Since monoculture forests are not fulfilling these requirements, the future management will concentrate on the improvement into mixed or even pure broad leaf tree stands.

2. Seed Storage

In times of climate change and many natural disasters every country should have a National Seed Storage. This refers nowadays even to tropical zones where under normal conditions one could depend on natural regeneration of stands only. After big forest fires or storms every country has to be in the position to react and to establish forests again. Seeds should be collected from autochthonous stands and tree species only. They should be separated according to origin, vegetation zone and altitude and the storage be well documented. More detailed information on the legal aspect can be obtained under google:

Forstvermehrungsgutgesetz

…and for more information about collection, storage, site preparation and stratification via google:

Niedersächsische Landesforsten
Forstamt Oerrel
Forstweg 5
29633 Munster-Oerrel
Tel.: 05192 - 9804-0
Fax.: 05192 - 9804-55
Email: Poststelle@nfa-oerrel.niedersachsen.de
www.landesforsten.de/oerrel

All the information is in German language unfortunately but it is worthwhile to be translated if required.

3. Stand Establishment

To keep broad leaf and mixed stands, one can depend on natural regeneration. To increase the number of those stands, planting or sowing with appropriate species should commence as soon as possible. Most of the gaps inside the forest, except for ecological and recreational reasons, should be treated accordingly. Most probably, these areas have to be protected by fencing against roaming livestock.

3.1. Natural Regeneration

Advantages of natural regeneration:

- Ecologically sound
- Cost effective
- Support by old stand: protection against frost and heat, seedlings are not subject to a planting shock.
- No root damage

During the last 2 decades of the rotation period of a stand, seed trees have to be cut free enough to develop big crowns and to gain sufficient sun light. The seed trees should be equally distributed over the forest area. A Crown Closure of 0,2 – 0,5 is recommendable. In case of pine regeneration the Crown Closure should not be bigger than 0,2. This is usually achieved by 2 to 3 cuts. One has to find a year where these mother trees carrying sufficient seeds. While carrying out the required thinning, the soil will be wounded, especially during yarding operation, and so the seed bed is prepared. If this seems to be not sufficient, site preparation becomes indispensable (see below).

3.2 Site Preparation

In old stands with a lot of ground vegetation and a big humus layer, site preparation can improve the generation of seeds and improve the growth of seedlings. On sensitive soils, which tend to compaction, e.g. clay or loam, the use of heavy machinery is not recommendable. In stands with a great amount of cutting debris, a clearing by hand or machinery might become necessary. If natural regeneration is not possible, the decision has to be made, based on cost calculations, either to sow or to plant. In case of planting, clearing is necessary only for planting plots, which could minimize the costs tremendously. Site preparation should be carried out just before the seeds fall and planting or sowing should commence.

3.2.1 Sensitive soils and "Impassable Areas"

Hand work is needed to establish planting plots, seed plots and/or seed rows. For planting plots the use of an Earth Auger can be highly recommended. Another option, especially for seed rows is the use of a horse pulling a forest plough. In case of sowing, the seed rows should go along the hillside, crosswise to the slope, to prevent erosion.

Tools:

Figure 1: Hook

(Der Forstwirt, 2000; 3. Auflage, Ulmer Verlag Stuttgart, Germany; Helmut Flebacher, Fellbach)

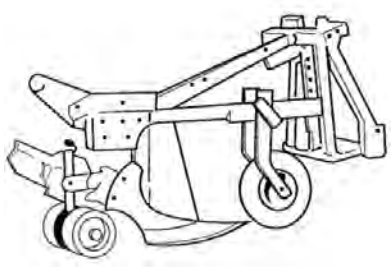


Figure 2: Forest plough

(Der Forstwirt, 2000; 3. Auflage, Ulmer Verlag Stuttgart, Germany; Helmut Flebacher, Fellbach)

Figure 3: Earth auger

(Foto: Internet search)

3.2.2 Drivable areas and insensitive soils

Here the use of machinery is recommended to improve performance and to minimize costs.

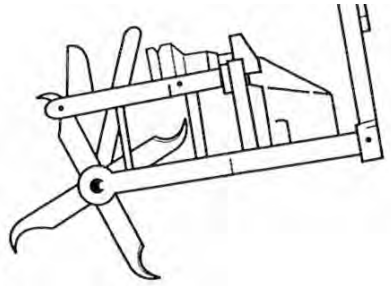


Figure 4: Cultivator

(Der Forstwirt, 2000; 3. Auflage, Ulmer Verlag Stuttgart, Germany; Helmut Flebacher, Fellbach)

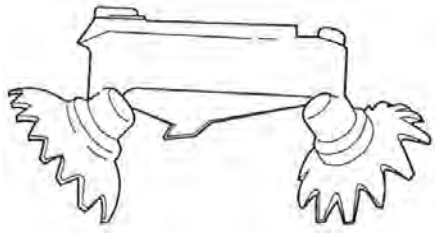


Figure 5: TTS/Rome cultivator

(Der Forstwirt, 2000; 3. Auflage, Ulmer Verlag Stuttgart, Germany; Helmut Flebacher, Fellbach)

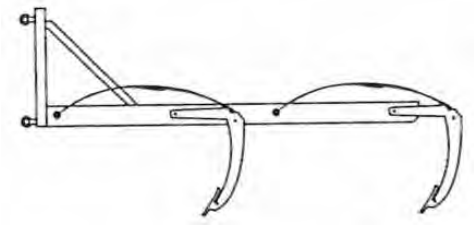


Figure 6: Hessian cultivator

(Der Forstwirt, 2000; 3. Auflage, Ulmer Verlag Stuttgart, Germany; Helmut Flebacher, Fellbach)

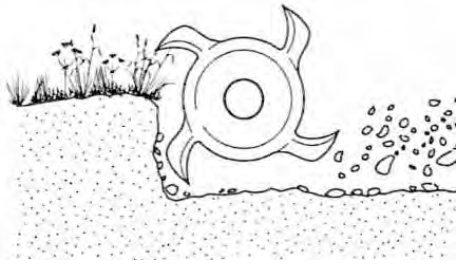


Figure 7: Rotator

(Der Forstwirt, 2000; 3. Auflage, Ulmer Verlag Stuttgart, Germany; Helmut Flebacher, Fellbach)

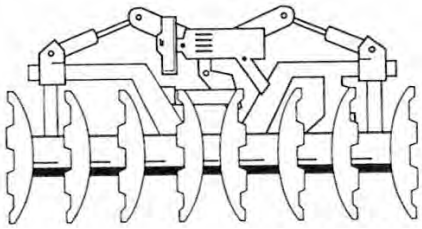


Figure 8: Rome plough

(Der Forstwirt, 2000; 3. Auflage, Ulmer Verlag Stuttgart, Germany; Helmut Flebacher, Fellbach)

3.3 Artificial Regeneration

3.3.1 Sowing

Sowing should be given priority against planting if sufficient seeds are available, the ground vegetation is limited and wildlife and roaming livestock can be controlled.

Sowing into a single rut along the hillside, crosswise to the slope, can be recommended. Conifer seeds should be stratified by watering for 24 hours, 7 – 10 days before sowing. Afterwards drying back is necessary until the seeds do not glue to each other anymore. The seeds should be stored in a linen bag and moved daily to prevent mold formation.

Refer to Poststelle@nfa-oerrel.niedersachsen.de, Preuss, A.; Kiefer, K.; Gille, K.; 2014; “Praxistips der fsb zur Freisaat im Wald”; Nds. Landesforsten; Forstamt Oerrel, Forstweg 5, 29633 Munster-Oerrel

Table 1: Sowing

Species	Seeds/kg	Germination Rate %	Sowing Time	Germ.after (weeks)	Seed cover, cm	Quantity Per ha, kg
Pine	160000	95	April	2-5	1	3
Oak	300-500	70-80	April	3-6	5-8	350
Beech	5000	80	April	2-4	3	100

3.3.2 Planting

Planting has some advantages too:

- Compared to natural regeneration independent of the previous residual stand and seed building.
- Overcoming faster ground vegetation pressure and browsing.
- Less maintenance costs later on.

All seedlings have to be handled carefully at all times! Roots exposed to sun and wind for a few minutes only, will die off!

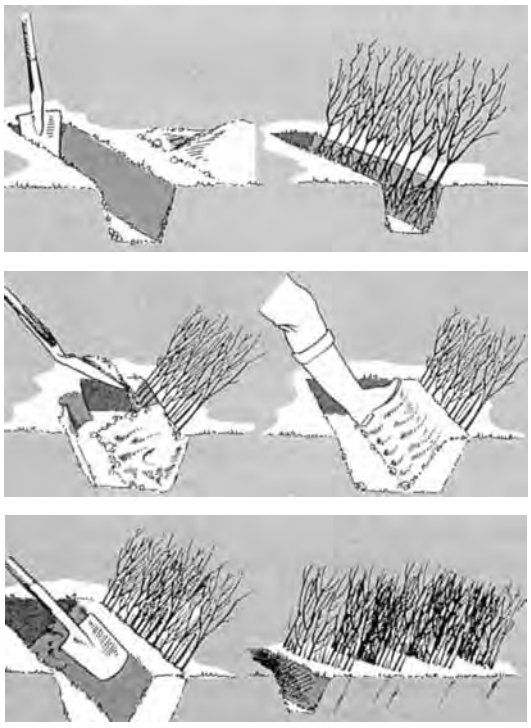


Figure 9: Storage of seedlings

(Der Forstwirt, 2000; 3. Auflage, Ulmer Verlag Stuttgart, Germany; Helmut Flebacher, Fellbach)

When seedlings are bought and transported to the planting site, its condition should be checked immediately at arrival. Additionally, each seedling transport has to be attached with an accompanying document where all important information can be found. Refer to “Seedling Checklist” below.

Table 2: Seedling checklist

Seed Collection					Date of Collection:	
Region	Forest District		Forest Range		Compartment	Sub/ Comp.
Species	Provenance	kg		Packed into	Collected by	
Transport to Nursery		Date		Transported by (Company)		
Arrived at Nursery (Name):				Date of Arrival:		
Stored (Date)						
from	to	Place				
Sowed						
Date	Place			kg		
Transplanted						
Date	From Place	No. of Seedlings		To Place		
Digging out of seedlings				Date:		
Sold to Company or Forest District						
Date	Age	Size cm	No of seedlings	Packed into	No. of seedlings per bundle/ container box	No. of bundles/ container box
Transport to Company or Forest District						
Date	Transported by (Company)					
Arrival at Company or Forest District						
Date	Company or Forest District					
Inspection by Company or Forest District:						
Date:		Name of Inspector:				
Freshness	Size	Quantity		Height/Bud diameter relation	Height/Root length relation	
Seedlings accepted				Seedlings rejected		
Date:				Date:		
Signature:				Signature:		

3.3.2.1 Container seedlings

It is highly recommended to make use of container seedlings to prevent losses and following re-planting. Container seedlings can be planted all over the year as long the soil is not frozen, but except during the summer months (June – August). In case of a wet summer, planting of conifer seedlings might be possible. Of course, if you are in the position to water the seedlings planting is possible all over the year. A lot of times container seedlings are grown already too big and do not match with the container size anymore. Subsequently root coiling has started. These seedlings will grow just normally the first years but become very unstable when reaching a DBH of around 10cm and finally will be thrown by wind. Therefore, check the container seedlings after arrival accordingly.

A) Planting Techniques and Tools

Successfully tested is the planting of container seedlings with **hoe and spade**. Additionally the use of an **earth auger** can be highly recommended. Container seedlings have to be taken out of the container just before planting them, one by one! Do not dig planting holes days before the actual operation starts!

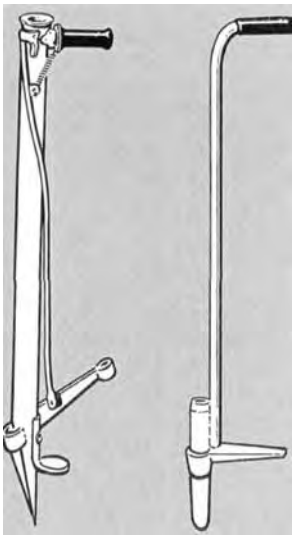


Figure 10: Container planting tool

(Der Forstwirt, 1993; 3. Auflage, ISBN 3-8001-1098-9, Ulmer Verlag Stuttgart, Germany)

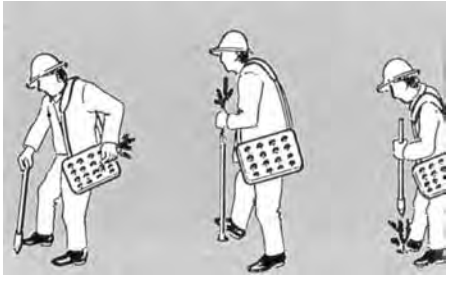


Figure 11: Container planting system

(Der Forstwirt, 2000; 3. Auflage, Ulmer Verlag Stuttgart, Germany; Helmut Flebacher, Fellbach)

Figure 12: Earth auger

(Foto: Internet search)

3.3.2.2 Bare-rooted seedlings

Root naked seedlings are much more sensitive. Therefore one has to be very carefully during the entire transport cycle, from collection in the nursery until the storage on the planting area. Damaged seedlings will most probably die off later on and a cost intensive re-planting becomes necessary.

Never expose the roots to wind and sun! Keep the seedlings always shaded! Transport optimally in plastic bags, sacks or buckets filled with a little soil and little water (just moist). Take seedlings out just before planting them, one by one.

Again, do not dig planting holes days before the actual operation starts!

Table 3: Planting Periods for root naked seedlings

Species	Planting Period
Conifers **Recommended:**	1. Spring, frost free time until May. Buds still closed. 2. Late Summer, August – September. Growth has ceased. Buds are closed.
Broad Leaf Trees and Larches **Recommended:**	1. Spring, frost free time until May. Seedlings do not bud yet. 2. Autumn, October until frost period starts. Seedlings have lost leafs, growth has ceased and buds are closed.

A) Planting Techniques and Tools

Planting of root naked seedlings with hoe and spade is definitely the best option but are very cost intensive. An earth auger can be highly recommended when the panting area is covered with a lot of weeds and/or debris.

The size (deepness) of the hole has to match with the size of the respective roots. Do not set the seed-

ling deeper than it stood in the nursery! Do not compress the roots into the hole! The roots have to be totally covered with soil! Compact the soil by stepping on it!

The following planting techniques are much more cost effective but require more skills. All workers making use of these techniques have to be trained by professional staff. The first step is always the removal of the top soil layer (40x40 cm).

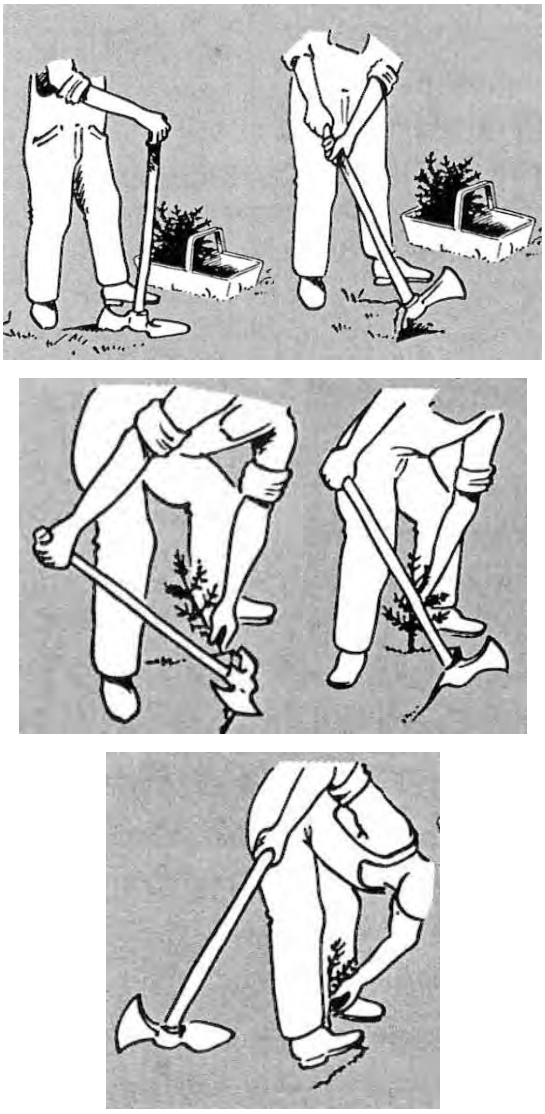


Figure 13: T-planting

(Der Forstwirt, 2000; 3. Auflage, Ulmer Verlag Stuttgart, Germany; Helmut Flebacher, Fellbach)

Figure 14: „Buchenbuehler“ planting system

(Der Forstwirt, 2000; 3. Auflage, Ulmer Verlag Stuttgart, Germany; Helmut Flebacher, Fellbach)

Table 4: No. of seedlings and spacing

Species	Spacing, m	Seedling / ha	Recommended size, cm
Pine	2 x 0,5	8000-10000	30 – 50
Oak	2 x 0,5 (0,7) 1,5 x 0,8	8000 - 10000	30 – 50
Beech	2 x 0,5 (0,7)	8000 - 10000	30 - 50
Other species	2 x 2	2500	30 - 50

Table 5: Fighting concurring vegetation

Concurring Vegetation	Mechanically Operations		Chemically Operations	
	Activity	Tools	Activity	Herbicide, Tools
Grass, weeds	Mowing	Lawn mower Scythes Sickle Motor trimmer	Spraying 2,4 L/ha 300 L/ha	 Round Up Water
Shrubs, bushes	Cutting	Slashing knife, Axe Motor trimmer	Spraying 4,0 L/ha 300 L/ha	 Round Up Water
Small trees	Cutting	Axe Chain saw Motor trimmer	-	-

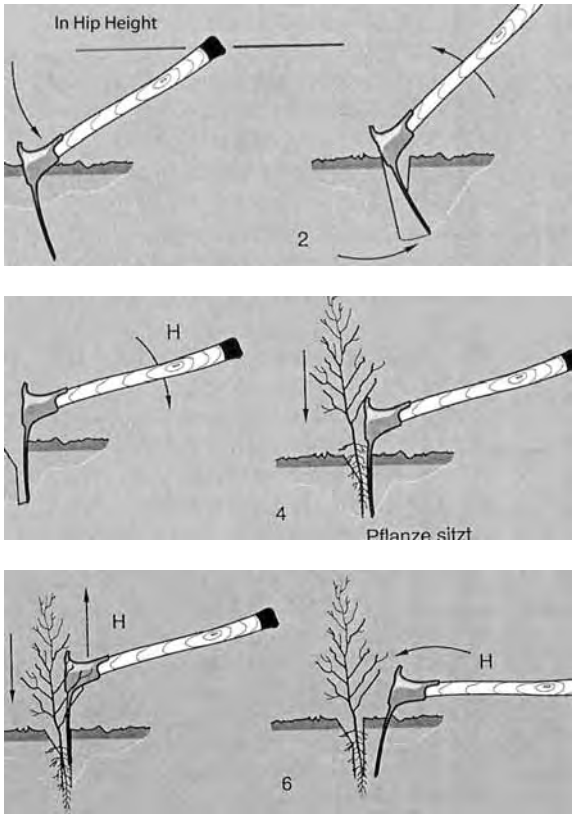


Figure 15: „Rhodener“ planting system

(Der Forstwirt, 2000; 3. Auflage, Ulmer Verlag Stuttgart, Germany; Helmut Flebacher, Fellbach)

3.4 Seedling Transport

During the entire seedling transport from the nursery to the planting area inside the forest, the seedlings have to be protected against sun and wind. Consequently they have to be covered with a tarpaulin, kept shaded, cool and moist at all times. Lying around for a few minutes only exposed to sun and wind can cause severe damages. Since truck- and tractor trailer floors are commonly made of metal which can heat up very much, these floors have to be cooled down before putting seedlings on it. Reaching the final destination, seedlings have to be stored correctly. (Refer to Fig.9)

3.5 Maintenance of Planted Area

The term maintenance is used until the seedlings have reached a height of 2 m. Depending on soil and light conditions, maintenance operations might become necessary. Concurring vegetation has not always to be considered harmful. It can assist the seedlings in prevention of over-heating, damages by frost and browsing. Only when this vegetation is suppressing the seedlings, one has to interfere. Mechanically operations are highly recommended. Cleaning of the entire planting area is not recommended. Clean around the seedling only. Chemical options only if mechanically are inefficient or much too costly.

3.5.1 Tools

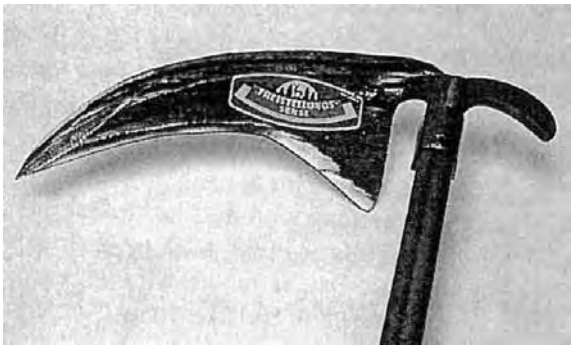
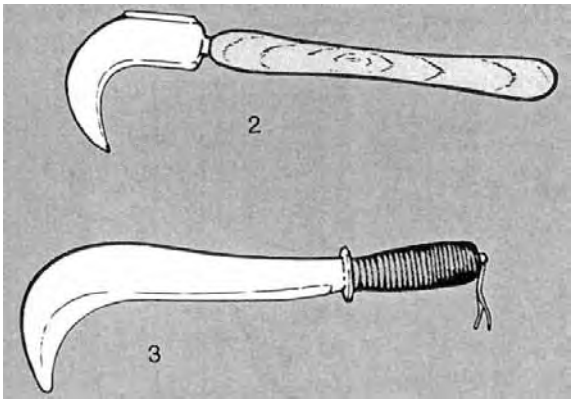
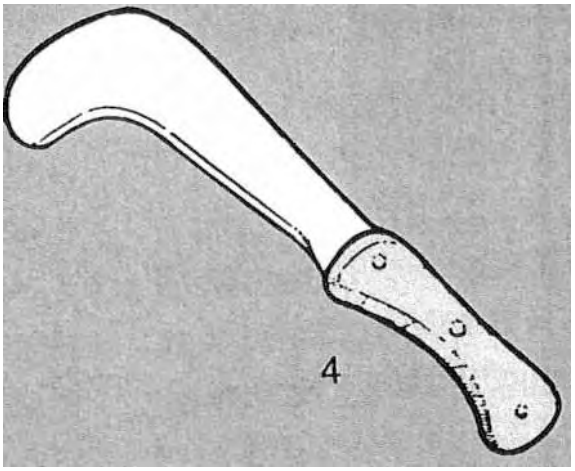
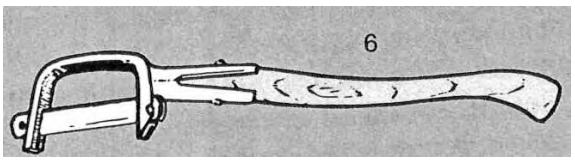


Figure 16: Forest scythes

(Der Forstwirt, 2000; 3. Auflage, Ulmer Verlag Stuttgart, Germany)







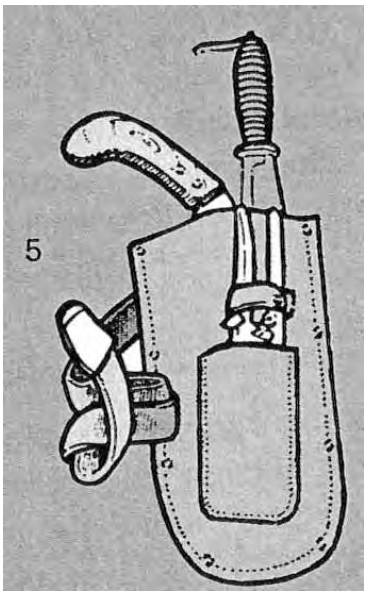


Figure 17: Other mechanical tools

(Der Forstwirt, 2000; 3. Auflage, Ulmer Verlag Stuttgart, Germany; Helmut Flebacher, Fellbach)

4. References

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V.2 Thinning Operations and Pruning

Glossary

a . . . . . anno (year)
AAC . . . . . Annual allowable Cut
AFA. . . . . Ajara Forest Agency
BHD . . . . . Diameter in Breast-Height
BLT. . . . . Broad Leaf Tree
CC . . . . . Crown closure
e.g. . . . . Example given
H. . . . . Height
Ha/ha . . . . . Hectare
h/d ratio. . . . . Height to Diameter Ratio
NTFP . . . . . Non Timber Forest Produces
PCT . . . . . Potential Crop Tree
SFM . . . . . Sustainable Forest Management

1. Silvicultural Guidelines

As already mentioned in the chapter Mgt. Planning, the formulation of the Mgt. Goals has to correspond with the legislative requirements of the respective country. The "Long Term Ecologically Forest Development" is described in the previous chapter.

The production of high value timber which has to be considered a pre-condition for the improvement of the forestry sector and generating of new jobs should be emphasized. This incorporates the production of firewood, biomass and NTFP.

For ecological reasons, forest management has to incorporate a big variety of tree species with different age classes incl. grass stripes, shrubs and bushes.

A prerequisite for any SFM is the correct assessment of the AAC. The amount of timber to be cut has to correspond with the increment. The assessment of the AAC should be based on research. If there are no reliable data available presently, one has to be very carefully by estimating the AAC. Always stay on the lower, the safe end. In temperate zones the AAC will be between 2 to 10 m^3/a/ha depending on tree species composition and site conditions. The increment in tropical zones for natural forests is between 1 to 2 m^3 only, for tree plantations up to 20 m^3/a/ha.

During the final tree marking operation, where the entire forest area can be assessed, the zoning process will be completed and all endangered species of fauna and flora can be found and taken care of. A good managed commercial forest should contain an amount of dead wood of approximately 10 %.

Keep forest land permanently under forest cover. Avoid clear-cuts, if becomes necessary by silvicultural requirements, keep them smaller than 2 ha!

Minimize the use of pesticides. Application only if mechanical or biological treatments are not successful!

1.1 Plantation Forestry

Plantation Forestry can be justified only for a short period, meaning 1 to 2 short rotation periods (10 – 20 years each) to overcome a lack of fuelwood and to gain more time to raise funds, train staff and to carry out the Mgt. Planning Process for SFM. This can be a close to nature forest management only as described in the Mgt. Goal previously. All plantations around the world have proven not viable in a long run. After 2 to 3 rotations the soils were depleted, the productivity became less, thus fertilizer had to be applied which in turn increased the costs tremendously and very often not once a break even could be achieved. This business model was and still is recommended by bankers who only think about their profits in the next 20 years and do not care about the forest in a long run. These plantations then had to be given up very often and government had to take over to restore the soil fertility and make the forests profitable again with tax payer's money. Another negative impact is the soil erosion, especially in areas with a high intensity of rainfall. Since these plantations are harvested in a clear cut system, the soil is exposed to these heavy rainfalls every 10 to 20 years which leads to severe erosion especially in hilly terrain. In tropical forests in which SFM is applied no tending operations are necessary. Just let the forest grow and when harvestable sizes are achieved a certain number can be cut recognizing all the previous and following criteria. Here the harvesting-, and especially the opening-up system play the key role. Un-professional harvesting operations lead to destruction of soils and finally forests which then need decades to recover.

2. Tending operations

2.1 Pre-commercial thinning operation

Pre-commercial thinning is carried out as long the trees are small and no commercial timber can be produced. This is usually the case from a stand height of 2 - 10 m and a BHD less than 8 cm.

In good quality regenerations, normally no tending operations are necessary. In case the regeneration is coming up under the canopy of an old stand, natural differentiation will start early and the selection of PCT's (Potential Crop Tree) is an easy task. On regeneration areas without residuals, more homogenous stands are growing but with the intention to produce bigger branches and even wolf trees.

The required Opening-Up system (refer to Harvesting Guidelines) should be established as early as possible, meaning 3 to 5 years ahead of the actual thinning operation or even keeping the skid-trails open when regenerating artificially. This gives the stand time to stabilize against wind and snow break.

(see Table 1)

Table 1: Pre-commercial Thinning Operations

Stand Condition	Stand Height	Activity
Bad quality stands	2 – 3 m	Cutting of wolf trees
All stands, only if required	6 -7 m	Selection of 250 – 350 PCT's
All stands, only if required	6 -7 m	Cutting of 1 – 2 competitors
Stands with good quality PCT's for high value timber production (Pine, oak)	8 - 10 m BHD > 10 cm	Pruning of PCT's Refer to **"Pruning Guidelines"**

2.1.1 Tools

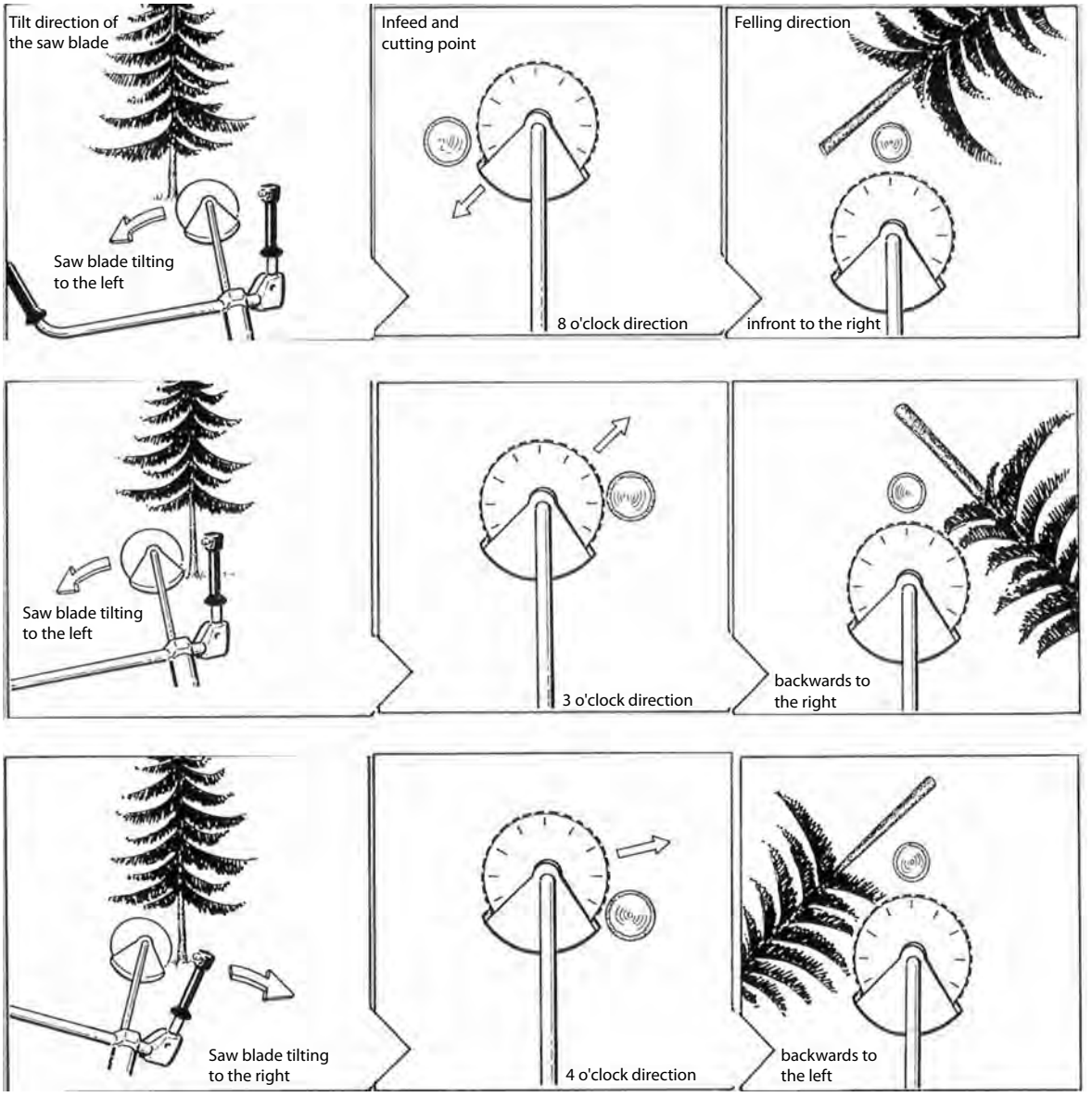


Figure 1: Tending operations with motor trimmer up to BHD of 8 cm

(Der Forstwirt, 2000; 3. Auflage, Ulmer Verlag Stuttgart, Germany; Helmut Flebacher, Fellbach)

Never cut in 2 o'clock direction: Heavily kick back!

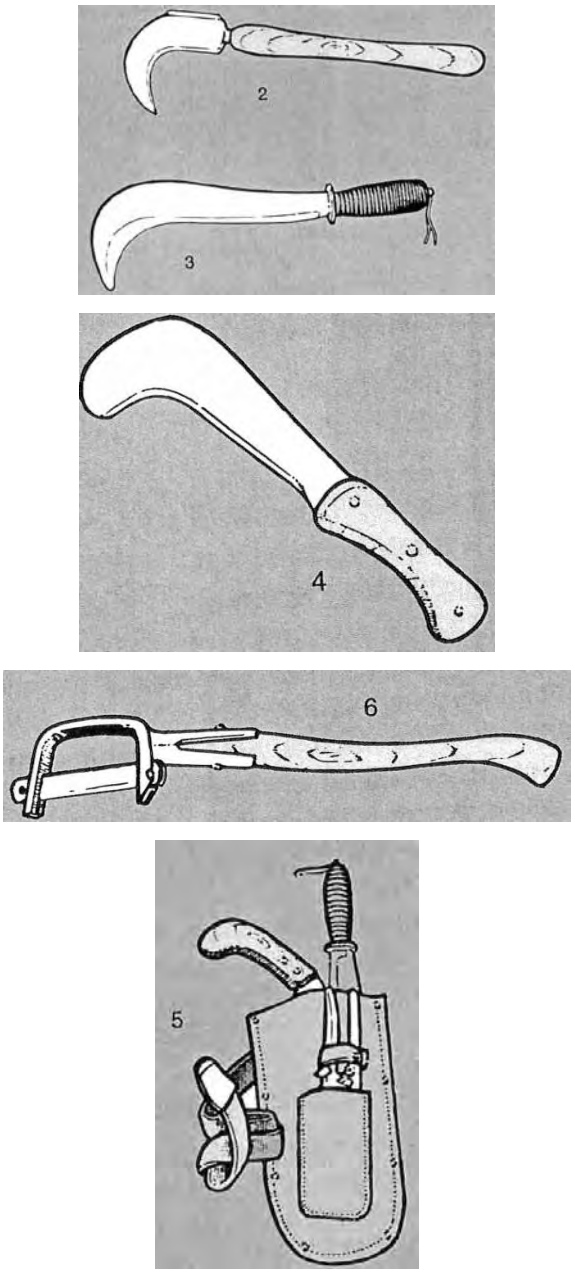


Figure 2: Mechanical tools

(Der Forstwirt, 2000; 3. Auflage, Ulmer Verlag Stuttgart, Germany; Helmut Flebacher, Fellbach)

2.2 Thinning Operations

The Mgt. Goal concentrates on the production of high value timber and firewood production will be only a side effect. For this scenario, thinning operations have to be carried out to regulate tree distribution, directing the growth to PCT's, eliminate bad quality and weak trees and last but not least stabilizing the stands. The activities differ according to tree species and age classes by harvesting techniques and intensity. For the actual harvesting operation refer to **"Harvesting Guidelines".**

Here again the required Opening-Up system (refer to Harvesting Guidelines) should be established 3 to 5 years before the actual thinning operation commences. This gives the stand time to stabilize against wind and snow break.

Production goal: Conifers BHD > 35 cm, Broad Leaf Trees: BHD > 40 cm.

To make full use of this guideline, one should understand the **„Kraftsche Stand Classes",** the **Crown closure** and what is a **PCT** (Potential Crop Tree). A PCT is a tree belonging to the Kraftsche Stand Classes 1 or 2 and should have a h/d ratio below 80. All trees with a h/d ratio above 90 can be considered weak and unstable.

2.2.1 "Kraftsche" Stand Classes

Kraftsche Stand Classes:

- 1 Pre-dominant Trees
- 2 Dominant Trees
- 3 Partly Dominant Trees
- 4 Under Storage Trees, but still alive
- 5 Under Storage Trees, but already dead

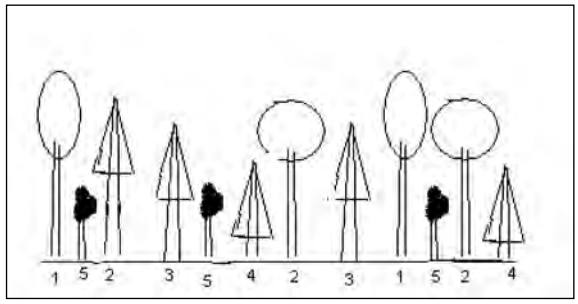


Figure 3: "Kraftsche" Stand Classes

2.2.2 Crown Closure (CC):

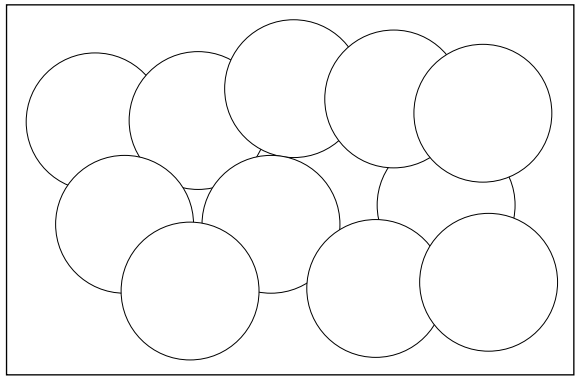


Figure 4: Crown closure, overstocked (1,1)

(The crowns growing into each other)

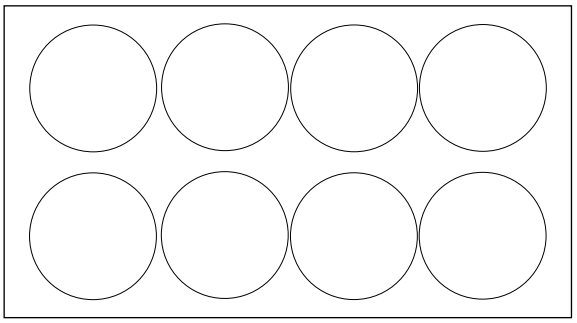


Figure 5: Crown closure, fully stocked (1,0)
(The crowns reaching each other)

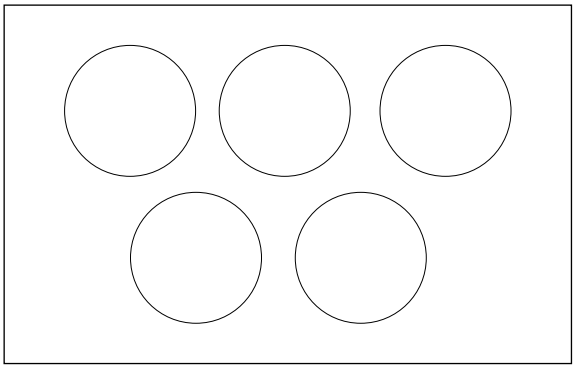


Figure 6: Crown closure, open (0,8)
(Nearly ½ a crown can fit in between)

Gaps: up to 1 tree lengths in diameter.
Openings/blanks: up to 2 tree lengths in diameter.

2.2.3 H/D Value

(the h/d ratio is calculated by H : BHD)

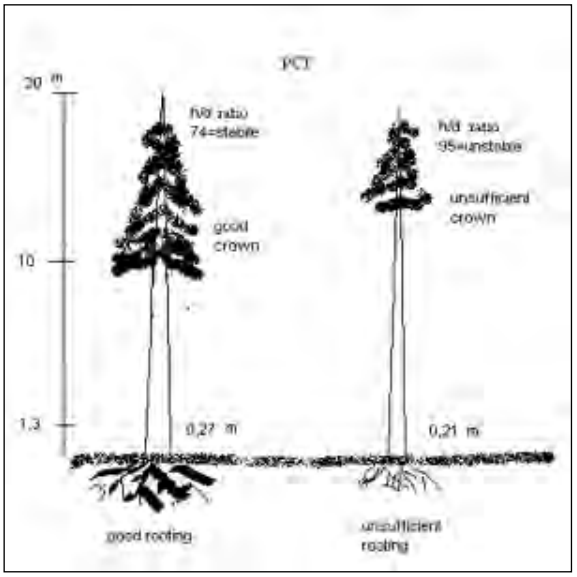


Figure 7: PCT, h/d value

h/d = 74, stable (20/0,27= 74)

h/d = 95, unstable (20/0,21= 95)

Good crown = good rooting, insufficient crown = insufficient rooting

2.2.4 Thinning operations according to tree species

A) Pine

A.1) Pine second age class (20- 40 years)
In this age class approximately 600 - 800 trees should stock on 1 ha, with a related distance to each other of 3 - 4 m.
Calculation: 1 ha = 10000 m^2 divided by 700 trees (average) = 14 m^2 per tree. $\sqrt{14}$ = between 3 to 4 m.

If not done at an earlier stage, one should select a PCT tree approximately every 5 to 6 m. This sums up to ca. 250 - 350 PCT's per ha. These PCTs have to be marked permanently with colored ribbon or better with paint. As already mentioned before, the min. requirements for a PCT are as follows: Kraftsche Stand Class 1 or 2, vital, good quality (straight, few branches not screwed), crown length min. 1/3 of the total stem length and h/d ratio below 80. Supporting these PCT's one has to cut 1 competitor, never more than 2! The thinning operations should be limited to max. 80 m^3 per ha in one cut. If more has to be cut, a second operation should commence after 3 to 5 years. At least 3 years before the selective cutting should commence the opening up system has to be implemented according to the selected harvesting system (refer to **Harvesting Guidelines**). Any broad leaf tree in coniferous stands and rare species have to be supported for ecological reasons, meaning giving them priority even against pine PCTs. All trees marked to be cut, have to be compiled in a **Felling Table** and the volumes estimated. These Felling Tables will become part of the **Harvesting Plan**.

A.2) Pine, third age class and older (> 40 years)

The already selected PCT's should be well maintained, meaning whenever the branches touch each other (Crown closure: 1,0 is reached), a thinning should be carried out (ca. every 5 – 10 years). In older stands, where no PCT's were selected before, a selection with the same requirements as mentioned above, incl. distances to each other should commence. The actual cut: 1 competitor, sometimes even 2. ! The thinning operations should be limited to max. 80 m^3 per ha. If more has to be cut, continue after 3 to 5 years. These cuttings continue until the rotation period of ca 100 – 120 years is reached. Important considerations: Keep the forest floor always covered to prevent the growth of too many weeds and erosion. This continuous until the last 2 decades of rotation. Then open up the stand carefully when the "Mother Trees" are carrying sufficient seeds, so that more light can reach the forest floor and natural regeneration can start. Removal of the top soil layer might become necessary to

allow the seeds falling into the mineral soil. Keep the canopy closure with a crown closure of ca. 0,2 - 0,5 until the regeneration is save. Better even, keep this crown closure until a height of 6-7 m of the new stand is reached. At the end, for ecological reasons, leave around 5 to 10 residual trees per ha.

B) Broad Leaf Trees and mixed stands

Independent of age classes, the number of PCT's can be reduced to 150 – 200 per ha with a distance to each other of ca. 7 - 9 m. The criteria for PCT's are the same as mentioned above. Priority should be given to species which occur less or are rare at all, meaning even a good PCT could be cut to support a rare species. Once selected PCT's should be well maintained, meaning whenever the branches touch each other (Crown closure. 1,0 is reached), a thinning should be carried out. This might occur every 5 – 10 years. In areas between these PCT's some bad quality trees can be cut for firewood production as long the forest floor is covered permanently. Do not cut all trees of "Kraftsche Stand Classes" 4 or 5, keep up at the end of the rotation period about 10% residual trees for ecological reasons.

Good quality stands should have a rotation period not less than 120 to 160 years for beech and 180 to 250 years for oak stands.

3. Pruning of Stands

Pruning is implemented as far as I know in temperate forests only. Of course it could be carried out everywhere if an extra profit can be achieved. All the following text is derived from FVA, Deutschland, Abt. Waldwachstum, " Die Wertästung", Internet search.

3.1 Tree Species and Stands

The assessment of the quality of trunk wood and its branchiness is a significant feature. In 80 to 90% the branchiness is defining the grading of timber and has a significant influence of the selling price. Thus, pruning at the right time and of an adequate number of PCT s can be useful and profitable.

Basically all tree species can be pruned. A selection of good quality and good growing PCTs is recommendable. At the end of their rotation period they should have a relation between branch-free and branch containing core wood of 2 : 1. Stands endangered by windthrow, red rot or decay in general or snow brake should not be pruned. For tree species which intend to keep their dead branches for a long period, a pruning at an earlier stage the trees still holding leafs or needles might become necessary. This especially refers to trees which are grown solitarily.

Picture 1: Pruning of broad-leaf stand

(Photo: Andreas Ehring)

3.2 Work Techniques

Pruning at an early time when the green branches are < than 3 cm, is important for a good result. The length of the green (living) crown has never to become smaller than 40 – 50% of the entire tree length. Pruned trees have to be given sufficient growing space (minimum crown closure 0,9 to 1,0). This has to be respected during all the coming thinning operations. Applying the correct pruning technique and using sharp tools, there will be no problems with any fungus disease. Important is that the entire branch is cut and no stumps are left.

Special attention is required for:

- No injuries at the branch insertion and the bole
- No left overs (stumps)
- Cutting even all small twigs
- Pruning of PCT s only
- Keeping the same pruning height for all PCT s
- Use of ladders only to prevent bark injuries

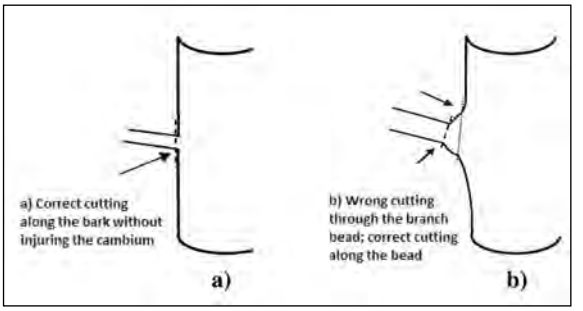


Figure 8: Correct pruning technique with and without bead

3.3 Pruning Heights

3.3.1 Coniferous Trees

- Pruning up to 2,5 m
  Only recommendable if a higher pruning would not preserve the requested crown length and the recommended branch diameter of 3 cm would be exceeded. Implementation at a dominant height of 5-6 m, DBH approximately 8-10 cm.
- Pruning up to 5 m
  This is the usual application. Implementation at a dominant height of about 12 m, DBH approximately 15-18 cm. In case the branch diameter has reached 3 cm earlier already, the pruning might commence already at a dominant height of 10 m.
- Pruning up to 10 m.
  Only recommendable for species reaching a top-diameter of 40 cm and a DBH of 65 cm at the end of their rotation period. Only then a sufficient branchless bole can be achieved. Implementation at a dominant height of 20m, DBH approximately 25 cm.

3.3.2 Seasons for Pruning

Pruning of dry branches can be carried out all over the year. The use of a "Baumvelo" is possible only after the vegetation period has ceased.

Picture 2: "Baumvelo"

(Photo: Grube KG Forstgerätestelle, Hützeler Damm 38, Bispingen, Germany)

For pruning green (living) branches the time between the end and beginning of the vegetation period or the end of the length growth (June/July) is recommendable. These times are optimal for curing the cuts. Maple and walnut trees are pruned between June and August. Pruning green branches one has to pay attention to apply the correct technique and not to damage the cambium.

3.3.3 Number of pruned Trees

Recommended number of PCT s to be pruned per ha.

Table 2: Number of PCTs to be pruned

Tree Species	Number of PCTs to be pruned per ha
Douglas Fir	100 – 150
Oak	70 – 90
Pine	100 – 200
Ash / Maple	60 – 80
Eur./ Jap. Larch	100 – 150
Norway Spruce	150 – 250
Walnut	60 – 80
Fir	150
Poplar	100

3.3.4 Time Requirement

The working times stated below are applicable for coniferous trees only. They are for average working conditions and worker performances. Working times for pruning of BLT are not available presently.

Table 3: Time requirement for pruning of coniferous trees

Pruning height	**Time requirement (min. / tree)**	**Tool**
0 to 2,5 m	3 – 6	Hand saw, rod saw
0 to 5 m	8 – 15	Rod saw,
5 m – 10 m	15 – 22	"Distel"-Ladder
> 10 m	25 - 34	"Baumvelo"

3: "Distel"-Ladder

(Photo: Grube KG Forstgerätestelle, Hützeler Damm 38, Bispingen, Germany)

3.3.5 Documentation

All pruned Stands (sub-compartments) have to be documented in the respective Forest Record Book. This is an indispensable requirement to guarantee the economic success. The area (ha), the tree species, the number of pruned trees, the pruned height and the year of implementation has to be recorded.

4. Appendices

Forstl. Bildungs Stätten der BRD, 2011: “Der Forstwirt”, Ulmer Verlag, Stuttgart, Germany

FVA, Deutschland, Abt. Waldwachstum “ Die Wertästung”, Internetrecherche

Felling a Giant, Sabah, Malaysia (Foto: W. Benneckendorf)

Yarding Operation, Sabah, Malaysia. (Foto: W. Benneckendorf)

V.3 Harvesting Guidelines

Glossary

e.g.	Example given
FO.	Forester Officer
FW	Forest Workers
Ha/ha	Hectare
°	Degree Inclination
%	Percent Inclination
Km	Kilometer
LDCCS	Long Distance Cable Crane System
M.	Meter
PCT	Potential Crop Tree
Sub-Com	Sub-Compartment
T	Ton

1. Introduction

Changes in forest management are technically supported by adequate harvesting systems. One of the management objectives is the sustainable production of high value timber. Since many timber harvesting practices have been identified as one of the major constraints to sustainable forest management, the development of resource-compatible harvesting techniques are essential. A detailed planning process of the harvesting operation has to commence well in advance.

These guidelines serve as **Harvesting Standards** and provide practical guidance to personnel involved in logging operations.

2. Harvesting Operations

All information mentioned below should be entered into the respective **Harvesting Plan**, (**Harv.1 Form**, s. appendix 6).

2.1 Planning Process

The following questions have to be answered:

What has to be done?	E.g. Thinning, final cut.
Where will the logging be implemented?	Selection of logging area (Sub-Com).
When will the logging be implemented?	Setting the timeframe for the operation.
How will the logging be implemented?	Employment of contractors and/or own staff, selection of harvesting system.
Which machinery and tools are needed?	Selection and employment of machinery and tools.
Who is / could be involved, who has to be consulted?	Other landowners, village population, other Departments.

2.1.1 Selection of Harvesting Systems

The decision which harvesting system has to be applied is based on soil condition, inclination and the related erosion risks. The following tables and figures can serve to come to the right decision:

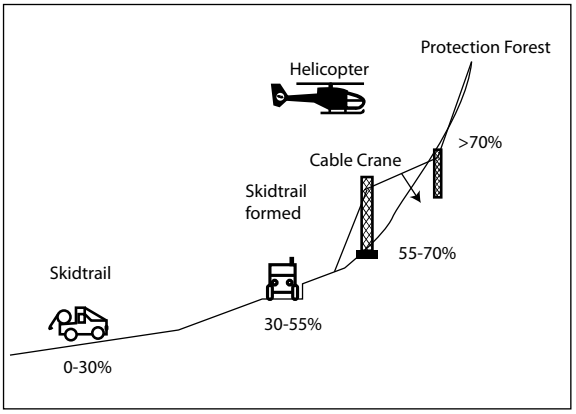


Figure 1: Selection of Harvesting System

Table 1: Selection of Harvesting System and respective Road Density

Inclination %	Harvesting System	Required Road / Skid-trail Densities			
		Classification	Density m/ha	Distances between roads/trails m	Average forwarding distance m
0 – 30 (skid trails, not formed) Age class Age class	Motor manually / Tractor 20-40 > 40	Sec. Road Feeder Road Skid trail Skid trail	3 5 (3+5=8) 500 250	3300 1250 20 40	825 313 5 10
30 – 55 (skid trails formed)	Motor manually / Tractor	Sec. Road Feeder Road Skid trail	3 5 (3+5=8) 100	3300 1250 100	825 313 25
55 – 70 (cable corridors)	Motor manually / cable crane	Sec. Road Cable Corrid.	3 100	3300 100	825 25
55 – 70 (Log lines)	Motor manually / hand work	Sec. Road Feeder Road Skid trail	3 5 (3+5=8) 100	3300 1250 100	825 313 25
55 – 70	Motor manually / Helicopter	Sec. Road	3	3300	825
> 70	Protection Forest	Sec. Road	3	0	0

Calculations:

Road density = 3m/ha, question: what is the distance between 2 roads?

1 ha = 10000m^2 divided by 3m/ha = 3333 m

Distance between 2 roads = 1250m, question: what is the road density?

1 ha = 10000m^2 divided by 1250m = 8m/ha

2.1.2 Duties of FO responsible for the harvesting operation

- Briefing of workers about the operation and safety regulations
- Marking of skid-trails and trees
- Indication of direction of fell (if required)
- Transport of materials and tools
- Setting grading rules
- Recording of length and diameter of timber, computing the volume and income
- Planning the yarding operation
- Control of barrier and warning signs

2.1.3 Duties of FW

- Provision and maintenance of tools
- Safeguarding the operation area by warning signs
- Working according to set safety regulations and appropriate working techniques,
- (refer to chapter XI. Ergonomics and Work safety)
- Setting appropriate work schedules
- Compliance with set working time and pauses
- Wearing always protection clothes during operations

2.2 Opening-Up Network

Before the first thinning operation commences, the final opening-up network has to be established.

The opening-up road and skid-trail network is based on the selected harvesting system as one can see in Table 1.

2.2.1 Passable Area (0 – 30% inclination)

With the help of a compass and measurement tape, skid-trails with a width of 4 to 5 m have to be laid. The distance between each other is the double tree length. These skid-trails are just following the forest floor, meaning they are not constructed by crawler tractors or excavator. They should be as straight as possible to allow yarding by tractor with trailer or yarding of long logs without damage to the remaining stand. The skid-trails hit the forest road in an angle of about 45° on flat terrain. In terrain with slopes > 15% the skid-trails have to flow with the slope and discharge into the forest roads funnel-shaped. Cutting the trees on these skid-trails should be carried out approximately 3 years before the actual thinning operation starts. This helps to stabilize the stand structure and minimizes the risk of wind throw.

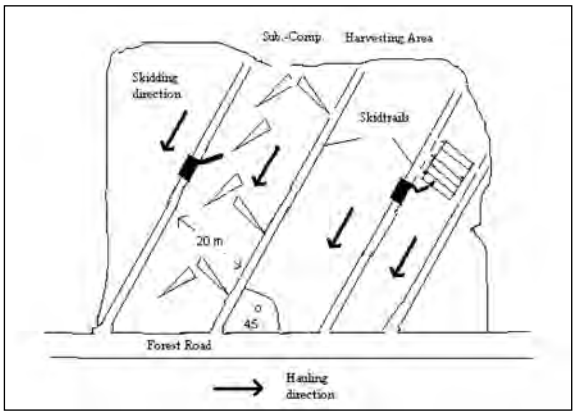


Figure 2: Establishment of skid-trails on flat terrain (cross slope < 15%)

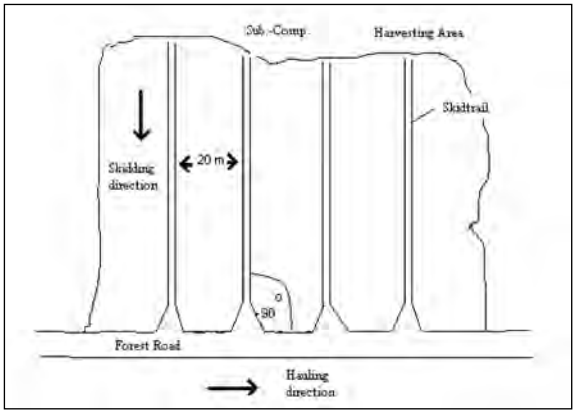


Figure 3: Establishment of skid-trails (slope 18 to 30%)

2.2.2 Impassable Area (inclination 30 – 70%)

On areas between 30 – 55% of inclination, the skid-trails have to be formed by crawler tractor or excavator. These skid-trails have to be 4 to 5 m wide and in curves even 5,50 m. Another option on areas between 55 – 70% are corridors for cable yarding or Log Lines. Cable corridors are straight and just follow the topography. They have a width of 3 – 4 m. On Log Lines the corridors are only 2 m wide and have a distance between each other of 20 m.

Example: Assuming a tractor's winch is equipped with a 80 m cable, the skid trail distance can be 100 m. (70 m winching uphill, 30 m winching downhill). That means the skid trail density is theoretically 100 m/ha (10,000/100). The maximum slope of skid trails for driving downhill should not exceed 30 % and for yarding uphill 20 % slope, due to the increase of soil erosion and the decrease of tractor performance.

For further information, refer to **"Guidelines for Forest Road Construction".**

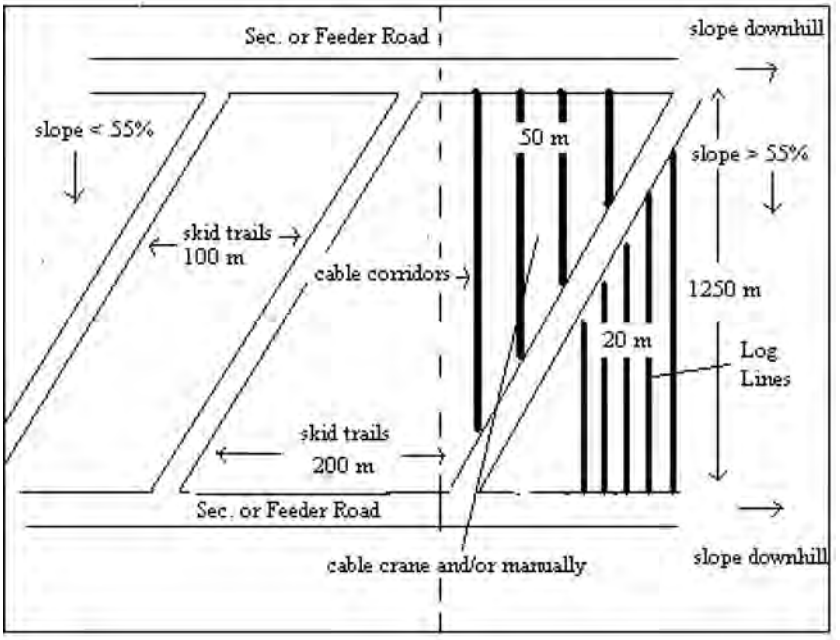


Figure 4: Opening-Up in impassable areas

2.3 Harvesting Coupe

In case of different management applications, the compartments have to be sub-divided into sub-compartments, the smallest management entity. Each sub-compartment can cover up to150 ha, and if any possible, has natural boundaries such as ridges, rivers and roads. An entire sub-compartment comprises the actual harvesting area. All PCT's and harvestable trees are marked. In some cases even the direction for felling is indicated.

2.3.1 Preparatory decisions to be made:

There should be no yarding operations or hauling of logs during the rainy season, except road conditions are suitable, meaning the roads and skid-trails have sufficiently dried up. At all other times yarding operations shall automatically cease when soil becomes saturated and/or free surface water commences to run in water tables or on log landings. It is the responsibility of FO or his representative to cease work under these conditions and that they do not recommence until free surface water run-off has ceased and driving can be carried out without creating deep ruts. The optimal yarding conditions are during the winter, when the ground is frozen. The FO has to ensure that the machine in question will not cause excessive damage to the environment. The FO reserves the right to extend the duration of automatic closures, to allow for drying and drainage after surface water run-off has ceased. The FO reserves the right to enforce a total closure when weather conditions are extremely adverse. During this time all extraction and haulage operations will cease. Contractors and / or others shall be notified of any extension of automatic closures and total closures immediately by phone. As far as possible the operation of machinery in the wet season should be avoided.

No roads or tracks are to be built or used other than those constructed by the respective Forest Department or allowed for, except with the permission of the supervising FO.

2.3.2 Safety Regulations

All **logging operations** likely to be hazardous to persons engaged or any member of the public using roads (and tracks) in the area. This area has to be clearly and legibly signposted on roads or hiking trails. It is the absolute responsibility of the FO, Contractor and / or FW to ensure the erection of portable signs stating "Blocked due to Logging Operation". These signboards are to conform to the respective country's regulations and are to remain in place for the duration of the logging operation. When trees are to be felled in a manner that the FO or Contractor considers it as a hazard to the road user, he shall take steps to temporarily close the road with the use of temporary barriers and temporary signs until felling and yarding are completed. Where, in the opinion of the FO additional traffic control measures are necessary, the services of a flagman should be engaged to control traffic whilst actual felling is in progress.

Although safety in logging operations near roads is primarily the responsibility of the Contractor, temporary road closures must only be carried out in co-operation with Forest Department Staff and/or Police, so as to ensure minimal disruption to traffic.

All detailed safety regulations are defined in the "Guidelines for Ergonomics and Forestry Work Safety".

2.3.3 Actual operations

2.3.3.1 Work Sequences

The following figure shows the work sequences for an ordinary logging in succession.

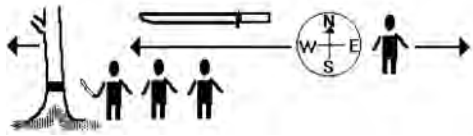
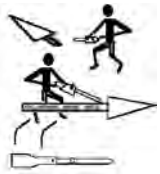
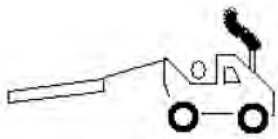
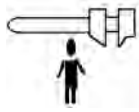
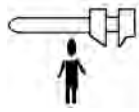
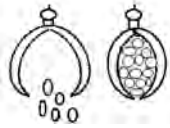
Work site **Work sequence**	**Stand**	**Skid trail**	**Road**
Coupe survey **Road Survey** **Skid trail survey** **Tree marking**			
Road construction			
Skid trail construction			
Felling Delimbing Bucking Debarking Grading			
Yarding			
Grading		**or**	
Loading			
Hauling			

Figure 5: Working Schedule

2.3.3.2 Felling operations

Properly implemented directional felling is a pre-requisite for eliminating the necessity for the yarding machine to approach or even to turn each log and thereby reducing the damage to the stand.

The re-filling of chain saws with fuel and oil should be carried out with care and without spilling. This can be achieved by using specially designed filler-caps. The flow of fuel or oil stops immediately when the tank is full. For the actual felling techniques refer to **Appendices 1-4.**

Figure 6: Filling of chainsaw with "Full-Stop-Filler-Cap"

(Drawing: unknown)

2.3.3.3 Yarding operations

Driving inside the stand, that means leaving the skid-trail, is generally prohibited without prior permission by Forestry Staff in charge. The logs have to be winched up to 100 m from inside the stand towards the skid-trail. The use of the decking blade to remove soil from the skid trails shall not be permitted without the approval of the FO. This does not include minor repairs or work which will not further excavate the track. Operators should avoid unnecessary use of the decking blade during routine yarding.

Due to the increased horsepower requirement and increased soil disturbance caused by the ploughing effect of the front of logs during yarding, harvesting equipment should be capable of raising the front end of the load during winching and yarding. This can be achieved by using machinery with a "Logging Arch" or crane.

A new developed yarding technique is the so called **"Log Fishing"** where a winch is mounted on a boom of a crawler excavator. The cable is directed through pulleys from the winch to the top of the boom. The yarded log can be moved into any position by rotating or lifting of the boom. Thus, damage to the remaining stand can be minimized. Attaching the excavator additionally with a hydraulic grapple, piling of logs becomes an easy task.

Picture 1. Logging Arch

(Photo: Skidder-Wikipedia)

Figure 7: Careless refueling
(Drawing: unknown)

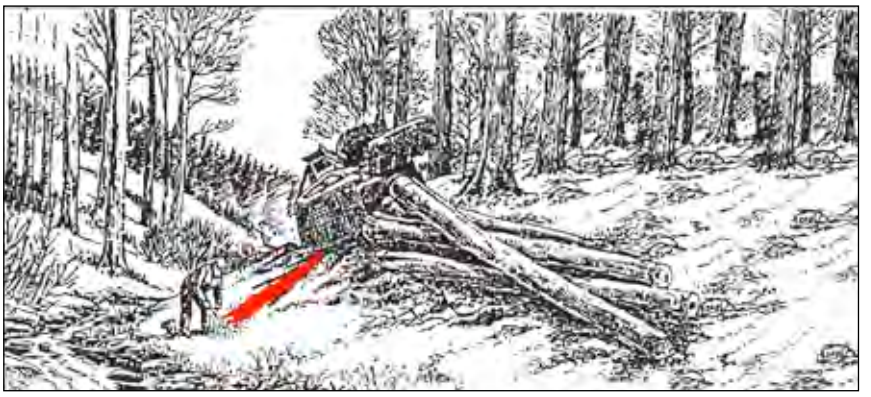


Figure 8: Applying oil-binding material (Drawing: unknown)

Pollutants that may enter streams as a result of the presence of machinery should be handled with care:

- All reasonable steps should be taken to prevent spillage during refueling.
- All reasonable steps should be taken to avoid oil spillage due to leaks or during oil changes.
- All refuse introduced to the forest as a result of logging operations e.g. packaging materials, bottles, tins, used oil filters, empty grease gun cartridges, drums etc. should be collected, disposed into garbage bags and finally disposed into public garbage disposals.

In case of accidents, leaking pollutants should be bound by oil-binding materials and safely disposed.

2.4 Cable Crane Yarding

Due to ecological reasons, the use of cable crane yarding systems is highly recommended, e.g. lesser road and skid trail density, less soil compaction, less yarding damage and less erosion. Since all these damages are increasing with the steepness of the terrain, this yarding system is recommended especially in hilly terrain.

There are two different cable crane set-ups, the gravity set-up and the all-terrain set-up. The first one can be applied on long slopes with a gradient of at least of 30%, where the yarder is stationed on the highest point of the set-up and the logs are transported fully suspended by their own weight (gravity) to the road in the valley. The all-terrain set-up is used in undulating terrain, where the logs can be transported uphill, horizontal or downhill.

Long distance cable crane systems (LDCCS) have a range of up to 2,000 m to each side of the road. This minimizes the total road density to app. 5 m/ha, which results in less erosion compared with a ground extraction system.

A suitable yarding system should meet several requirements. Above all it should minimize destruction to stand and soil. At the same time it should satisfy the economical expectations of contractors like reasonable investment costs, low operating costs and easy repair and maintenance of the equipment. In the light of these requirements the Long Distance Cable Crane System can be favored compared with all other yarding systems. For shorter distances, up to 400 m, Tower Cable Crane Yarders can be preferred because saving a lot of time during the rigging operation.

The Philippine-German Dipterocarp Forest Management Project has developed a “Manual for Cable Crane Yarding, Layout, Planning and Yarding with an All-terrain Cable Crane”, LUDWIG, R. and LAIMINGER, J., 1991, which is available with the author.

2.5 Helicopter logging

Heli-logging is applied in very steep terrain and forests with valuable timber. It is a highly sophisticated operation and requires a lot of specialists. Heli-Pilots going for logging can be considered as one of the best in the world. The decision to carry out a Heli-logging operation is based on cost benefit calculations. Personal experience from such an operation in Sarawak, Malaysia I could gain in the mid-1990. Tropical timber was forwarded by an Ericson Sky-Crane Helicopter with a carrying capacity up to 8 t. According to their cost calculation logs could be transported from the forest to the log-landings within a radius of 3 km. Transporting logs from further places, the flying time would have been too long, not covering the costs. Helicopter logging can be considered environmentally friendly, in terms of logging impact to soil and remaining stand. In terms of fuel consumption it is rather unfriendly compared with conventional tractor logging and cable crane systems.

The following table provides an estimate of the fuel consumption for the respective harvesting system not including road and skid trail construction. Heli-logging is the last choice when all other options will not work.

Table 2: Fuel Consumption

	Tractor Logging	Cable Crane Yarding	Helicopter Logging
l/m^3	7.5	1.0	30.0 - 40.0

3. Loading

The logs should preferably be stored alongside of roads. This could reduce the amount of log-landings to be constructed and consequently the amount of forest area lost for future timber production. However, decking alongside the road requires a loading with "Knuckle Boom Cranes" with a telescopic arm, either mounted on a truck or as a hydraulic grapple on an excavator.

Picture 2: Loading of logs by means of a crane mounted on a truck

(Foto: Internet search)

4. Hauling

All vehicles using forest roads must comply with government configuration in relation to maximum wheel loads unless authorized in writing by the respective Forest Department. In addition, they shall comply with any specific restraint in regard to speed of travel, weight or length that may be prescribed by the Supervising FO.

A loaded logging truck should not exceed a total cross-weight of 60 t.

All loads shall be securely restrained before the haulage vehicle leaves the logging site.

5. Appendices

1. Tree and Risk Assessment

2. Chain Saw Operations – 14 cm

3. Chain Saw Operations + 14 cm

4. Safety procedures für Logging Operations

5. Chainsaw Maintenance

6. Harvesting Form

Winch for Long Distance Cable Crane Yarding, Sabah, Malaysia (Foto: W. Benneckendorf)

Appendix 1: Tree and Risk Assessment

1. Tree height: Assessment of risk area, neighboring trees, other obstacles inside the stand.

- How high is this tree?
- Size of felling- and danger area
- Place the crown will hit, setting barriers on roads and lanes.
- Possible danger for power lines, vehicles and structures.

2. Tree crown: Dead branches, weight distribution, forked trees.

- Weight distribution of crown regular or one sided?
- Forked tree?
- Green crown?
- Broken crown?
- Is there a gap the tree could be felled in?

Consequences:
- Tree is heavily leaning to one side. Corresponding felling techniques are needed.
- Prevention of tree breakage and splitting by application of appropriate felling techniques.
- Felling techniques adapted to weight distribution.

3. Stem leaning: straight, crooked (weight distribution).

- Center of gravity of tree outside the center of the stem foot. Leaning forward, backward or to the sides?
- Stem is crooked?
- Better assessment of crown from a certain distance.

Consequences:
- Adaptation of the felling technique. Eventually with the assistance of a tractor winch.

4. Stem foot and bole: Decay, circumference, root fiber orientation.

- How big are the stolon? Which direction?
- Necessity to cut them first?
- Are there damages, decay, breeding holes?

Consequences:
- Cut stolon only on healthy trees!
- Consider the leverage effect during wetching; consider the risk for the entire felling operation.

5. Stem diameter: Health of stem foot in case of suspected decay:

- Knocking the bole: hollow sound (not very safe methodology).
- Vertical cut from the front or back side into the bole. Brownish or soft sawdust: decay! Do not cut into the safety band.
- Experiences from previous harvesting operations in the same sub-compartment may give information about the occurrence of decay.
- In case of decay, do not cut the stolon! Attention!
- How big is the tree? Stem diameter?

Consequences:
- Requested length of chainsaw bar. Consider appropriate felling- and cutting technique. For big trees make use of chainsaw with more horsepower. Cut stolon first.

6. Branches: Center of gravity, health, broken branches.

- Are there dead branches which could fall down during the felling operation?
- Are there branches which could stop the fall of the tree?

Consequences:
- Risks through falling branches! Consider branches of neighboring trees too. If parts of the crown still hanging do never work underneath!

7. + 8. Neighbouring trees, surrounding areas: Distance, risks, ditches, water flow, PCTs…

- Neighboring trees and the tree to be felled are hanging together?
- Could the tree to be felled take other trees down?
- Could the tree to be felled hit on obstacles, altering the direction of fall and kicking side- or backwards?

Consequences:
- Carefully determination of the felling direction!
- Observe the neighboring trees during the fall of the cut tree

9. Wind: Direction, intensity, crowns with leafs.

- Consistent and weak winds coming from the same direction have hardly an impact on the felling operation.
- Eventually has the safety band kept a little bit bigger or special safety cuts to be applied.
- Gusty winds from different directions or even storm: Cessation of the felling operation!

Please note: After tree assessment the felling technique can be decided!

Appendix 2: Chainsaw operations < 14 cm

(derived from Hessen Forst; FWM Uwe Holl; "Chain Saw Operations – 14 cm"; Landesbetrieb Hessen-Forst, Bertha-von-Suttner-Straße 3, D-34131 Kassel-Wilhelmshöhe)

Timber Harvesting 1: Chainsaw Operations < 14 cm BhD

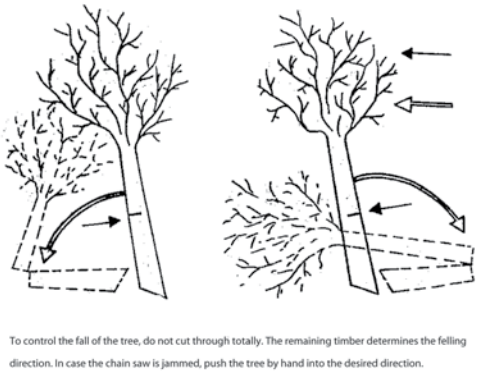
1.1 Requirements:
- Light chainsaw, one-man work
- Safety requirements:
  - Keep distance between each other twice the tree length
  - Divide harvesting coupe into work-fields, 1 worker in 1 work-field
  - Depressed undergrowth has to be set upright after logging
  - Forest roads, ditches have to be cleaned after logging
  - All timber pieces have to lay on the ground for better decay
  - All forest roads and trails have to be closed well in advance

(Foto: HessenForst, Forstamt Weilburg, 35781 Weilburg, Germany)

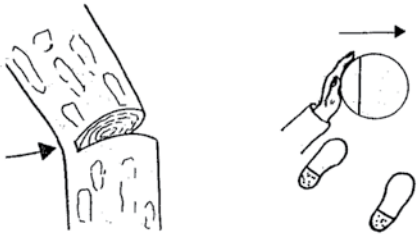
Felling techniques up to 14 cm BHD:
- 1. Cut: Cut in hip height diagonal and push down
- 2. Cut: Close to the ground

(Foto: HessenForst, Forstamt Weilburg, 35781 Weilburg, Germany)

Felling techniques up to 14 cm BHD:
- More cuts (folding techniques)might be necessary to bring the tree on the ground



To control the fall of the tree, do not cut through totally. The remaining timber determines the felling direction. In case the chain saw is jammed, push the tree by hand into the desired direction.



(Fotos: HessenForst, Forstamt Weilburg, 35781 Weilburg, Germany)

From 15 cm BHD onwards felling with scarf, if necessary with „Felling-Lever".

(Foto: HessenForst, Forstamt Weilburg, 35781 Weilburg, Germany)

Trees above 15 cm BHD which are not falling to the ground have to be turned down with a felling-lever or by cutting of a „V" on the pressure side with a final cut from the tension side.

(Foto: HessenForst, Forstamt Weilburg, 35781 Weilburg, Germany)

(Foto: HessenForst, Forstamt Weilburg, 35781 Weilburg, Germany)

All wood pieces incl. the crown have to be put down on the ground to improve the decay

(Foto: HessenForst, Forstamt Weilburg, 35781 Weilburg, Germany)

Appendix 3: Chainsaw operations > 14 cm

(Derived from Hessen Forst; "Chain Saw Operations + 14 cm"; Landesbetrieb HessenForst, Bertha-von-Suttner-Straße 3, D-34131 Kassel-Wilhelmshöhe

Timber Harvesting 2: Chainsaw Operations > 14 cm BHD

Index

1. Safety rules

According to international safety regulations for logging operations the following requirements have to be adhered to strictly:

- Never work alone
- Keep in calling-, sight or other contact at all times
- No narcotics (drugs and alcohol)
- Establishment of meeting points with police, fire brigade and ambulance
- Assure that your mobile phone is operational
- Emergency call no.: 112
- Close all forest roads and trails

Personal Protection Gear

- Wearing is compulsory
- Helmet with ear- and face-protection
  - Gestation period 3-5 years
  - Change hygiene sets frequently
- Cut-protection trousers
  - Gestation period 18 months/ 50 x washing
- Cut-protection boots
  - With steel cap and cut-protection inlays
- Gloves
- Jacket in signal colors
- First aid kit

(Foto: HessenForst, Forstamt Weilburg, 35781 Weilburg, Germany)

Personal Protection Gear

- Check your protection gear and tools for CE certification mark
- The GS mark stays for safety tested equipment

CE and GS marked equipment applies with the newest standards and techniques.

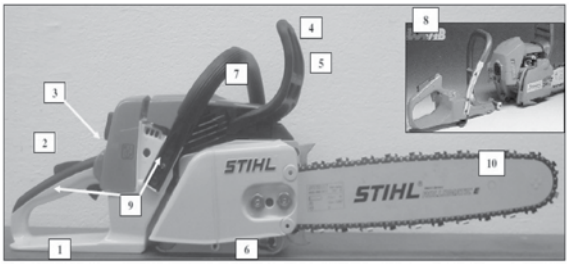
This certification mark stays for forestry equipment tested especially for forest work

(Der Forstwirt, 2000; 3. Auflage, Ulmer Verlag Stuttgart, Germany; Helmut Flebacher, Fellbach)

2. Chainsaw

Chainsaw with safety devices:

- 1. Hand Protection
- 2. Throttle Control Lockout
- 3. Shifter
- 4. Hand Protection
- 5 Chain Break
- (kick back stop)
- 6 Chain Protection Pin
- 7 Exhaust Protection
- 8 AV – Setup
- 9. Grip Heating
- 10. Safety Chain
- 11. Chain Protection
- Cover (not in the picture)



(Photo: Stihl Werkfoto, Waiblingen, Germany)

Chainsaw fuel:

- Normal gasoline with special 2-stroke oil, ratio 1:50
- Alkylate-gasoline is ready mixed by dealers

Content of	Alkylat gasoline	Normal gasoline
Benzol in Vol %	0,01	3 – 5
Aromate in Vol %	0,1	30 – 50
Olefine in Vol %	0,1	5 – 10
Sulfur ppm	5	100 – 500

Advantages of Alkylat-gasoline:

- Less pollutants
- Optimal mixture
- Long storage time possible (up to 2 years)
- No deposits in the engine chamber
- Less exhaust smoke
- Less sulfur, better for catalyzer
- Transport in plastic or steel canister only
- Period of use for plastic canister max. 5 years
- Max transport volume: 25 liter
- Marking of canisters

Chainsaw transport

- During walking cut off engine or engage chain-brake
- Chainsaw bar and hot exhaust showing backwards
- Only carry it on the chain saw fingering
- If possible use chain protection

Starting chainsaw:

- Visual check
- Chain tension
- Safety zone of 3m to fuels
- No persons next to starter
- Safe stand
- Never start it hanging in your hands

Starting small chainsaw:

- Clamp it between the legs

(Foto: HessenForst, Forstamt Weilburg, 35781 Weilburg, Germany)

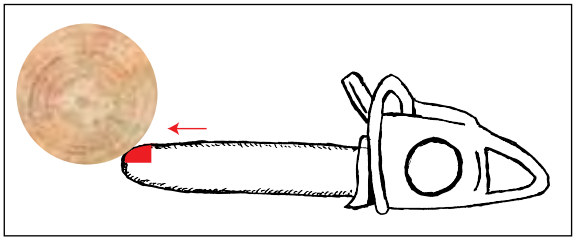
Starting of professional and heavy chainsaw:

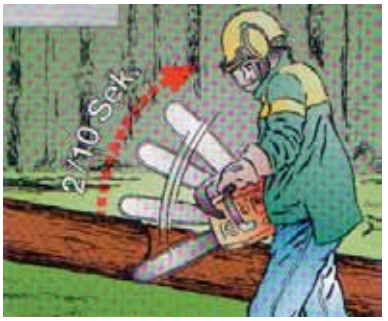
- Put chainsaw safely on the ground
- Chain should be freely moving
- Press the chain saw on the ground
- Use your left foot to step inside the hand grip
- Use your right hand to start the engine by pulling the rope
- Lift it only, when chain stands still

(Foto: HessenForst, Forstamt Weilburg, 35781 Weilburg, Germany)

Handling of chainsaw

- Always use both hands!
- Right hand at the backside hand grip
- **Also when you are left-handed**
- Fix the hand grip with your fingers and thumbs
- Take care for safe standing
- Take care that no parts of your body are within the bending range of the chain saw
- Start cutting with full speed, if possible collar the steel claws to the stem
- Work safely, don't cause dangers for you and others
- Always check that the chain stands still when machine is idling
- Kickback can be caused by:
  - Mistakes in sharpening (depth regulator too low, teeth to deep
  - Cutting with the bar tip
  - In case the bar tip is clamped shortly
  - In case a branch is touched unintended during delimbing





(Drawing: unknown)

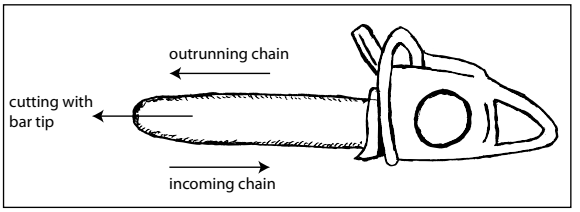
- Minimizing kickbacks
  - Use low kickback chains, and sharpen them correctly
  - Hold chain saw with both hands at all times
  - Do not use the bar tip careless
  - Never cut several branches at the same time
  - Never cut above the height of your shoulder
  - Only cut with the bar tip if you are familiar with the technique

3. Logging Equipment and Tools

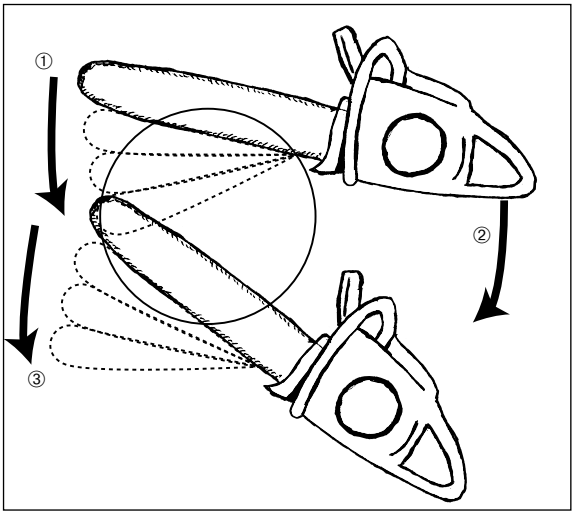
- Timber logging of standing trees
  - Chain saw, canister with filler tube
  - Measuring Instruments (caliper, measuring tape, meter)
  - Axes, wedges (aluminum or plastics – **never iron or steel!)**
  - Turning devices ("Felling-lever")

4. General cutting Techniques

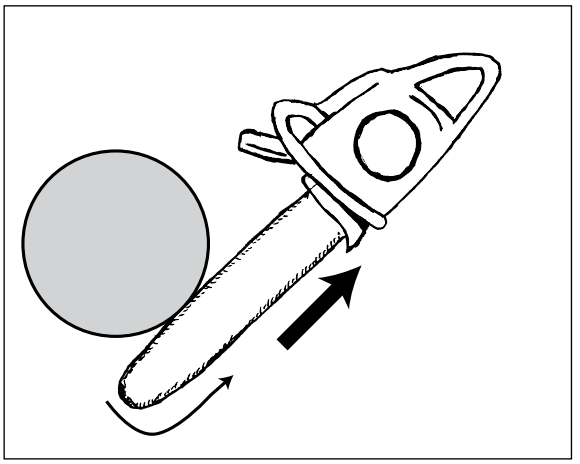
- Cutting with incoming chain (under the guide bar)
- Cutting with outgoing chain (on top of the guide bar)
- Cutting with bar tip



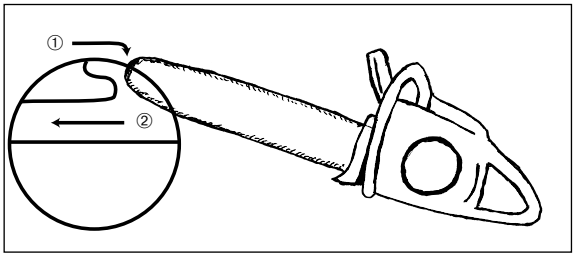
- Cutting with incoming chain
  - Chain cuts itself into the lumber
  - Weight and vibrations remaining on the machine
  - At large diameters: cut fan-like, pull the chain saw and cut fan-like again



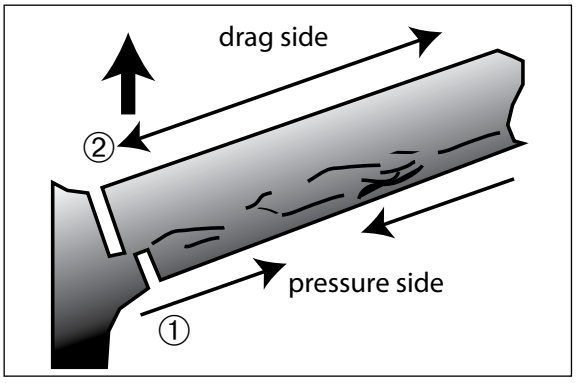
- Cutting with outgoing saw chain
  - The chain saw must be pushed against the lumber
  - Support chain saw on one knee
  - The right hand presses the bar down while at the same time the left hand pulls the bar upwards
  - The unloaded knee is standing backwards

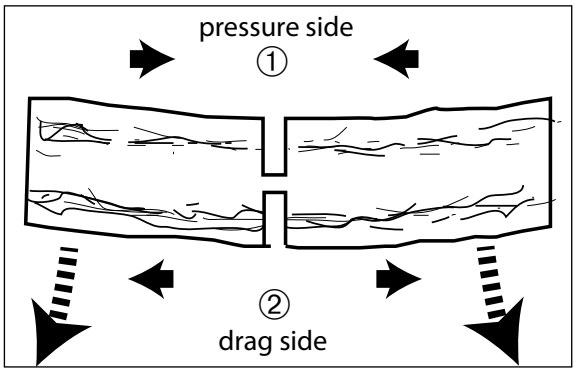


- Cutting with the bar tip
  - To prevent kickbacks, first cut a guiding cut(1) with the incoming chain until the bar tip is inside the wood. Then push the bar tip forward with incoming chain (2)
  - Support the chain saws with your body (arms, knees)



- Always take care of tension and pressure
  - Always stand at the pressure side
- Laying timber(slightly pressure only)
  - 1. Cutting into the pressure side: watch the cutting and be aware of bar clamping
  - 2. Cutting into the tension side: watch the tension





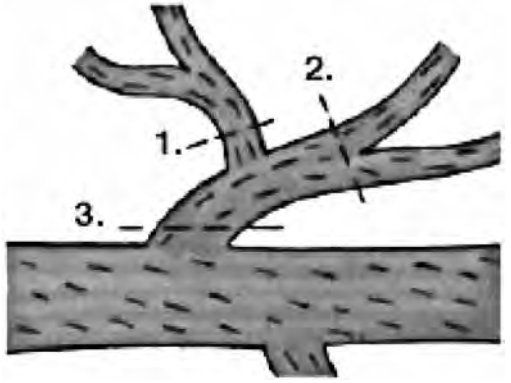
- Delimbing principles:
  - Safe standing while cutting
  - Only move forward if log lies between body and chainsaw bar
  - Evaluate tensions
  - Work ergonomically correct, use knee and stem to support the chain saw
  - lever the chainsaw over the iron claws
  - No delimbing with bar's tip
- Delimbing, **Deciduous wood:**
  - 1. Start with the delimbing of the log
  - 2. Then delimbing the crown. Cut off branches from the outside to inside, from above to the ground. Be alert for tensions, pressures and risks

(Drawing: unknown)

- Delimbing of big branches
  - Delimbing of big branches are similar to grading cuts

- Strong branches: Always start from the pressure side, then from the tension side to prevent bursting
- Always observe the reaction of the log and branches

- Clamping and splintering can be avoided by applying the correct cutting sequences:
  - 1. Cut off branches which hindering the workflow
  - 2. Cut off branches which are under tension
  - 3. Cut off main branch
  - Correct technique
  - Watch for tensions



5. Special Felling Techniques

Felling Techniques
- Steps of Harvesting
- Tree Evaluation
- Felling Techniques

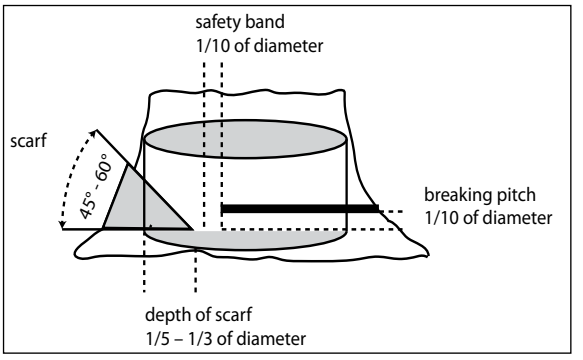
(Photo: unknown)

Felling operations:
- Tree evaluation
- Rough determination of felling direction
- Place for tools and devices
- Cleaning workplace and determination of escape routes
- Determination of felling direction exactly
- Cut off root collars (bigger trees)
- Scarf cut
- Check danger zone, warning shout
- Felling cut - correct technique
- Move backwards on the escape route
- Check working zone (workplace around the tree)

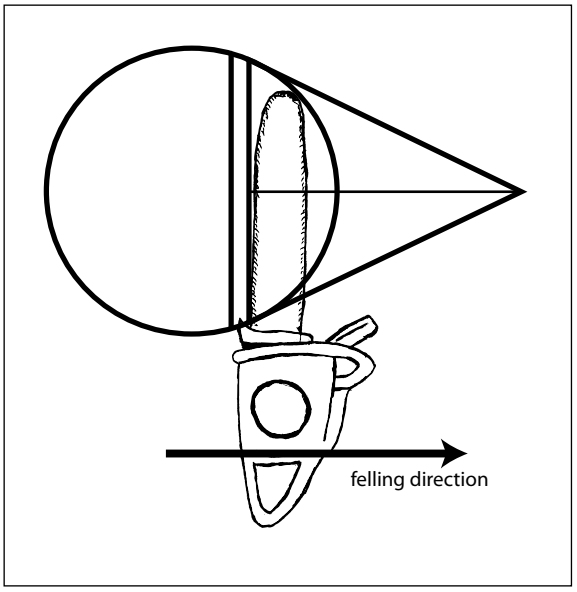
Tree assessment
- 1. Tree height, (Distance to each other)
- 2. Crown (Dead wood, leaning direction, fork trees)
- 3. Stem alignment (straight, bended, fungus infected)
- 4. Branches (gravity, physical health)
- 5. Stem foot (decay, buttresses)
- 6. Stem diameter
- 7. Neighboring trees/ area
- 8. Wind!

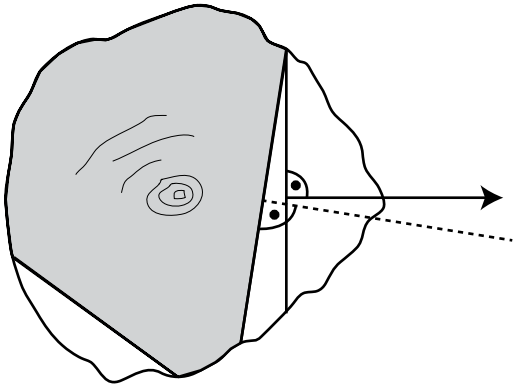
Cutting the buttresses:
- Easier determination of the felling direction and cutting of the scarf
- The scarf is cut in a wood area with straight fiber course
- Better overview during the final cut
- Use of short chainsaw bar is possible
- **Cutting rotten wood:**
  - Do not cut buttresses first
  - Cut trees into the leaning direction

Scarf and final cut:



Cutting scarf, determination of felling direction





Cutting scarf, determination of felling direction

(Fotos: HessenForst, Forstamt Weilburg, 35781 Weilburg, Germany)

Scarf Cut: Lower Notch Cut

- Lower Notch Cut
- 1/5 – 1/3 of root diameter

(Fotos: HessenForst, Forstamt Weilburg, 35781 Weilburg, Germany)

- **Scarf Cut: Upper Notch Cut**
- Upper notch cut 45 – 60°

(Fotos: HessenForst, Forstamt Weilburg, 35781 Weilburg, Germany)

Scarf Cut:

1.

2.

3.

4.

(Fotos: HessenForst, Forstamt Weilburg, 35781 Weilburg, Germany)

Scarf Cut: line of the undercut

- Must be clearly prepared
- Determines the direction of falling
- If a correction has to be done: always over entire width

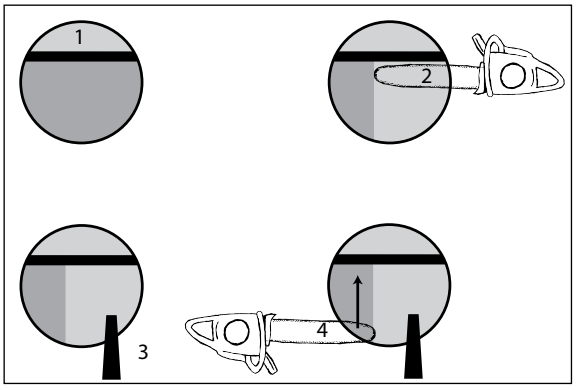
(Fotos: HessenForst, Forstamt Weilburg, 35781 Weilburg, Germany)

Wrong Tree Evaluation

- It was not recognized that the tree was tilted
- Cutting without a standard safety felling technique, the worker got injured

(Fotos: HessenForst, Forstamt Weilburg, 35781 Weilburg, Germany)

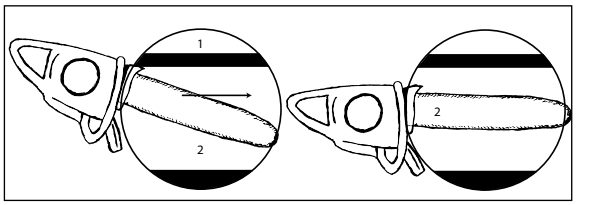
- **2/3 Cut (with supporting tools or wedges)**
- 1. Scarf Cut
- 2. Cut with outgoing chain
- 3. Set wedge
- 4. Cut with incoming chain at the same level
- 5. Use the axe or splitting hammer to fell the tree safely



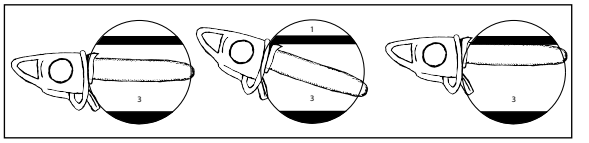
Standard Safety Felling Technique

- 1. Scarf Cut, 1/5 of root diameter, mark the notch
- 2. Felling cut with the bar tip in the middle, start between notch and safety joint

(Fotos: HessenForst, Forstamt Weilburg, 35781 Weilburg, Germany)

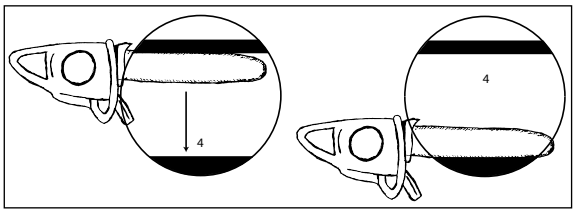


- 3. Cut at your side towards the safety band (approx. 1/10 of diameter)
- Use the iron crawl and cut from the opposite side down to the safety band mark
- Alternative: cut straight until the safety band



- 4. Finally cut from both sides down to the safety band(approx. 1/5 of diameter)
- (If you have a tilted tree, keep a bigger band)

(Fotos: HessenForst, Forstamt Weilburg, 35781 Weilburg, Germany)



5. Use wedges if it's a "normal" tree.

- Check danger zone, warning shout, cut safety band
- (Attention: Leaning forward trees– cut from 30°above with full power, exceptionally with outstretched arms, stand sideways and never directly behind the tree
- Move back on escape route, watch the tree crowns

(Fotos: HessenForst, Forstamt Weilburg, 35781 Weilburg, Germany)

6. Normal tree

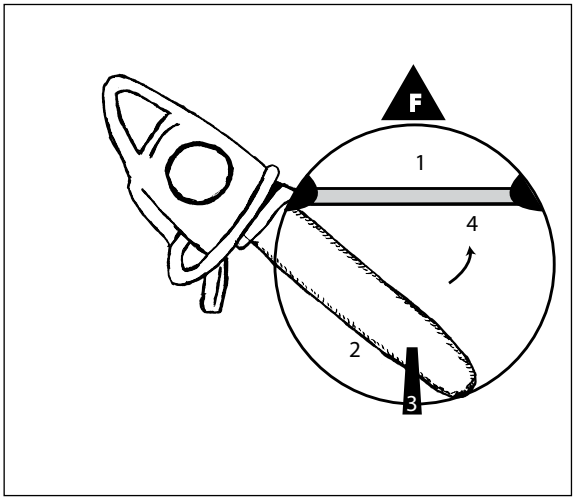
- After final cut is completed, put down chainsaw and use wedges and splitting hammer.
- Watch for falling branches after each stroke

(Fotos: HessenForst, Forstamt Weilburg, 35781 Weilburg, Germany)

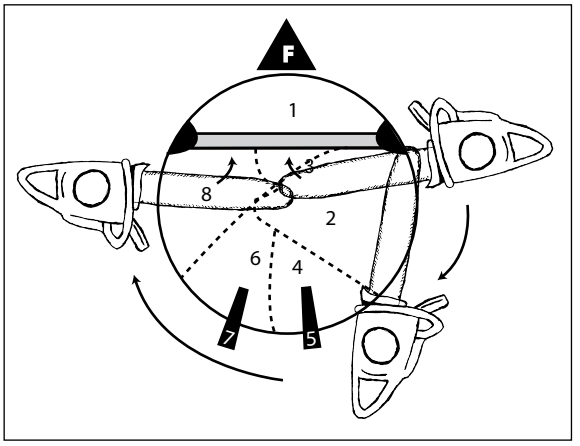
- If the tree falls by its own, retreat backwards on the escape route and watch the crowns
- When the crowns have stopped swinging, you can go back to the tree. Always look upwards, watching for hanging branches or crown parts

(Fotos: HessenForst, Forstamt Weilburg, 35781 Weilburg, Germany)

- Stem diameter smaller than the chainsaw bar (normal tree)

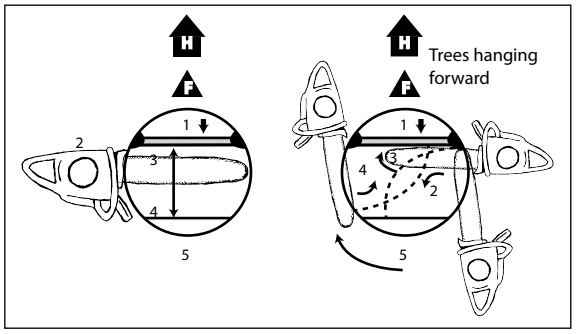


- Diameter is bigger than the bar length

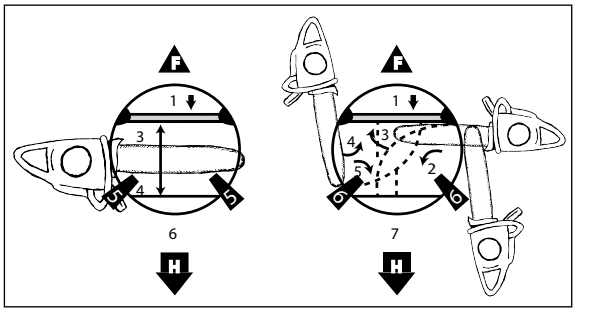


(Der Forstwirt, 2000; 3. Auflage, Ulmer Verlag Stuttgart, Germany; Helmut Flebacher, Fellbach)

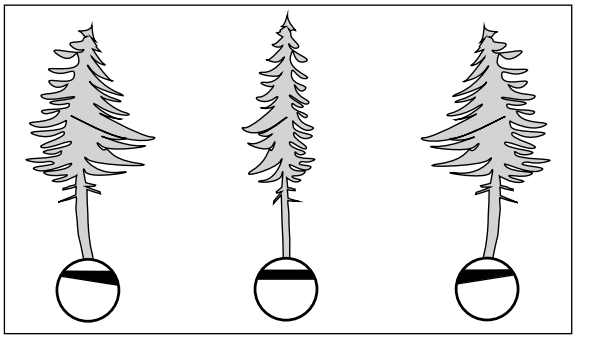
- Trees hanging forward



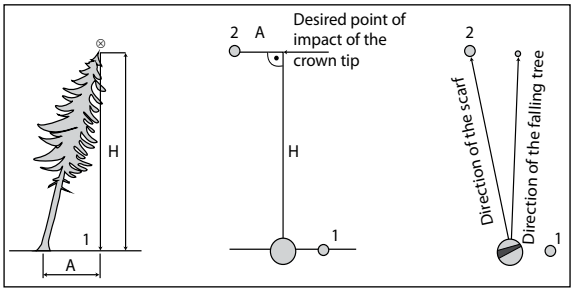
- Trees hanging backwards



- Leaning trees

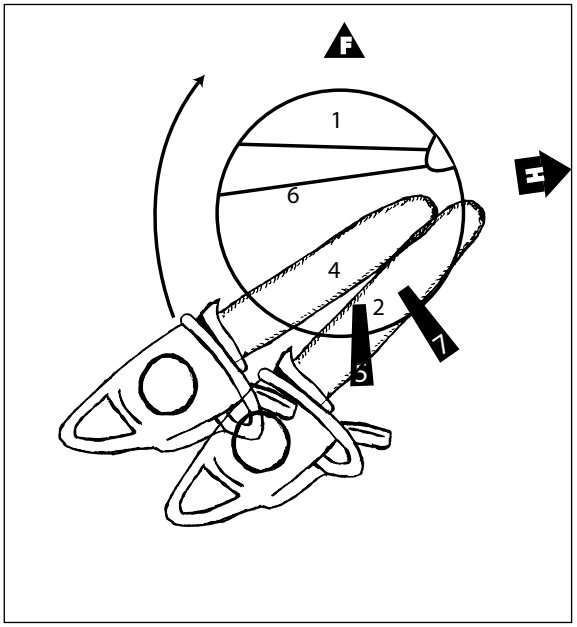


- Determination of the felling direction by leaning trees

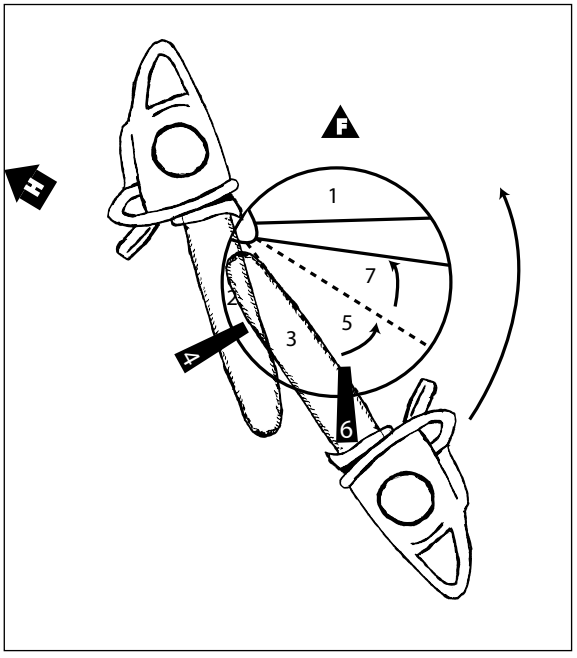


a) actual situation, tree is leaning to the right side, distance A is the distance between the stem foot and the leaning crown tip
b) desired felling direction, the point where the crown should hit
c) cutting the scarf towards the point 2, the safety band is kept bigger on the left side, the distance between the desired hit of the crown and point 2 is the same distance A

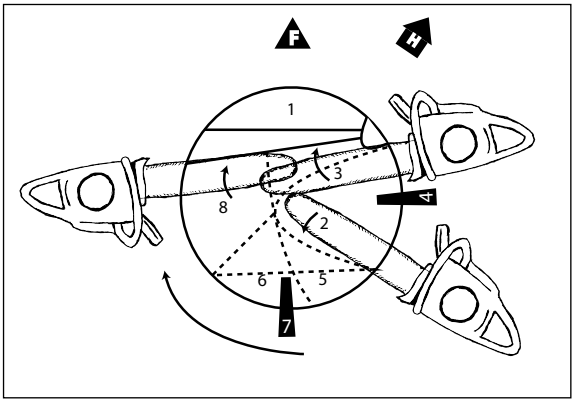
- Diameter is smaller than the bar length (tree tilts to the right)



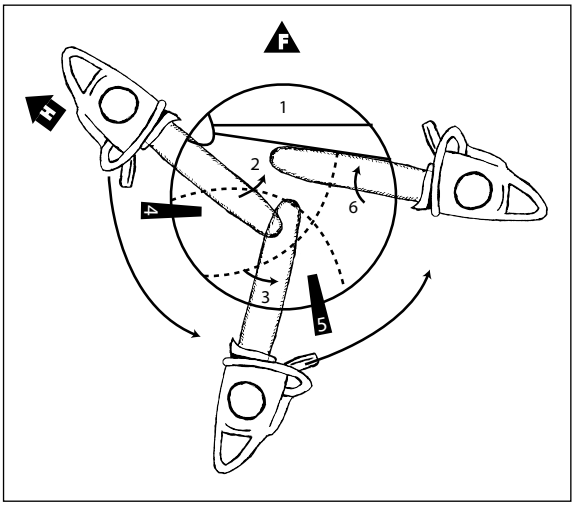
- Diameter is smaller than the bar length (tree tilts to the left)



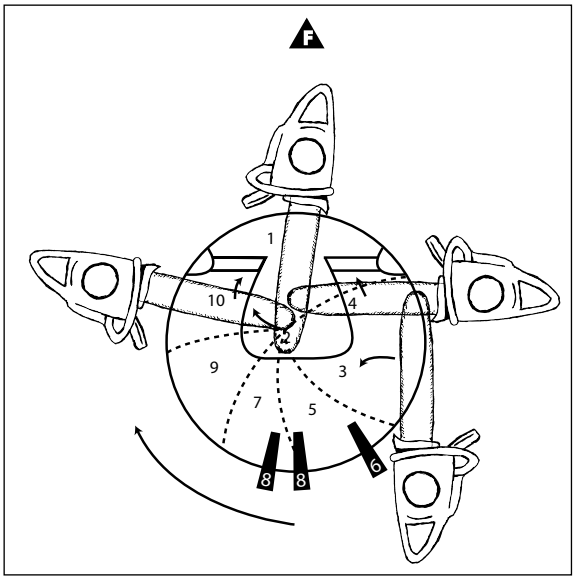
- Diameter is bigger than the bar length
- Tree tilts to the right



- Diameter is bigger than the bar length
- Tilts to the left

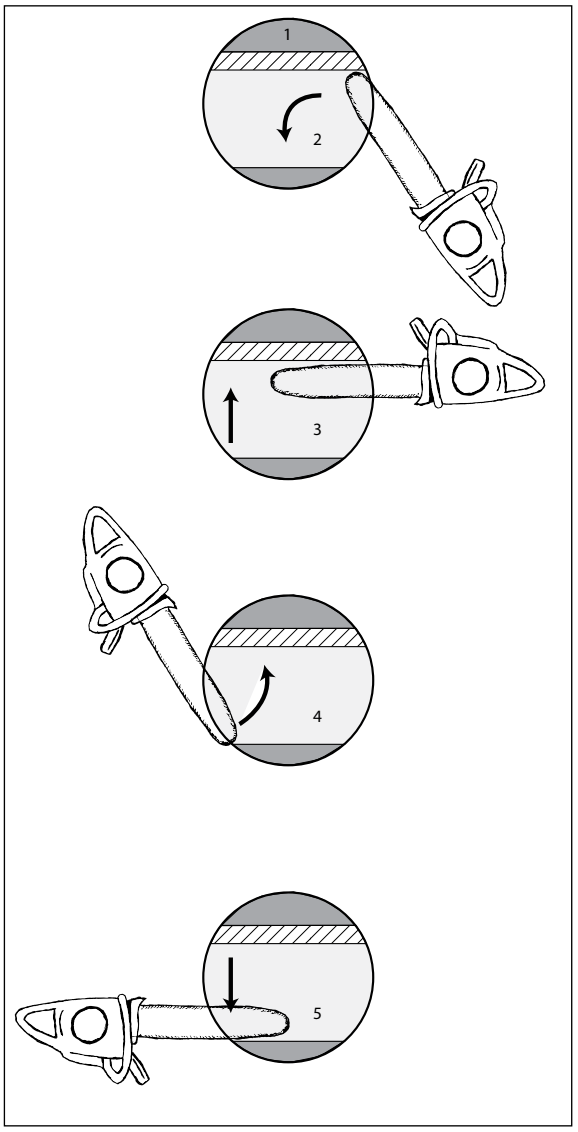


The Heart Cut (for extra ordinary big trees)



Safety cut

- 1. After cutting the scarf, start the felling cut by pricking in (2)
- 2. With outgoing chain cut towards the safety band. By looking over the chainsaw housing one can determine the felling direction. Elaborate the safety band consistently (3).
- 3. Pricking in from the opposite side with ingoing chain (4). Cut towards the safety band and afterwards with outgoing chain up the holding band.
- Cutting this holding band is the final cut.



Combination of box-cut and safety felling techniques

Advantages:

- Less damage to the timber
- Exact compliance with the determent felling direction
- Full compliance with all safety criteria possible

Box-cut, general considerations:

- 1. A normal tree, growing on flat terrain with a crown round and equal to each side, which could serve as a general example, one will hardly find in the forest, especially in deciduous stands nearly never.
- 2. A felling technique should not only provide a save and fast cut, but should even minimize the danger for the forest worker. Therefore an appropriate felling technique has to prevent mistakes during the felling process and to give the forest

worker sufficient time to retreat far enough out of any danger zone.

Box-cut

- After determination of the felling direction, the buttresses on the scarf side will be cut first in a right angle to the felling direction. The following scarf cut can be cut now much easier and precisely.
- At least one of the side-buttresses will be cut now in a right angle to the previous buttress cut. So, a kind of „box“ is developed

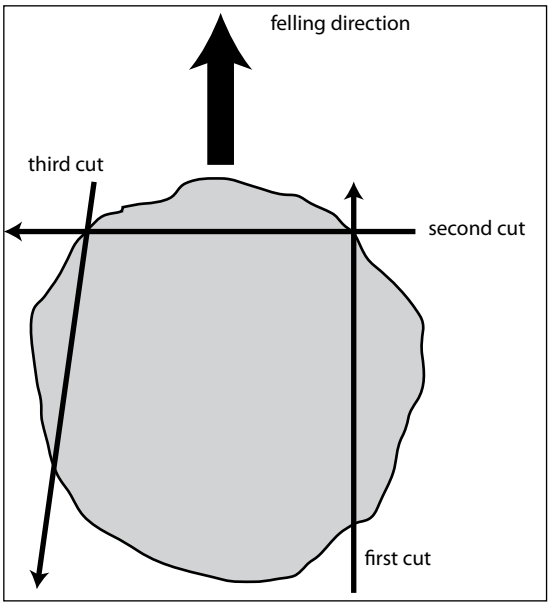
(Fotos: HessenForst, Forstamt Weilburg, 35781 Weilburg, Germany)

(Fotos: HessenForst, Forstamt Weilburg, 35781 Weilburg, Germany)

Box-cut

Work sequences:

- 1. Cut the buttress on the right side of the determined felling direction. Here, the forest worker can predict the felling direction exactly by viewing over his chainsaw bar.
- 2. Now cut the buttress which shows into the felling direction in a right angle to the previous cut. So, a kind of squared timber or „box“ is developed.
- 3. With the last cut the buttress on the left side of the felling direction is cut. The „box“is completed.



(Drawing: unknown)

- 1. Execute the lower notch cut straight and parallel. This is quite easy now, since the buttresses are gone.

(Fotos: HessenForst, Forstamt Weilburg, 35781 Weilburg, Germany)

- The upper notch cut can be executed now very precisely, since the lower cut can be seen easily. The scarf can be corrected easily if required. The scarf mouth should have an angle of 45-60°. In case of very big trees a „Heart-cut“could be executed easily.

(Fotos: HessenForst, Forstamt Weilburg, 35781 Weilburg, Germany)

As one can see, the scarf is cut very precisely. The notch cuts are meeting each other exactly.

(Fotos: HessenForst, Forstamt Weilburg, 35781 Weilburg, Germany)

- Of course, the felling direction has to be controlled. Hanging up of trees can be avoided.
- The chainsaw or other tools, e.g. caliber, can be used as an iron sight.
- Deviations from the felling direction can be detected and corrected. These controls are effective only if the two notch cuts meet each other exactly.

(Fotos: HessenForst, Forstamt Weilburg, 35781 Weilburg, Germany)

- For trees with a stock diameter bigger than the chainsaw bar, the final cut starts at the lower side of the hillside. This is the dangerous side.
- The cut is carried out with the bar tip behind the notch. Attention, do not cut through the notch!
- In case the chainsaw bar is long enough, cutting from the save side only, the upper hillside, is carried out.
- For bigger trees one has to cut from both sides. The two cuts do not have to meet exactly. The two cut levels should not exceed 3-5 cm

(Fotos: HessenForst, Forstamt Weilburg, 35781 Weilburg, Germany)

- The stabbing cut is carried out with the lower side of the bar tip. Then the bar is moved between the notch and the rear safety band.

(Fotos: HessenForst, Forstamt Weilburg, 35781 Weilburg, Germany)

- Make use of the entire bar length to prevent cutting with the bar tip and cutting through the notch. Cut with ingoing and outgoing chain.

(Fotos: HessenForst, Forstamt Weilburg, 35781 Weilburg, Germany)

If possible control the cut on both sides, meaning on the chainsaw- and the bar tip side. Try to be parallel to the notch. At the end the safety band is cut.

(Fotos: HessenForst, Forstamt Weilburg, 35781 Weilburg, Germany)

Size of the safety band:

- The size of the safety band depends on tree diameter and leaning of the tree.
- Before cutting the safety band, all safety precautions can be taken, e.g. controlling the felling area, warning shout, make contact to workmates.
- Wedges are used and hit from the side. In case of back-leaning trees they must be hit firmly.

(Fotos: HessenForst, Forstamt Weilburg, 35781 Weilburg, Germany)

The wedges have to be put far enough from the safety band, not hindering the final cut

(Fotos: HessenForst, Forstamt Weilburg, 35781 Weilburg, Germany)

- The moment safety can be guaranteed, the safety band can be cut.
- The felling time, opposite to normal felling procedures, can be determined exactly.
- On trees leaning forward heavily, the safety band is cut diagonal from above. In all other cases the final cut is carried out on the same level as before. This allows setting more wedges if required.

(Fotos: HessenForst, Forstamt Weilburg, 35781 Weilburg, Germany)

Back-leaning trees can be secured as illustrated below.

(Fotos: HessenForst, Forstamt Weilburg, 35781 Weilburg, Germany)

- A finally cut stock with all its safety features:
- Clear cut and straight notch.
- A good, repeatable and not accidently achieved working result!

(Fotos: HessenForst, Forstamt Weilburg, 35781 Weilburg, Germany)

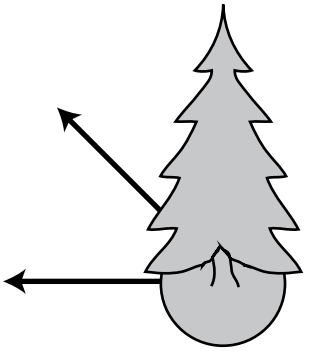
Appendix 4: Safety procedures for logging operations

- Planning and organization
- Risks assessment for each tree
- Escape routes
- Felling techniques
- Danger zones
- Felling support and tools
- Bringing down of hang-ups
- Weather effects
- Working on slopes
- Organization
  - never work alone in the forest!!!
  - Close all forest roads and trails for the public

(Photo: unknown)

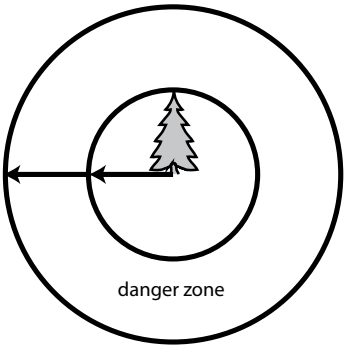
Escape routes

- The workplace around the stem has to be cleared from obstacles
- Assure that for each person involved in the felling operation an escape route is available
- Escape routes should direct diagonal backwards from the tree and have a length of at least 9 m



Danger Zone:

Felling area is double the length of the tree to be felled!



Felling tools and supports:

- Never use iron or steel wedges

(Fotos: HessenForst, Forstamt Weilburg, 35781 Weilburg, Germany)

Bringing down hang-ups correctly and safely

1. Turn tree down with appropriate tools

2. Lever tree

3. Make use of a winch

(Fotos: HessenForst, Forstamt Weilburg, 35781 Weilburg, Germany)

NEVER fell a hang-up tree!

Never cut-off a hang-up tree!

Never throw other trees on top!

Never climb on hang-ups!

Environmental impacts

Environmental impacts can affect work safety. Interruption of work might become necessary

Sight: Don't fell trees if you cannot see properly (dawn, rain, mist).

Strong Wind: Never fell trees if you cannot assure a correct directional felling

(Drawings: unknown)

Working on slopes:

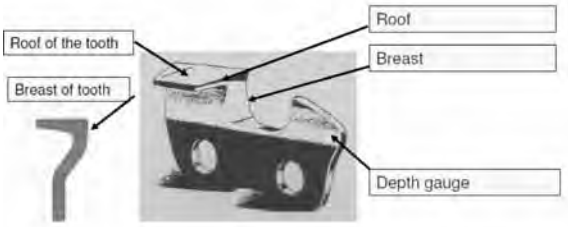
- Working on slopes is dangerous. Pieces of wood, stones, branches can start moving by themselves.
- Always work from the upper side of a log laying on a slope. Especially when you are cutting assortments.
- Secure logs against rolling.
- Always work side-wards, parallel to your workmate

(Fotos: HessenForst, Forstamt Weilburg, 35781 Weilburg, Germany)

Appendix 5: Chainsaw maintenance

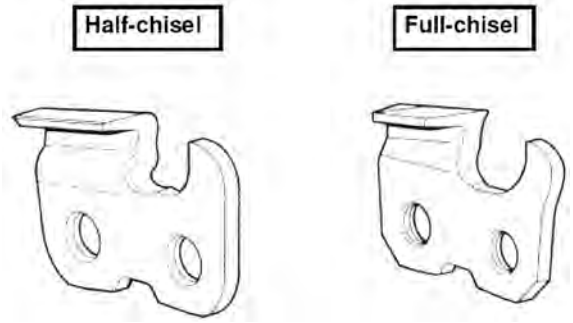
Chain sharpening:

Construction of a cutting tooth



(Der Forstwirt, 2000; 3. Auflage, Ulmer Verlag Stuttgart, Germany; Helmut Flebacher, Fellbach)

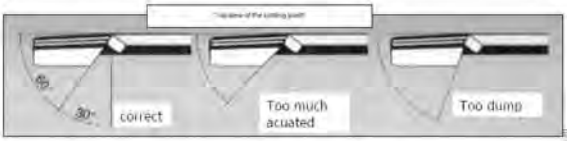
Different teeth



(Der Forstwirt, 2000; 3. Auflage, Ulmer Verlag Stuttgart, Germany; Helmut Flebacher, Fellbach)

Angle for sharpening

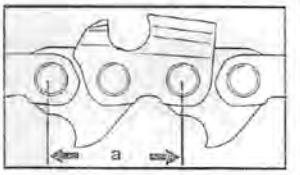
- For all planer-chains between 25° and 35°
- (check producer's indications)
  - **Stihl** 30°
  - **Oregon**
    - Half-chisel 30°
    - Full-chisel 25°
- Oregon can serve as the model for angles of other producers (e.g.: Windsor)



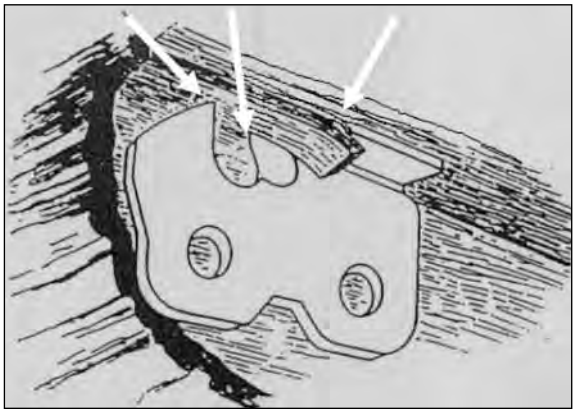
(Der Forstwirt, 2000; 3. Auflage, Ulmer Verlag Stuttgart, Germany; Helmut Flebacher, Fellbach)

Chain Division

- Length of cutting teeth and other chain links is determined by the division of the chain.
- **1 Zoll = 2,54 cm**
  - ¼" = 6,35 mm
  - 0,325" = 8,25 mm
  - 3/8" = 9,52 mm
  - 0,404" = 10,26 mm
  - ½ " = 12,7 mm
- Attention : chain, bar and bevel always must have the same chain division



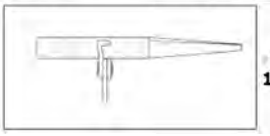
Cutting tooth function



(Drawings: unknown)

File sizes

Sizes	Full chisel		Half chisel		Flat profile chain	
Oregon 0.325	4,8	4,5	4,8	4,5	4,0	4,0
Oregon 3/8	5,5	5,16	5,5	5,16	4,5	4,0
Stihl 0.325	4,8	4,5	4,8	4,5	4,0	4,0
Stihl 3/8	5,16	4,8	5,16	4,8	4,5	4,0

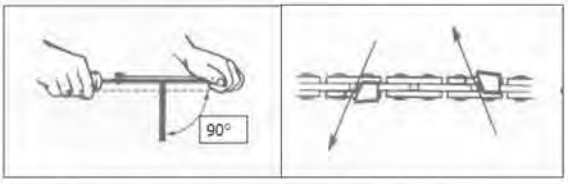


Overlap of the file is:
1/5 (0,8 mm) – 1/10 (0,4 mm)

(Drawings: unknown)

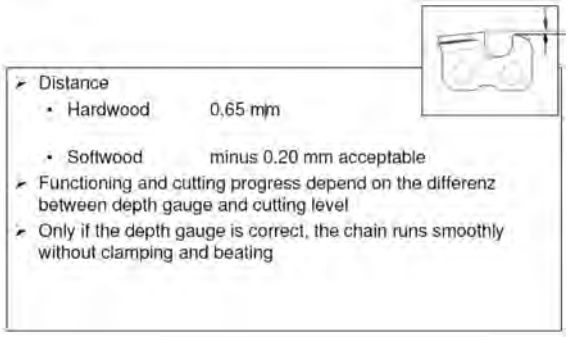
Handling the file

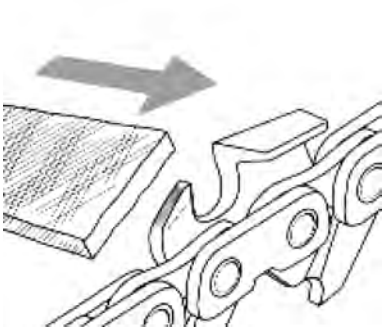
- horizontally (90°)
- From inside to outside



(Drawings: unknown)

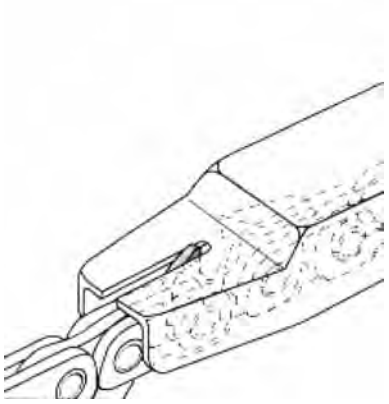
Depth gauge





(Drawings: unknown)

- Depth gauge
  - Stroke diagonal and parallel to the set marks
  - Keep the horizontal part of the tooth of appr. 0,5 mm



Maintenance

- After assembling the chain saw, check proper functioning
  - Brake
  - Tension
  - Check greasing
- Sharpening procedure
- Check tension of the chain
- Identify the shortest tooth by means of the caliper gauge
- Sharpen the shortest tooth
- Adapt all teeth on this side to that length
- Control depth gauge/lower depth gauge
- Change side of chain
- Adapt all teeth on the other side to those of the first side
- Control depth gauge/lower depth gauge
- Turn around the bar
- Tools: depth gauge, screwdriver, round and flat files, file-brush, caliper gauge, sharpening grid, brass brush, grease gun,

Maintenance

	daily	weekly	monthly	yearly
Chain saw	• Sight check • Accelerator block • Chain wheel brake • Air Filter • Ventilation slits	• Clean fly wheel • Clean cilinders • Check Vibration buffer • Greasing • Clean ignition plug • Clean carburator	• Check bevel, clutch, chain brake • Control starter	replace if necessary: • Air filter • Petrol filter • Oilfilter
	daily	weekly	monthly	yearly
Bar	• Turn around • Clean slot and oil entry wholes • Clean side cover	• deburring		
	several times daily			
Chain saw	• Tension of chain • Sharpening if needed			

- Do not clean with petrol! Spray parts with chainsaw cleaner and put in warm water with detergent
- Check tension of chain before start working!
  - For spanning the chain, loosen the screws at the chain wheel cover a bit.
  - Lift the tip of the bar during spanning. Turn bolt of chain until chain fits
  - The chain links at the lower side of the bar have to fit tightly
  - It must be possible to lift the chain in the middle of the upper side of the bar, so that one can see the tips of the chain links
  - The chain fits correctly when it can be pulled easily with two fingers

Distance Cable Crane Yarding, transport of logs to the Log-Landing

Rigging of an Intermediate Support Tree

Appendix 6: Harvesting Form (Example)

Harvesting Plan		Date: 22.04.2017	
Fdis: Khulo	FRa: Zegani	Comp.: II.7-36	Area ha: 3,3
Age: 51	Species: Pi, Hb,	**Crown closure: 0,9**	**Incl.: S 16**
Average BHD, cm	**Average Height, m**	**No.of cut trees**	**Average vol., m^3**
25	19	236	0,42
Opening-up system to be constructed, m			**Comments:**
Road	0		
Skidtrail	200		
Proposed time:	June 2017		
Cutting operation	ha	M^3	
For road			
For skidtrail	0,1	42	
On area	3,2	57	
Total volume	-	99	
Total m^3 per ha	-	30	
Total harv. Volume/ha	-	25,5	-15% for conifers
Total harv. Volume/ha	-		-20% for BLT
Total harv. Volume/ha	-	25,5	
Cutting type	Thinning		Thinning/clear cut
Proposed harv. time	Skidtrail: Apr. 2017 Area: Dec. 2019		Thinning
Stakeholders informed	Zegani Village Administration, NGOs		
Harv. System	Manually, tractor		Manually, tractor, etc
FW/Contr. briefed	Work-safety		
Date:	Needed Tools		
	Working time		
	Environm. issues		
	Barrier & warning signs posed		
Grading rules: Pine: min.dia.: 16 cm, min. length: 4 m; full m only; healthy, no decay; rest: firewood: 1 m long, no splitting			
Yarding operations			
Proposed time	Dec. 2019/Jan. 2020		
Needed machinery	Tractor with winch		
Contr./License Holder: Mr. Vasil Chaladze, Tbilisi Contract signed, Date: 22.04.2017			Name, Adress
Decking places marked			
Comp.: II.7-36 **Remarks:**			
Compiled, Date: 22.04.2017	Signature:		
Approved, Date: 23.04.2017	Signature:		

6. References

AID; Bundesanstalt für Landwirtschaft und Ernährung (BLE) 2016; „Sicherheitsfälltechnik“; Deichmanns Aue 29; Bonn; Germany

Benneckendorf, W. (1993): Guidelines for Forest Road Construction, Project Report No.17, Malaysian-German Sustainable Forest Management Project, Sabah, Malaysia

Benneckendorf, W. (1994): Guidelines for Timber Harvesting in Commercial Class II Forest Reserves in Sabah, Project Report No.187, Malaysian-German Sustainable Forest Management Project, Sabah, Malaysia

Benneckendorf, W. (1994) Operator‘s Manual for Forest Road Construction, Project Report No.194, Malaysian-German Sustainable Forest Management Project, Sabah, Malaysia

Hessen Forst “Tree and Risk Assessment”; , Landesbetrieb HessenForst, Bertha-von-Suttner-Straße 3, D-34131 Kassel-Wilhelmshöhe

Hessen Forst, FWM Uwe Holl “Chain Saw Operations – 14 cm”; Landesbetrieb HessenForst, Bertha-von-Suttner-Straße 3, D-34131 Kassel-Wilhelmshöhe

Hessen Forst “Chain Saw Operations + 14 cm”; Landesbetrieb HessenForst, Bertha-von-Suttner-Straße 3, D-34131 Kassel-Wilhelmshöhe

Hessen Forst “Safety Cut”; Landesbetrieb HessenForst, Bertha-von-Suttner-Straße 3, D-34131 Kassel-Wilhelmshöhe

Hessen Forst “Work Planning and Organization”; Landesbetrieb HessenForst, Bertha-von-Suttner-Straße 3, D-34131 Kassel-Wilhelmshöhe

Gabbion Construction close to Khorog, Tajikistan (Foto: B. Neussel)

VI. Economics

Glossary

B	B-Quality of timber
BLT	Broad Leaf Tree
C	C-Quality of timber
FW	Forest Worker
GEL	Georgian Lari
Ind.	Industrial timber for paper mills, particle boards, etc.
Mgt.	Management
MOH	Machine operating hour
PAL	Timber quality for pallet construction
SFM	Sustainable Forest Management

1. Introduction

Despite serving for all the other forest functions, forestry aims to make a profit. This is the point where a lot of environmentalists start to complain - and there are good reasons for since in many countries the forestry sector was or still is characterized by corruption and a bad, not sustainable management. It was and is very often a mere exploitation not taking biodiversity and sustainability into account. In many countries there are not much trust left and the Forest Departments facing hard times. To return this trust, they have to operate extremely transparent, involving whenever appropriate NGOs and citizens in decision making. Approaching the public as mentioned in the chapters "Education" and "Recreation" will help that citizens consider the Forest Departments again the advocates of the forests and get the feeling again that their forests are in good hands. The production function of the forest should not be underestimated. Timber is the most environmentally friendly construction material since carbon is fixed for a long period.

To make SFM economically viable a general rule is to minimize the number of interventions. All activities e.g. weeding, seedling protection, non-commercial thinnings, etc. are costing money. Putting this money instead on a bank account and let it stay there for approximately 100 years (average rotation period) one might earn more money by collecting the interest rates than try to earn money with SFM. Of course, there are many risks in a 1oo year time span, e.g. inflation, financial crises, etc., but in SFM too, e.g. forest fire, windthrow etc.

Implementation of those activities only which are absolutely necessary to achieve the set Mgt. Goal. In other words, let nature work and emphasize more on so called "biological automatization". The intensity of interventions is definitely related to the silvicultural and Mgt. Goal.

The first step is to assess all the costs for a certain management area and to calculate the possible revenue. Comparing these two one can easily realize the economically situation, there is a loss, a favorable balance or just a break even.

2. Mgt. Costs

The management costs are described and explained best by an example. I have chosen a Forest District in Georgia of 37323 ha. This business model is programmed on Excel and available with the author. All the yellow underlined fields have to be filled in, the figures in the green fields are computed by the program. These figures are rounded up or down by the Excel program thus the results differ slightly from calculations with a hand calculator. All costs and selling prices are referring to the local Georgian situation in 2017.

First step: Listing of all costs and adding up:

2.1. Headquarter

2.1.1 Salaries / Headquarter

	Dir.	Dep.	Head Of Serv	Head Of Dep.	For. Spec.	Ento mol-ogist	Phyto-Patho-logist
No. of Staff	1	1	3	4	8	1	1
Salary / Month GEL	1550	1300	960	850	680	680	680
Annual Salary GEL	18600	15600	11520	10200	8160	8160	8160
All Staff GEL	18600	15600	34560	40800	65280	8160	8160
All Staff + 20% bonus	22320	18720	41472	48960	78336	9792	9792

Lab. Assist.	Road Constr. Spec.	Driv.	GIS Spec	IT MGT	Other Dep. Staff	Total Staff	Total Costs per year GEL.
1	1	9	1	1	13	45	
650	680	320	680	680	680		10390
7800	8160	3840	8160	8160	8160		124680
7800	8160	34560	8160	8160	106080		364080
9360	9792	41472	9792	9792	127296		436.896

2.1.2 Running Costs / Headquarter

	No.	Price GEL	Depreciation time (years)	Annual Costs GEL
Construction Costs of Building	1	457000	50	9140
Repair and savings for new construction	1	1000000	50	20000
Suzuki 4 wheeler	5	11075	1	55375
Nissan Pick-up	1	18393,75	1	18394
Computer	35	5000	5	35000
Stationary	1	13000	1	13000
Furniture	1	25000	10	2500
Costs for Gas, Electricity, Internet, Water for 1 year	1	86915	1	86915
Total				**240.324**

2.1.3 Total Costs per year / Headquarter

	Ha	GEL per year
1.1 Salaries		**436896**
1.2 Running Costs		**240324**
Total		**677220**
Costs per ha forest (total area)	**150115**	**5**
Proportion for Forest District	**37323**	**168.377**

2.2 Forest District

2.2.1 Running Costs (Salaries)/ Forest District

Forest District	Dir. Of Adm.	Dep. Of Adm.	For. Spec	For. Spec. (Temp)	Heads Of FR	Forest Worker* (FW)	Janitor	Total Staff	Total Costs GEL
No.	1	1	1	1	3	28	1	36	
Monthly Salary GEL	1000	800	650	650	670	0	250		4020
Annual Salary GEL	12000	9600	7800	7800	8040	0	3000		48240
All Staff GEL	12000	9600	7800	7800	24120	0	3000		64320
All Staff + 20% bonus	14400	11520	9360	9360	28944	0	3600		**77.184**

* Costs for FW are considered in the Harvesting Costs below.

2.2.2 Other Running Costs

Other Running Costs	**No.**	**Price GEL**	**Depreciation time (years)**	**Annual Costs GEL**
Construction Costs of Building	1	50000	50	1000
Repair and savings for new construction	1	60000	50	1200
Suzuki 4 wheeler	30	11075	1	332250
Lada Niva	1	10363	1	10363
UAZ	1	9353	1	9353,13
Shantui Crawler Tractor	1	108092	1	108092
Belarus Tractor	1	102672	1	102672
New tractors	4	152872		611488
Computer	4	5000	5	4000
Stationary	1	5000	1	5000
Furniture	1	2500	10	250
Costs for Gas, Electricity, Water and internet for 1 year	1	3028	1	3027,75
Road maintenance costs per year		67181		67181
Total				1.255.877

Total Running Costs for Forest District per year, GEL	**1.333.061**

2.2.3 Investment Costs

Calculation of additional needed staff	
28912	Harvestable Timber (m^3/year)
0,7	m^3 performance of 1 FW per hour (cutting, delimbing, scaling)
5	m^3 performance of 1 tractor per hour (yarding)
220	working days per year
8	working hours per day
23	FW needed
4	Tractors needed

Tools

FW	Chainsaws	Protection gear	Other tools*, No. of sets	Total costs, GEL
23	47	47	28	
Costs per unit, GEL	2600	780	1000	
Total costs, GEL	122031	36609	28161	186.802
Depreciation time, years	5		Investment Costs for tools, GEL/year	37.360

* Splitting hammer, wedges, felling lever, chains, planting hooks

Machinery

Tractors			
No.	4		
Costs per unit, GEL	400000	Depreciation time (years)	10
Total costs, GEL	1.714.182	Investment Costs for machinery (GEL/Year)	**171.418**

New road construction

Road Min. m/ha	Price per km, GEL	Total km	Total Price, GEL	Total Price (40 years)
3	26700	112	2989572	74739
Skid-trail Min. m/ha	Price per km, GEL	Total km		
50	3200	1866	5971680	149292
Cable corridors 50 m/ha	0	1866	0	0
New road Construction Costs per year				**224.031**

Total Investment Costs per year, GEL	**432.809**

2.2.4 Harvesting Costs

Harvesting Costs	Commercial Timber, GEL for 1 m^3	Firewood and PAL/Ind., GEL for 1 m^3	for total Commercial Timber, GEL	for total Firewood, GEL	Total Harvesting Costs
Cut	4,5	9,5	20399	231601	251999
Yarding	21	27	95193	658233	753426
Total Harvesting Costs	25,5	36,5	115592	889834	**1.005.425**

3. Possible Income from Timber Sale per Year (GEL)

Species	% of total Volume	Assortment	m^3	Price per m^3, GEL	Total GEL
Fagus	80	B / C	425	260	110427
		PAL / Ind.	2013	170	342230
		Firewood	1342	90	120787
Oak	3	B / C	16	650	10353
		PAL / Ind.	88	260	22899
		Firewood	38	90	3397
Other Broad leaf Trees	17	B / C	90	500	45127
		PAL / Ind.	214	130	27806
		Firewood	499	90	44918
Coniferous Trees	100	B / C	4002	230	920483
		PAL / Ind.	16148	130	2099240
		Firewood	4037	50	201850
Total			28912		**3.949.517**

4. Financial Result for Forest District

Proportionally Costs from Headquarter	Running Costs District, GEL	Investment Costs per year, GEL	Harvesting Costs, GEL	Income from Timber Sell, GEL	Balance, GEL
168.377	**1.333.061**	**432.809**	**1.005.425**	**3.949.517**	**+1.009.845**

106	**Income GEL, per ha/a**
79	**GEL, Costs per ha/a**
27	**Profit per ha/a**

All costs for harvesting and investment are based on the respective machine cost calculations as stated below.

Costs for any other work as planting, forest protection etc. are not included in this example, but, of course, have to be considered if they appear.

5. Machine Cost Calculation

All above mentioned machinery costs (including vehicles and chainsaws) are calculated according to the Calculation Sheet below. Software on Excel is available with the author:

Machine Calculation, New Tractor, 02.04.2017				
No.	Data	Calculation	Unit	**Price**
1	Purchase price		GEL	400000
2	Operation time in years		years	8
3	Operation time in hours		hours	10000
4	Operation ratio	03:02	Hours/ year	1250
5	Realistically operation time		Hours/year	800
6	Fuel consumption per hour		L/hour	25
	Fuel price		GEL/L	2,20
7	Repair factor			1,2
8	Grease factor			0,1
9	Interest rates		%	8,00
	Calculation			
10	Depreciation			
	If 5 > 4	01:03		0
	If 5 < 4	1 : (2 x 5),	GEL	62,50
		400000 : (8 x 800)		
11	Interest rates / year	(1 x 10 %) : 2 : (5), (400000 x 10%) : 2 : 800	GEL	20,00
12	Repair and maintenance	(1 : 3) x 7, (400000 : 10000) x 1,2	GEL	48,00
13	Fuel and grease	6 x GEL/L x (1 + 8),	GEL	60,5
		25 x 2,20x1,1		
14	Transport	3 per month x12 months x 2h/(5)	GEL	0,09
		3x12x2/800		
15	**Total costs per hour**		GEL	**191,09**
16	**Total costs per year**	15 x 5	**GEL**	**152872**

6. Harvesting Costs

6.1 Cutting

The cutting costs are based on the German EST tariff which was developed in 1979 already. This tariff is based on many time studies where a certain time for the production of 1 m^3 of timber, including all side work as scaling, measuring, splitting etc. is calculated. This calculated time shows how many minutes a Forest Worker can spend to produce this 1 m^3 of timber while maintaining an average monthly salary. This time has to be multiplied with a money coefficient per minute which has to be based on an average monthly salary of a Forest Worker in his specific country.

At a later stage a bonus for steepness, snow, rocks, swamp etc. on the cutting area can be added.

A software of this tariff is available with the author.

Salary Data Base

Labour Costs

Average monthly salary GEL:	500	**Chainsaw:**	GEL/hour	GEL/Min.
Monthly working hours:	160		9,55	0,159167
Additional charge for piece work %:	20			
Total monthly salary, GEL:	600			
Minute factor, GEL:	0,0625			

Time consumption for 1 m^3, Timber, delimbed, fully measured and marked

Dia. class	**Mid. Dia.**	**Spruce**		**Fir**		**Pine**		**Beech**		**Oak**	
	no bark	Labor	Chain-saw	Labor	Chain-saw	Labor	Chain-saw	Labor	Chain-saw	Labor	Chain-saw
	cm	min	min	min	min	min	min	min	min	min	min
L0	8	259	92	258	92	205	72				
	9	190	65	190	65	144	55				
L1a	10	141	50	153	57	108	43	90	26	103	29
	11 , 12	102	38	114	47	78	31	65	21	78	26
	13-14	67	29	78	36	56	22	50	16	66	22
L1b	15-16	54	23	58	28	43	16	41	13	56	19
	17-19	46	18	49	21	35	11	35	11	48	16
L2a	20-24	36	14	40	16	27	8	29	9	39	13
L2b	25-29	30	11	34	12	20	5	24	7	31	10
L3a	30-34	26	9	29	9	17	4	21	6	26	8
L3b	35-39	22	8	24	8	14	3	19	5	23	7
L4	40-49	17	6	19	6	10	3	17	5	21	7
L5	50-59	15	5	16	5	9	3	14	4	18	6
L6	> 60	13	4	15	4	8	3	13	4	17	6

Time consumption for 1 m³, Firewood, delimbed, cut into pieces (1, 2 or 3 m), produced from rolls

Piece dia.	**Spruce/ Fir**				**Pine**				**Broad leaf trees (BLT)**	
	1 m		2 or 3 m		1 m		2 or 3 m		1 m	
with bark	Labor	Ch. saw	Labor	Ch. saw	Labor	Ch. saw	Labor	Ch. saw	Labor	Chain-saw
cm	min	min	min	min	min	min	min	min	min	min
10	112	53	101	48	94	40	84	35	81	30
12	88	44	79	40	73	33	65	30	58	24
14	76	38	68	34	60	29	54	26	47	20
16	67	34	60	30	52	25	47	22	41	18
18	58	29	52	26	46	22	41	19	35	16
20	50	25	45	22	40	19	35	17	31	14
22	43	21	38	19	35	16	32	15	29	13
24	37	18	33	16	31	14	28	13	26	12
26	33	15	29	14	27	13	25	12	24	11
28	29	13	26	12	25	11	23	10	23	10
30	27	12	25	11	23	10	21	9	23	9
32	26	11	23	10	21	9	19	8	22	9
34	25	10	22	9	20	8	18	7	21	9
36	24	9	21	8	19	8	17	7	21	9
Splitting	68	18			55	18			55	12

Time consumption for 1 m³, Firewood, delimbed, cut into pieces, produced from complete trees

Piece dia.	**Spruce/Fir**				**Pine**			
	1 m		2 or 3 m		1 m		2 or 3 m	
with bark	Labor	Chainsaw	Labor	Chainsaw	Labor	Chainsaw	Labor	Chainsaw
cm	min	min	min	min	min	min	min	min
10	103	50	92	45	83	43	74	39
11	83	42	77	38	71	37	64	34
12	73	36	65	34	63	32	57	29
13	66	33	59	30	56	28	51	26
14	60	30	55	28	51	25	47	24
15	56	28	51	26	47	23	42	22
16	53	26	49	24	44	21	40	20
17	51	24	47	22	42	19	38	18
18	49	23	45	21	40	17	36	15
19	47	21	43	19	38	15	34	14
20	45	20	41	18	36	14	32	13
21	43	18	39	16	34	13	30	12
22	41	17	37	15	32	12	28	11
23	39	16	35	14	30	11	26	10
24	37	15	33	13	28	11	25	10
25	35	14	31	12	27	10	24	9
Splitting	68	18			55	18		

Time consumption for 1 m³ firewood, Transport in m, conifers

Piece dia.	1 m long	1 to 3 m	4 to 6m	7 to 10m	11 to15m	16 to 20m	21 to 30m
cm		min	min	min	min	min	min
10		21	29	36	44	53	68
12		18	25	30	37	45	58
14		16	21	26	32	39	50
16		14	19	23	29	35	45
18		13	17	21	26	31	40
20		12	16	19	23	29	37
22		11	14	18	22	26	34
24		10	13	17	20	25	31
26		9	13	16	19	23	30

Time consumption for 1 m³ firewood, Wood piece collection and piling, Conifers

	Heap	Heap	Heap	Heap	Piling in open heaps
	< 1m³	1 to 2 m³	2 to 5 m³	> 5 m³	
	min.	min.	min.	min.	min.
Conifers	22	16	13	11	6
BLT	17	13	11	10	5

Time consumption for 1 m³ firewood, Transport in m (BLT)

Piece dia.	1 m long	1 to 3 m	4 to 6m	7 to 10m	11 to15m	16 to 20m	21 to 30m
cm		min	min	min	min	min	min
10		24	32	39	48	58	74
11		22	29	36	44	53	68
12		20	27	33	41	49	63
13		19	25	31	38	46	59
14		17	23	29	35	43	55
15		16	22	27	33	41	52
16		15	21	26	31	38	49
17		15	20	24	30	36	46
18		14	19	23	28	34	44
19		13	18	22	27	33	42
20		13	17	21	26	31	40
21		12	16	20	25	30	38
22		12	16	19	24	29	37
23		11	15	19	23	28	35
24		11	15	18	22	27	34
25		11	14	18	21	26	33
26		10	14	17	21	26	33
> 27		10	13	17	20	25	32
Splitting		10	13	16	19	24	31

Time consumption for 1 m^3 firewood, Wood piece collection and piling, BLT

Piece dia.	2 m long	1 to 3 m	4 to 6m	7 to 10m	11 to15m	16 to 20m	21 to 30m
cm		min	min	min	min	min	min
10		10	17	23	29	35	43
11		11	16	22	26	32	39
12		12	15	20	24	30	36
13		13	14	18	23	28	34
14		14	13	17	21	26	32
15		15	12	16	20	25	30
16		16	11	15	19	23	28
17		17	11	15	18	22	27
18		18	10	14	17	21	25
19		19	10	13	16	20	24
20		20	9	12	15	19	23
21		21	9	12	15		
22		22	9	12	14		
23		23	8				
24		24	8				
25		25	8				
Splitting			8	10	12	15	18

Extra Charges for Cutting

Inclination %	Extra charge %	
	without Snow	with Snow
< 15	0	3
15-24	2	5
25-34	4	8
35-44	7	13
45-54	12	19
55-64	20	30
> 65	30	30

Hindering Vegetation or brushwood				
Area of total harvesting area	Extra charge %			
	up to 1/4	> 1/4	> 1/2	> 3/4
No hindrance	0	0	0	0
Middle hindrance	0	5	5	10
Strong hindrance	0	5	10	15

Hindering topography				
	Extra charge %			
Area of total harvesting area	up to 1/4	> 1/4	> 1/2	> 3/4
Ditches and floor unevenness	0	0	5	5
Swampy area	0	5	10	15
Rocks	0	0	5	5
Big rocks	0	5	10	15

Extra Charges for any other reasons
up to 10%

FW Calculation sheet Date: Compartment: Forest District:

Spec., Assortm.	Work sequ.	m³	Mid.Dia.	Labor	Extra Charges		Labor Total	Labor Total	Chain-saw	Chain-saw Total	Total
				Min.	%	Min.	Min.	GEL	Min.	GEL	GEL
Fir, CT	Cut,Scal, Del., Meas.&Mark	1	2b	34	17	5,78	39,78	2,48625	12	1,91	4,40
Fir, FW	Cut,	1	20	45	17	7,65	52,65	3,290625	20	3,183333	6,47
Fir, FW,	Trans	1	20	19	17	3,23	22,23	1,389375	0	0	1,39
Fir,	Pil.	1	20	6	17	1,02	7,02	0,43875	0	0	0,44
		0	0	0	17	0	0	0	0	0	0
		0	0	0	17	0	0	0	0	0	0
		0	0	0	17	0	0	0	0	0	0
		0	0	0	17	0	0	0	0	0	0
											12,70

		%	Work sequence	
Inclina-tion		7	Sp	Splitting
Vegeta-tion		0	Trans	Transport
Topogra-phy		5	Pile	Piling
Extra		5	Cut	Cutting
Total		17	Scal	Scaled

The above calculation indicates that a laborer can earn by producing timber of certain species and assortments, carrying out all the different work sequences, 12,70 GEL for 1 m³. Working with an average performance, including all breaks he can achieve the set monthly income of 600 GEL. If his performance is higher his salary will increase, if it is lower it will decrease accordingly.

6.2 Yarding

The yarding cost calculation is based on performance of tractors, with double drum winches and according to the size of the timber. Here no cost calculations for Forwarder and Harvester are made since they are hardly found in these developing countries.

Data Base			MOH = Machine operating hours
Yarding Costs			
Assortment	No.	**Performance**	**Equipment**
		m^3 / MOH	
Thick timber (> 1m^3 per stem)	1	10 to 13	(Skidder with winch)
Small timber (< 1 m^3 per stem)	2	3 to 6	(Skidder with winch)
Firewood, 1 m long	3	4 to 6	(Truck, 3 workers)
Firewood, 2 m long	4	6 to 8	(Truck, 3 workers)
Firewood, 1 m long	5	6 to 8	(Tractor with trailer and crane, 1 worker)
Firewood, 2 m long	6	8 to 10	(Tractor with trailer and crane, 1 worker)
2 Laborers	7	6	(Collecting, Loading)

Monthly wages GEL:	500
Monthly working hours:	160
Additional charge for piece work %:	20
Total monthly wages, GEL:	600
Minute factor, GEL:	0,0625

Extra Charges for Yarding

Inclination %		
	Extra charge %	
	without Snow	with Snow
< 15	0	3
15-24	2	5
25-34	4	8
35-44	7	13
45-54	12	19
55-64	20	30
> 65	30	30

Hindering Vegetation or brushwood				
	Extra charge %			
Area of total harvesting area	up to 1/4	> 1/4	> 1/2	> 3/4
No hindrance	0	0	0	0
Middle hindrance	0	5	5	10
Strong hindrance	0	5	10	15

Hindering topography				
	Extra charge %			
Area of total harvesting area	up to 1/4	> 1/4	> 1/2	> 3/4
Ditches and floor unevenness	0	0	5	5
Swampy area	0	5	10	15
Rocks	0	0	5	5
Big rocks	0	5	10	15

Yarding distance	**%**
up to 200 m	0
up to 300 m	5
up to 400 m	10
up to 500 m	15
> 500 m	20

Extra Charges for any reasons
up to 10%

Yarding cost calculation Comp.: Date:

Species	Assortm.	m^3	Perfor-mance	**Income Mach.**	**Salary**	**Extra Charge**	**Extra Charge**	**Total Income**
Work se-quence			m^3/MOH	GEL/m^3	GEL	%	GEL	GEL/m^3
Fir	2	1	6	17,45	0,63	15	2,71	20,79
Fir	3	1	5	20,94	0,75	15	3,25	24,94
Fir	7	1	6	0,00	1,25	15	0,19	1,44
		0	0	#DIV/0!	#DIV/0!	15	#DIV/0!	#DIV/0!
		0	0	#DIV/0!	#DIV/0!	15	#DIV/0!	#DIV/0!
		0	0	#DIV/0!	#DIV/0!	15	#DIV/0!	#DIV/0!
		0	0	#DIV/0!	#DIV/0!	15	#DIV/0!	#DIV/0!
		0	0	#DIV/0!	#DIV/0!	15	#DIV/0!	#DIV/0!
		0	0	#DIV/0!	#DIV/0!	15	#DIV/0!	#DIV/0!
		0	0	#DIV/0!	#DIV/0!	15	#DIV/0!	#DIV/0!
Total								**47,17**

Extra Charges		**%**						
Inclination		5						
Vegetation		0						
Topogra-phy		5						
Yarding Distance		5						
Extra		0						
Total		15						

The above calculation indicates that a laborer or contractor can earn by yarding small timber with a skidder (Assortment 2) 47,17 GEL for 1 m^3. Working with an average performance, including all breaks he can achieve the set monthly income of 600 GEL. If his performance is higher his salary will increase, if it is lower it will decrease accordingly.

7. References

Benneckendorf, W.; 2017; “Business Model fort Khulo Forest District”, Ajara Forest Agency, Batumi, Georgia

Forstverwaltung 1979; „EST“; Kernerplatz 10, 70182 Stuttgart, Germany, Baden-Württemberg

Nds. Forstliches Bildungszentrum 2000; „Maschinenkalkulation“; Sautalstrasse 5, 78723 Seesen

VII. Forest Protection Guidelines

Glossary

AFA	Ajara Forest Agency
a.b.	above mentioned
e.g.	Example given
ha/ha	Hectare
°	Degree steepness
%	Percent steepness

1. Introduction

Since in each country fauna and flora is different, guidelines for forest protection have to be developed separately incorporating the respective national biodiversity regulations and laws. The following can serve only as an example:

As an overall guide the **"European Regulations on Nature Protection**" can serve.

Natura 2000 is an ecological network of protected areas in the territory of the European Union.

The **Habitats Directive** (more formally known as **Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora**) is a European Union directive adopted in 1992 as an EU response to the Berne Convention. It is one of the EU's two directives in relation to wildlife and nature conservation. It aims to protect some 220 habitats and approximately 1,000 species listed in the directive's Annexes. Annex I covers habitats, Annex II species requiring designation of Special Areas of Conservation , Annex IV species in need of strict protection, and Annex V species whose taking from the wild can be restricted by European law. These are species and habitats which are considered to be of European interest, following criteria given in the directive. The directive led to the setting up of a network of Special Areas of Conservation, which together with the existing Special Protection Areas form a network of protected sites across the European Union called Natura 2000. Article 17 of the directive requires EU Member States to report on the state of their protected areas every six years. The first complete set of country data was reported in 2007.

The other directive in relation to wildlife and nature conservation is the **Birds Directive.** More formally the directive is known as **Council Directive 2009/147/EC on the conservation of wild birds** and is a European Union directive adopted in 2009. It replaces Council Directive 79/409/EEC of 2 April 1979 on the conservation of wild birds which was modified several times. It aims to protect all European wild birds and the habitats of listed species, in particular through the designation of Special Protection Areas (often known by the acronym SPA).

Since the a.m. refers to Europe only, it can still serve as a guide for other countries.

2. Protection according to zoning

According to the zoning guidelines the following protection categories can be defined for forests. Of course, there might be even more categories which have to be added if considered necessary**.** All protected areas, except steep terrain, have to be made recognizable to the public by signboards or to be fenced additionally. In some cases even forest closure might become necessary meaning the access by citizens is prohibited. These areas have to be registered and marked in a **"Protection Map for Forests"**, scale 1:10000. A leaflet, showing all these areas with restrictions and all activities which are prohibited (e.g. entering, littering, open fire etc.) including the respective penalties should be produced. This information should be published through public media.

Any cases of entering of protected areas, picking, possessing or damaging of protected species have to be prosecuted!

As already mentioned previously, forests should be zoned according to their functions. A lot of examples are listed below and derived from Lobzhanidze, Besarion,(refer to references):

Zone 1: Protection forest (no or restricted management, refer to HCV-classes I-VI)

- Steepness of terrain

Above 35° (70%) slope – protection forest, no forest management interventions at all, but approachable for the public!

- Nature protection

Endangered species of flora and fauna have to be protected including their related habitats.

Rare, threatened, or endangered ecosystems, habitats or refuges.

- Erosion risks

In case of sensitive soils, even below 35° slope, which are easily erodible, forest management can be ceased or limited. Rock formation areas which are dangerous to the public should to be fenced and signposted.

- Protection of vulnerable soils
- Erosion risks:
  - Soil sensitivity
  - Rock formation
  - Geological formations
  - Grasslands providing buffering against flooding or desertification
  - Steepness, no commercial harvesting operations above 35° slope
  - Forest strips existing around avalanche formation and downstream;
  - Anti-erosion forest strips of particular importance;
  - Protecting forest strips against landslides;
- Forest area protection
- Forest district, existing around landslides, rock fall- and exposed areas;
- 300 m protecting strips of subalpine forests;
- 50 m protecting strips of forest edges;
- 100 m protecting forest strips existing on limestone and cave formations and around them; protecting strips of forests, existing around natural hollows;
- Forests, represented on the cliffs, cliff projections and rock (stone) piles;
- Forest areas on the grounds sensible towards the impact of wind and water;
- Forest districts, existing around deep ravines, canyons, precipices;
- Forest districts, existing around rehabilitated or abandoned quarries;

- Protective forest strips existing around snowdrifts and windy areas;
- Forest strips intruded into areas without forest cover;
- Forest areas up to 100 ha represented on bare areas;
- Forest areas existing around travertine and beginnings of natural springs;
- Forest areas existing on inversion slopes.
- Forest areas located around special purpose objects:
  - Protective forest areas existing around communication facilities;
  - Protective forest areas existing around railroads and motor roads;
  - Protective forest areas existing around water head-facilities;
  - Protective forest areas existing around hydronods and canals;
  - Protective forest areas existing around pipelines;
  - Protective forest zones of power transmission communications;
  - Protective forest strips existing around cableways and skiing routes;
  - Cattle routes and forest strips existing around them.
- Water protection

Any activities having a negative impact on ground and surface water formations and the water quality have to be prohibited. Therefore forest management in water sheds can be ceased or limited.

  - Water Courses
- Any intervention in a distance of 20 m (tree length), left and right of a creek or river, is prohibited.
- **Use of chemicals in forest management are prohibited or limited in:**
  - Ground water formation and recharge zones influencing water quality
  - Water shed
  - 200 m protecting strips along the rivers, forest strips existing around lakes, water reservoirs and water bodies
- Forest strips protecting spawning areas with special protective value, along the rivers;
- Forest districts, existing around wetlands, river hears, spring hears and glaciers;
- Forest strips contributing to prevention of formation of mudflows; river bank-protecting strips for prevention of mudflows;
- Floodplain forests;
- Forest strips around existing mineral and thermal waters of healing qualities.
  - Regulations on Water Protecting Strip:
  - Springs

Any intervention in a distance of 50 m around the spring of a creek or river is prohibited.

  - Watershed forests

Areas which are serving for drinking water. Any intervention should be prohibited.

- Climate protection

Forests around public roads, airports, railroads and housing estates should be kept densely to give protection against noise and increases the air quality and purity. These forests exist, at least partly, of ever green species to give protection even during the winter period. A mixture of trees, bushes and shrubs, uneven aged, can be recommended. These forest stripes should have a width of at least 50 m.

- Forests with high protective values

These are forest with a high value for communities or the public in general. Management can be limited or prohibited at all.

- Water sources necessary for drinking water and sanitation
- Items which are bartered in exchange for other essential goods, or sold for cash which is then used to buy essentials including medicine or clothes, or to pay for school fees.
- Areas for collection of non-wood forest resources;
- Areas for collection of wild fruit and berries by local community;
- Areas for collection of leaf vegetables, plants for pickling, seasoning-flavouring- dressing plants and edible mushrooms;
- Forest areas with high concentration of the best honey plants;
- Forest areas for nesting of endemic bees;
- Traditional tree-based bee-keeping forests;
  - Pollination services, for example exclusive pollination of subsistence crops provided by native bees where the pollinators are dependent on the presence of suitable forest habitat and do not survive in purely agricultural landscapes.
- Forest areas rich of medicinal herbs;
- Fishing areas;
- Monuments, churches, religious centers
- Forests with wild plants, used in production of traditional garments, household items, decoration of living environment;
- Forests with plants containing colouring and astringent (tannin-based) matters;
- Forest areas represented by plants for baskets, wicker-work, tying up, fencing, making pillows, mats, brooms;
- Forests important for the use of wood resources:
  - Forest areas intended for special fire-wood use for the part of the village community which doesn't have any other means of alternative heating;
  - Forest areas intended for reserve fire-wood use, where use of resources shall be permitted if, in extreme situation, local community doesn't have other energy resources;
  - Forest areas to be used for utilization of timber and fire-wood for agricultural and ritual purposes, for constructing roves, including coppiced forest stands.
  - Forest areas intended for obtaining timber for the purpose of construction of houses or other personal use.

- Forests with recreational, climate regulating, sanitary-hygienic and other properties having particular value for population;
- Forests of significance for balneology(forests existing around resort areas of various kinds);
- Forest strips, existing around holiday homes, children's camps and medicinal and recreational establishments;
- Forest strips existing around tourist tracks of national and regional importance;
- Forests existing around suburban areas, summer cottages and settlements;
- Green zone forests.
- Critical condition forests

Forests with low density, degraded, etc.. Management can be limited or prohibited at all.

- Forests presenting important fire barriers

Management can be limited or prohibited at all.

- Forests, wetlands and other ecosystems which provide a protective barrier against destructive fires that could threaten communities, infrastructure or other HCVs.
- Fire prevention and protection
- Forest areas with anti-fire purpose;
- Forest areas existing around burnt areas.

3. Forest Protection in Production Forest

The zoning process is part of the Mgt. Inventory and later further executed during the final tree marking inside the stand.

Considering all the above listed protection possibilities, meaning every forest not serving above listed protection, should become Production Forest and /or Forests for community needs, welfare and recreation. But even here the production can be limited or even prohibited if necessary, especially in Zone No. 3.

Zone 1: Protection Forest
Zone 2: Production Forest
Zone 2.1: Close to nature forest management
Zone 2.2: Plantation forests, mixed plantations and forests considered to be converted into natural forest management.
Zone 3: Forests for community needs, welfare and recreation

4. References

Internet search

Bayerische Landesanstalt für Wald und Forstwirtschaft;

Bayerisches Staatsministerium für Ernährung, Landwirtschaft und Forsten;

Waldwissen.net

Krehan, Hannes et Steyrer, Gottfried, BFW Österreich

Lobzhanidze, Besarion, January-April 2010; "Recommendations on Zoning of Georgian Forests according to their Functional Purpose and Methods and Guiding

Principles of Sustainable and Integrated Management of Forest Ecosystems", Tbilisi, Georgia.

Fungus Disease in Pine Forests, Tbilisi City Hall Forest, Georgia (Foto: Vasil Chaladze)

VII.1 Forest Fire Fighting Guidelines

Table of Contents

Photo: www.pixbay.de

Glossary

CF . . . . . Community Forest
CFFO . . . . . Circle Forest Fire Officer
FDis . . . . . Forest District
FE . . . . . Forest Enterprise
FFDC . . . . . Forest Fire Danger Classes
FFO . . . . . Forest Fire Officer
FRa . . . . . Forest Range
M. . . . . Meter
Mio . . . . . Million
PF . . . . . Private Forest
Rad . . . . . Regional Administration
RFFO . . . . . Regional Forest Fire Officer

1. Forest Fire Management

1.1 Frame Work Conditions

In the last 40 years more than 30.000 km² of forest have been destroyed by fire worldwide. Only 4% of this area had natural causes, the majority was man-made. Most wildland fires started from burning of agricultural land. The conclusion to emphasis on forest fire prevention becomes obvious. Each country should develop a law or regulation on forest fire management.

The "Global Fire Monitoring Center" (GFMC) in Freibug (Germany) is since 1998 the only European research center for the collection of all relevant data about wildland fires worldwide. This institute is commissioned by the United Nations (UN International Strategy for Disaster Reduction (UN-ISDR)).

http://www.fire.uni-freiburg.de/

Under the leadership of J.G. Goldammer this institute has published three books concerning wildland fires which can be highly recommended:

- "Wildfire Investigations- Guidelines for Practitioners" (ISBN: 9783941300996),
- "Prescribed Burning in Russia" (ISBN: 9783941300712) and
- "Vegetation Fires and Global Change" (ISBN: 9783941300781)

all published by Kessel-Verlag (www.forestrybooks.com)

1.2 Set-Up of Forest Fire Danger Classes (FFDC)

As a first step it has to be cleared up who is responsible for fire management in the respective country. The schedule of responsibilities should be clearly outlined and everybody should know his task in case a wildland fire occurs. It is highly recommended that the responsible Ministry elaborates a wildland fire- fighting strategy and is responsible for the setting of the following FFDC.

Fire management incorporates:

- Fire prevention
- Avoidance of unnecessary burnings on agricultural land
- Suppression of fire
- Use of controlled fire

The following shows the most disseminated and international recognized Fire Warning Systems:

- WBI/M 68 index: used for example in Germany
- Fire Weather Index (FWI): used in Canada (6 levels from very low – extreme)
- ANGSTROEM: used in Sweden
- NESTEROV: used in Russia
- METEOALARM: for entire Europe, comprising all national European indices; 4 risk classes: Green – Yellow – Orange – Red;
- EFFIS *(European Forest Fire Information System)*: the consolidated European warning system based on French and Canadian systems
- ALPFFIRS *(Alpine Forest Fires)*: joined warning system for the European alp countries

Out of all these systems 5 FFDC have arisen:

- 1 very low risk
- 2 low risk
- 3 medium risk
- 4 high risk
- 5 very high risk

The input data for this risk calculation have to be collected by the respective Weather Forecast Institutes and are as follows:

- Air temperature at noon
- Relative air moisture
- Wind velocity and air pressure
- Amount of rainfall in 24 hours
- Snow height in the morning (only in springtime)
- Vegetation conditions: Forest floor cover, tree crowns (green or dry)

The vegetation conditions are used as a correction factor and divided into 3 classes according to the inflammability and combustibility: conifer-, mixed- or broad leave tree stands. They are further divided and described in the following codes:

- *Fine Fuel Moisture Code* (FFMC),
- *Duff Moisture Code* (DMC),
- *Drought Code* (DC),
- *Buildup Index* (BUI),
- *Initial Spread Index* (ISI)
- *Daily Severity Rating* (DSR))

All different forest fire forecast systems and necessary calculations of parameter are described very well in the dissertation of Thomas Patzelt:

„Waldbrandprognose und Waldbrandbekämpfung in Deutschland" – zukunftsorientierte Strategien und Konzepte unter besonderer Berücksichtigung der Brandbekämpfung aus der Luft"

Steffen Thomas Patzelt
Mainz, Mai 2008
(refer to google: Steffen Thomas Patzelt)

With a.m. data a wildland fire early warning system could be elaborated. The FFDC have to be announced by the respective Ministry. According to the announced FFDC certain preventive measures have to be implemented, e.g. FFDC 3: Observers on watch towers, FFDC 4: Announcement of forest fire danger by public media, tank trucks are filled with water, FFDC 5: no open fire in the vicinity of forests, entering of forests prohibited, fire brigades are on high alert, etc.

Together with the set-up of the FFDC a fire risk assessment should be carried out, showing all endangered areas, including all different vegetation types.

(Refer to chapter IV Inventory and Forest Record Book, compilation sheet)

1.2.1 FireLess2

Derived from internet search:

FireLess2 is a new innovative instrument informing foresters and fire-brigades permanently about the change of humidity in the humus layer. So the danger of forest-fires can be much better assessed.

To minimize the times of high-alert of firefighters during dry seasons and related costs FireLess2 was developed by Swiss experts. This system can assess the risks of forest-fires directly at the forest floor using sensors in the leaf, needle, twigs and the subjacent humus layer. The measured values are directly transferred by server and mobile-phones to forestry and fire-brigade staff.

Is the needle or leaf layer dry but the subjacent humus layer still moist, forest fires can start but spreading slowly only. In case both layers are dry the risk is much higher that the fire will spread in a big scale.

First tests in 2011 have shown that after adjusting the system, forecasting of wildland fires could be well assessed.

FireLess2 can determine the FFDC automatically since it is developed for the permanent observation by professional staff. It is therefore a good supplement to the conservative determination of the FFDCs.

FireLess2 has proven to be resistant against bad weather conditions, the consumption of energy is small only and it is granting a stabile data transfer.

The components of FireLess2: wireless sensors communicating on 433 MHz frequency and the batteries are lasting up to 10 years. They are charged by a solar panel. The communication ensues via GRPS or SMS. The online-platform for the data exchange is based on a “Cloud Advanced Engine” with the opportunity to handle all data on any browser. (see Picture 1)

1.3 Forest Fire Officer (FFO)

Each FDis administration should employ a FFO. They have to be trained to become professionals and they are in charge and responsible in all forest fire related issues. They take the decisions how, when and with whom (local or regional staff) to fight forest fires. They are in close contact with the Public Administration, local fire brigades and the police. They are conducting trainings according to “Euro Fire Standards” in forest fire fighting with local fire brigades and are responsible for their readiness for duty. This applies for FE staff, CF and PF. Each of these entities should provide personal in case of forest fires. They should be equipped with appropriate tools as fire beater, hooks and fire extinguisher, etc.

One of the first duties has to be the assessment of available fire fighting forces in the vicinity of each FDis or community and their status of training.

1.4 Prevention Activities for the Public

The Forestry Departments are responsible for the sensitization and awareness creation of the public with regard to fire management strategies. This includes information events for:

- Schools
- Clubs
- Forest Enterprises
- Community Forests
- Private Forest Owners
- Etc.

Especially farmers and livestock keeper should be involved in this sensitization processes.

1.5 Fire Prevention Structures

1.5.1 Fire Break Lines

Fire break lines are at least 20 m wide and should be kept free of any vegetation or planted with broad leaf trees (no birch) to prevent crossing of fires. They should follow hill tops and ridges since fires hardly can be stopped on slopes. Maintenance costs are quite high. Those forests, wetlands and other ecosystems which provide a protective barrier against destructive fires could assist in protection of communities and infrastructure.

1.5.2 Watch Towers

Watch towers should be constructed on mountains or hills, where a good visibility on many ha of forests is guaranteed. FDis, CF and PF should be responsible for construction in their areas.

1.5.3 Water reservoirs

Artificial and natural water reservoirs have to be maintained permanently. They have to be equally distributed over the entire forest area to provide for a fast refilling of tank trucks. Their position has to be marked in FDis maps and listed in Forest Fire Fighting Plans.

1.6 Communications

An information chain on state level has to be established. Who has to inform whom in cases of forest fires. Radio communications might serve better in remote areas than mobile phones.

1.7 Maps

Maps used for forest fire fighting should indicate the following features:

- Scale 1:25.000
- Contour lines
- Meeting points for all forest fire fighters, police, FDis staff
- All water sources as rivers, creeks, lakes and ponds.
- All preventive structures.

Picture 1: Fire Less 2 components (Photo: Internet search)

Picture 2: Tanker aircraft in action
(Photo: Internet search)

Picture 3: Fire beater

Picture 4: 4-wheel drive tank fire fighting vehicle

Picture 5: Fire extinguisher
(Photos: Internet search)

1.8 Forest Fire Fighting

Forest fire fighting is possible as results from North America, EU countries and Russia show. It is finally a question of accessibility meaning is there sufficient infrastructure to reach in time the burning areas. Furthermore it is a question of financial and human resources. Appropriate equipment is available everywhere. If it is affordable it is highly recommended.

The actual fire- fighting should be led by the respective Circle Administration and professional staff (CFFO). If wild land fires jump over circle boundaries the RFFO is in charge.

2. References

Environment and Security (ENVSEC) 2014: Initiative Project Phase Three – Enhancing National Capacity on Fire Management and Wildfire Disaster Risk Reduction in the South Caucasus", Proposal for a National Fire Management Policy of Georgia

Internet search. Wikipedia

Patzelt, Thomas 2008; „Waldbrandprognose und Waldbrandbekämpfung in Deutschland- zukunftsorientierte Strategien und Konzepte unter besonderer Berücksichtigung der Brandbekämpfung aus der Luft"; Mainz, Germany

Sylviane Blum (Uni Bern), Wald wissen.net, Information für die Forstpraxis, Marco Conedera et al. Redaktion: WSL, Schweiz

Rehabilitation of degraded Land, Amhara, Ethiopia (Foto: C. Wieland)

VIII. Recreation Guidelines

(Foto: J. Mees, pixelio.de).

Glossary
NGO . . . . . Non- Governmental Organization
PEFC . . . . . Pan European Forest Certification
SFM . . . . . Sustainable Forest Management

1. Introduction

According to the respective Forest Laws in nearly all the countries I worked with, citizens have the right to enter the forest for recreational purposes. Therefore all attractive sceneries, e.g. springs, waterfalls, nice views, lakes, etc., should be entered into a **"Recreational Map"** and made public. A hiking trail and bicycle network should be established, starting and ending at parking grounds, connecting these sceneries. The deployment of benches and other resting facilities can be recommended.

Recreational forest is forest land in the vicinity of congested areas and serves primarily for the recreation of the citizens. This function takes priority over the production and in a few cases only even over nature conservation functions. Of course, a forest can even serve for several functions at the same time. These forest functions have to have a legal basis in the respective Forest Laws. The following shows an example of Germany:

Definition of Recreational Forest in the German Federal Forest Law:

"Forests can be declared as Recreational Forests if they are demanded for the welfare of the population. Those forest areas have to be protected, maintained and shaped for recreational purposes."

2. Recreational Forest

These forests are characterized by their close vicinity to cities, by old tree populations and densely road and trail networks. Contrary to parks they consist of closely stocked and mixed forest areas without sizeable meadows and open spaces. Their forest edges, adjacent to roads, agricultural land and trails, have to be maintained, meaning should contain a high diversity of tree species, bushes and flowers.

Questionnaires in Germany have shown that people who are seeking for rest and relaxation are looking for forests where they can experience forest typical sensory experiences, e.g. chirping of birds, noises made by and feeling of the wind, babbling of a brook, etc. It seems that people can relax best when plunging into the forest which is far away from civilization and daily burdens. The entire forest complex with its impact on the humans five senses together with motivation to stay in nature are decisively for the effect of recreation and attractiveness of a forest. Therefore Recreational Forests are indispensable for the population since they give them the chance to experience nature in a way they cannot receive from any other land use system.

2.1 Selection of Recreational Forests

Forest with a remarkable nice scenery and demanded for recreation by the population should be selected and during the zoning process (part of Sustainable Forest Management) gazetted as Recreational Forests.

Results from questionnaires in Germany about the motivation for visiting the forest are shown in Tab. 1. Similar questionnaires should be carried out with town citizens before selecting the corresponding Recreational Forests. (see Table 1)

3. Guidance of Forest Visitors, Avoidance of Conflicts

3.1 Guidance of Forest Visitors

Considering that most of the forest visitors want to experience the forest with their senses, the establishment and direction of trails has the biggest impact for the "adventure" forest and the recreation of visitors. Consequently the construction of many recreational facilities along such a trail is not decisive for the well- being of the visitor, but the way they are guided through the forest, what they can see and which trail they can use. The direction of the trail through the forest and permanently marking of them can minimize a lot of conflicts between relaxation seeking visitors, bicyclists and forest management operations (dirty and broken roads and trails).

Ideally, all trails are designed as circular tracks of different lengths. So everybody can choose the respective trail by themselves. Trail displays should indicate whether they can be used by wheelchair users and people with baby buggies.

Table 1: Reasons for visiting the forest

Frequency	Motivation
> 90% of the people	Just experience nature (96%) just to exercise (93%) just to go for a walk (90%)
> 70% of the people	To be out with family, children or friends (85%) to watch Flora and Fauna (80%) Hiking (80%) driving with bicycle or mountain bike (70%)
others	To be alone in the forest (64%) Collection of mushrooms, berries and flowers (53%) having picnic (40%) jogging (34%) to walk the dog (17%)

3.2 Recreational Facilities

In general forest visitors are considering recreational facilities, especially benches, sign-boards convenient and trail displays important. Trail displays are not recognized at all if not needed but in unknown forest land for all kind of activities considered indispensable.

In Germany, 40 to 50 years ago recreational facilities supposed to increase the recreational value of the forest and all forest owners, public and private, started to "furnish" the forest. Nowadays the attitude of forest visitors has changed and studies show that "less" can become "more".

Educational trails, information boards and children playing grounds should not be seen in the context of recreation. They are not contributing to the typically relaxation and recreation of visitors. They are separate attractions and contribute more to nature education.

In case of high demands for recreational facilities the deployment, construction and maintenance can be handed over to foundations, clubs, NGO's or private persons. All facilities have to be controlled regularly and maintained if required. In the vicinity of cities vandalism can become a problem.

3.2.1 Waste Baskets

Especially the deployment of wastebaskets has ceased nearly totally in Germany because garbage collection in the forest is an expensive operation. The personal responsibility of forest visitors had to be strengthened. Most of them have learnt and agreed that all the garbage they take into the forest they have to take out again and dispose at the public garbage collection.

3.2.2 Tables, Benches and Mountain Huts

Benches should be deployed on places inviting the visitor for "rest and peace". All these benches have to be maintained. Older citizens, especially those who are using the same trails more frequently are supporting the deployment of benches. Mountain huts are useful only on long distance trails where trekking can last for several days. Here they can help in bad weather situations and other emergency cases.

3.2.3 Information boards

Information boards are necessary only in case untypically forest measurements are shown with a high stimulation effect for the average forest visitor. Here explanations are helpful.

3.2.4 Sports Facilities

The deployment of sports facilities in Recreational Forests becomes more and more superfluous. Fitness-studios and special parks are taking over this demand. Horseback-riding- and bicycle tracks should be established if there is an existing demand. These tracks should be separated from hiking trails.

3.2.5 Parking Facilities

Parking places are the gateway to the forest. Even to forests which are located close to cities, people will not go without their car. Construction and location of these parking places are important for trail concepts since they are very often the starting- and ending points of circular tracks. Their location and size are influencing significantly the number of visitors. In Germany up to 76% of forest visitors using a car. Close to cities the bicycle plays an important role (48% in Germany) and pedestrians who walk directly into the forest are rather uncommon (19% in Germany).

3.2.6 Barbeque Places

Many people like barbeque outdoors very much. The construction of such places should be only in the vicinity of parking places. Nobody likes to carry all the food and drinks very far. Here the deployment of information boards, especially concentrating on garbage disposal and forest fire prevention is highly recommended.

3.3 Certification of Recreational Forest

In the following text recommendations for a certification scheme for Recreational Forest of PEFC Germany is described. Certification puts the forest owner into the position to use the declaration "Certified Recreational Forest" by PEFC for example. This might increase the attractivity. The requirements catalog consists of several objectives:

Recreational Concept: is developed and implemented
It consists of:

- Formulation of objectives
- Planning of infrastructure (benches, boards, etc.)
- Forest Management Plan
- Forest esthetics (buildings, support of single trees, use of tree marking paint etc.)
- Concept for conflict management
- Concept for monitoring
- Concept for public relation
- Implementation of SFM
- Concept for forest education
- Concept for steering of visitors

The forest owner has to work towards diverse and structured forests by sustainable forest management, e.g. support to single trees, promotion of mixed forests, access for visitors to water and nice sceneries.

4. References

Schaffner, Dr. S., Lehrstuhl für Wald- und Umweltpolitik der Fakultät für Wirtschaftswissenschaften der TUM, LWF, Deutschland

Suda, Prof.Dr.M., Lehrstuhl für Wald- und Umweltpolitik der Fakultät für Wirtschaftswissenschaften der TUM, LWF, Deutschland

Internet search

IX. Education Guidelines

IX.1 Education Guidelines for the Forestry Sector

(Photo: Kuhlmann, T.; 2012)

Glossary

BSc. . . . . Bachelor of Science
e.g. . . . . Example given
FD. . . . . Forestry Division
FO. . . . . Forest Officer
FR. . . . . Forest Ranger
FTC. . . . . Forestry Training Center
FW . . . . . Forest Worker
MSc . . . . . Master of Science
NGO . . . . . Non-Governmental Organization
SFM . . . . . Sustainable Forest Management

1. Introduction

For implementing SFM each Forestry Department needs qualified staff. Depending on the size of the forest and number of required staff, the number of education facilities, e.g. universities and vocational training centers, should be selected or maintained. Efforts should concentrate on a few institutes only for each level, as BSc and MSc degree course and vocational training. In other words, it is better to keep a few good maintained institutes, with sufficient staff and teaching equipment than operating many with a low level of education.

Primarily for the practical training of FO and FR, but even for further trainings of all other forestry staff including forest workers (FW) and for the purpose of holding workshops and seminars for each country a "Forestry Training Center" should be founded. To conduct practical trainings, it should be located close to the forest site. The Forestry Training Center should serve for classes up to 25 students at the same time.

The respective Forestry Department together with the respective Ministry of Education should be responsible for the establishment and the respective curricula.

Corresponding recommendations for these curricula are available with the author.

2. Training of Staff

In many counties most of the Forest officers have a university degree in forestry but lacking practical experience in SFM. For their respective duties they have to be trained in all subjects as listed in the "Mgt. Planning Guidelines".

Chainsaw handling and directional felling courses should be given for all FW employed and even for Forest Enterprises and firewood producers.

All private companies can participate in tenders for any forest operation only with trained staff, personal safety equipment and certified tools.

A governmental body should not work with unqualified companies!

It should follow international accepted harvesting procedures and standards which are all incorporated in the respective guidelines!

(Refer to "Harvesting Guidelines", "Guidelines for Ergonomics and Work Safety in Forestry").

2.1 Training Courses

Efforts should be concentrated on at least one BSc and one MSc degree course in one of the country's universities. Theory in forestry subjects for FW could be given in Vocational Training Centers. All practical training should be conducted in a Forestry Training Center. This should serve for classes up to 25 students at the same time. 8 courses for FR and 4 courses for FW could be conducted annually

Table 1: Education Plan for Forestry Training Centre

Total weeks for training per year: 32 weeks					
Staff	No. of courses	Duration of course (weeks)	Total training weeks	No. of students	Total No. of students trained per year
FR	8	3	24	25	200
FW	8	1	8	25	200

These courses should be repeated for 3 successive years. Corresponding Curricula are available with the author.

An example for cost calculations of a Forestry Training Centre including construction and running costs is specified below. Of course, these costs can differ a lot according to the respective country conditions.

2.2 Forestry Training Centre

2.2.1 Construction Costs

Table 2: Forestry Training Centre construction costs (Example only)

	No.	**Unit**	**€**
Construction Costs (*)	1	1000 m² x 1 000 €	1 000 000
Second hand Logging Machines	2	30 000	60 000
Mini Bus	2	30 000 €	60 000
Chainsaw	20	1 000 €	20 000
Hand Tools			30 000
Books, Stationary			10 000
Total equipment costs			1.180.000

(*) The costs comprising all construction, furniture and housing equipment costs (TV, Overhead, Beamer, Canvas, kitchen equipment etc.)

2.2.2 Running Costs Forestry Training Centre

Table 3: Salaries Forestry Training Centre (Example only)

Salaries Forestry Training Centre Staff			
Position	**No.**	**Monthly Salary €**	**Annual Salary €**
Head	1	500	6000
Deputy/ Teacher	1	450	5400
Teacher	4	400	4800
Trainers for practical subjects (FR)	5	400	4800
Clerk	1	200	2400
Drivers 4		250	3000
Kitchen staff, cleaning, janitor	6	150	1800
Food ?			
Total Staff	22		**28.200**

Table 4: Running costs Logging Machines and Equipment (Example only)

for Machinery and Tools			
No.	**Subject**	**Unit**	**Annual Costs €**
2	Logging Machines	30000	60000
2	Busses	12000	24000
25	Chainsaws	700	17500
-	Other Tools		3000
Total			**104.500**

3. Sustainable Firewood Production

For the production of firewood by private user, trainings should be given, subjects e.g. appropriate tools, working techniques, storage facilities, burning firewood after drying of at least one year, etc. These trainings could even be outsourced and would be a good working field for NGOs.

4. References

Benneckendorf W., 2013: Concept for Forestry Sector Development in Georgia, Project Report, Tbilisi City Hall, CIM Advisor

Benneckendorf, W., 2014: Management of Tbilisi City Hall Forests, Project Report, Tbilisi City Hall, CIM Advisor

Benneckendorf, W., 2014: Sustainable Firewood Production, CENN, Leaflet, Tbilisi, Georgia

IX.2 Education Guidelines for Citizens and School Students

All Pictures: Lower Saxony Forestry Department, Husarenstraße 75, 38102 Braunschweig, Germany:
"Unsere Waldpädagogik, Lernen – Erleben – Erfahren"

Glossary

BLT . . . . . Broad Leaf Trees
DBH . . . . . Diameter in Breast Height
e.g. . . . . Example given
FO. . . . . Forest Officer
Ha. . . . . Hectare
HCV . . . . . High Conservation Value
NGO . . . . . Non-Governmental Organization
SFM . . . . . Sustainable Forest Management

1. Introduction

A state forest administration has not only the duty to maintain and manage its forest, but to inform and educate the people and to familiarize them with this extraordinary beautiful part of their living environment. Forest managers are used to think in long terms, overlapping even generations and have to take care of the entrusted forests in a sustainable way. In this sense the forests should be an important established part of one's general education. This offers a big chance that especially young people will understand "Sustainability".

Any Forestry Department has many different obligations to fulfil. In a SFM nature conservation and educational work are ranking equally among the fields of work as forest maintenance and harvesting. Forest education is a very important task. It gives the opportunity to bring especially young people closer to nature. Forest education is opening a chance to familiarize children, adolescents and adults with the complex term of sustainability and nature. Here sustainability should not be understood in terms of making use of the resources only, but to impart with the educational work economical, ecological, social and cultural aspects equally. The main objective is that all citizens appreciate the forests values, so they take over more responsibility for our natural livelihood.

For the implementation of a.m. objectives, the forest itself with its complex and cross-linked systems can serve. One has to show different aspects and points of view about forests and nature and to give a brief glimpse into this fascinating world. Thereby especially young people should be motivated to think in future in long terms and holistically and finally even act accordingly. One has to join people in the forest and bring nature subjects into the schools. Authentically, practice and activity oriented transfer of knowledge is required. For the success of this forest education the permanent exchange of ideas between Forestry Departments and school staff is inevitable. Only then the forest education will have a sustainable impact.

2. Students

2.1 Infrastructure and Staff

2.1.1 Infrastructure

2.1.1.1 Forest Camps

Forest Camps serve for school classes between 15 to 20 students plus 2 teachers. They should be placed inside the forest and attainable by car or bus. They must have a classroom, bedrooms, and sanitary facilities and have to have workshops equipped with appropriate working tools. Additionally they should be equipped with exhibits of flora and fauna and have an open fire place, football-, volleyball- and/or basketball fields. These Forest camps admit an intensive engagement with forest related subjects. During the stays students undergo an important social and group-dynamic learning experience. They are guided by experienced forest workers.

2.1.1.2 School Forests

Each school emphasizing a long-time co-operation with a respective Forestry District should have a small school forest in its vicinity. These small forest areas (1 to 2 ha in size) should be taken care of by the students themselves together with the respective teacher and FD staff. Flora and Fauna could be shown and management options discussed and explained. The establishment of a small nursery can be highly recommended.

Picture 1: Experiencing the forest in a group under the supervision of an experienced Forester – far away from internet and hastiness.

Picture 2: This way environmental education brings fun: A lot of nature can be discovered in the exhibition room

Picture 3: Accommodation in forest huts

Picture 4: Planting of trees

2.1.2 Staff

Corresponding to the number of schools, the number of Forest Officers (FO) with a special pedagogical training should be employed. They organize the forest related education and co-operate with the respective schools.

All administrative work, e.g. booking of forest camps, issuing of bills etc. should be taken care of by a clerk.

2.2 Teaching Material

Forests consist of different species and forest cover types. There are coniferous and broad-leaf trees (BLT), mono-cultures and mixed forest stands. Herewith a lot of subjects can be connected, where wildlife- and plant species are as interesting as harvesting, forest history, forest maintenance and the protection of High Conservation Values (HCV). Additionally, all forest functions, e.g. climate- and water protection, can be explained much better inside the forest. During these stays in the forest the students will make important social and group-dynamic experiences. (Picture 5)

2.2.1 Forest Camp operation

Half a day the participants have to fulfil practical forest- and nature conservation operations in the forest and the other half day they are taught by FD staff about forestry and environmental subjects. Getting up early, driving to remote working places, working in any wind and weather and accompanied and guided by real forest workers are unfamiliar circumstances for the students. At the same time team work is strengthening the co-operative behavior and the social competence. Due to the practical work they gain knowledge and skills about the development and utilization of the forest.

Classical subjects for practical tasks are:

- Collection of garbage in the forest
- Cutting grass with sickles in cultivated areas
- Protection of seedlings against browsing
- Construction of nest boxes
- Construction of recreation facilities
- Application of fertilizer to seedlings
- Measurement of DBH and height of trees

2.2.2 Project one day class trips

One day class trips are connected with a certain subject or project relevant to the forest. It gives the students the opportunity to develop and screen these subjects independently. Social and global aspects are considered as well as sustainable development. Project class trips are ideal supplements to the school lessons. It gives the students the opportunity to deal intensively with forest related subjects. Action- and experience oriented aspects bringing fun and joy.

Classical subjects for one day class trips are:

- Forest & Water
- Forest & Timber
- Forest & Climate
- Forest & People

2.2.3 Adventure one day class trips

The forest is a special place for gaining experiences and has a lot of opportunities for practical tasks. The cooperation within the students has to be considered the main focus. Beside this, fun, nature experience and living learning in a living environment are important. Active and playfully the forest should be explored together with forestry staff. The participants are learning from the forest and its challenges. Whether team- and interaction games, different outdoor activities, night activities, sense perception or other creative actions – these class trips are an individual offer for every age class of students. The particular programs can be handled flexible and adapted to the respective groups. There are a lot of information in the internet about forest games and forest education.

2.2.4 Forest Games

The objectives of Forest Games are to bring as many students as possible into the forest and to increase their interest in forestry and environmental issues. Experiences from Germany show that students in the age of 10 to 12 years are fit best for this kind of education.

A parkour is established with up to 20 different stations. Each group of students (1 group = 5 students) compete with each other and have to walk through this parkour answering the respective questions or conducting certain tasks. The best groups will be rewarded. All the subjects treated in the different stations have been prepared in the schools previously.

Classical subjects for Forest Games are:

- Determination of different wild animals
- Determination of different plants
- Determination of different timber species
- Questions about importance of forests for:
  - Climate
  - Water protection
  - Habitats
  - Soil protection, erosion
  - Noise protection
- Orientation in the forest (finding the northern direction, procedure in case one gets lost)
- Behavior in case of forest fires, storms

2.3 Co-operation with Schools

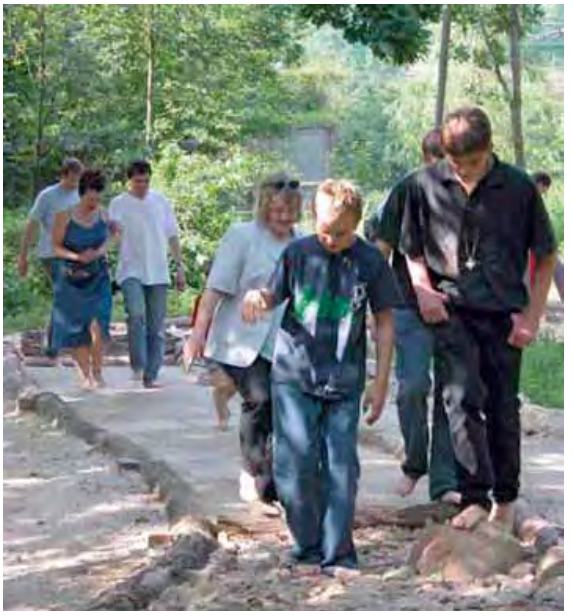
To achieve optimal benefits for students out of all these different education, a long-time co-operation between respective FD and selected schools should be targeted. Only then different subjects which are depending on each other could be executed in succession and school- specific requests be considered.

Picture 5: Playful and exited the students can discover the forest

Picture 6: Storage of seedlings

Picture 7: Explanation of forest functions by a Forester

Picture 8: Adventures can be everywhere…



Picture 9: Sense perception: the bare feet path

Picture 10: Even just playing in the forest brings a lot of fun

3. Citizens (Adults)

A modern Forestry administration has to be transparent and open for public recommendations and even criticism. Nowadays administrating with commands and restrictions only will be not successful. Integration of the society, having open discussions and giving them the chance to comment will be highly appreciated. Of course, an administration cannot please everybody, but as long the decisions are made transparent and the reasons for are explained clearly, they are much easier accepted.

Forest Camps can serve for the education of citizens too. Here panel discussions, presentations for the society and NGO's could take place. The subjects are more or less the same as for the students. If the Forest Camps are attached with workshops, chainsaw courses could be conducted additionally. The latter is very important and nearly overdue since so many citizens are producing their firewood themselves. Any operation in the forest should be announced beforehand through public media. This will bring transparency and will improve the relation with citizens and NGO's.

4. References

Lower Saxony Forestry Department, (2012), "Unsere Waldpädagogik, Lernen – Erleben – Erfahren" Husarenstraße 75, 38102 Braunschweig, Germany

Benneckendorf, W. (2014): Sustainable Firewood Production", CENN, Tbilisi, Georgia

Excursion on Mindanao, Philippines (Foto: W. Benneckendorf)

X. Guidelines for Pasture Management

Glossary
GIZ . . . . . German Agency for International Co-operation
Ha/ha . . . . . Hectare
LU. . . . . Livestock Unit

1. Introduction

Land use planning has to incorporate the issue of pasture management. Of course this would bring the biggest impact or change for many of a country's rural population. The present situation, where everybody can use any not fenced land for free grazing should come to a halt as soon as possible. With intensifying of the forestry and agricultural sector an intensive competition for land will start. Consequently, the grazing pressure on the forest will further increase with all its negative implications. Voluntarily, only a few will give up the right of free grazing. This is the moment when government has to appear on the scene. Pasture land has to be distributed and assigned to individual owners one day, which finally will have a lot of benefits. Each herder family can manage their own land, investments as fencing and fertilizing will become useful. Cut & carry systems and other optimized livestock management scenarios can be implemented which allow herders to keep up to three times more livestock on the same area compared with a free grazing system and the fattening process of livestock is much faster. This process should be accompanied by the creation of different value chains for marketing possibilities for herder's products, e.g. slaughterhouses, dairies, meat control by veterinarians and export markets. Anyhow, even this approach will not prevent the necessity to limit the total number of livestock one day.

Everywhere in the world, a pasture in a certain area influenced by soil fertility and climate can bear a certain amount of livestock only.

In many of the developing countries roaming livestock is a thread to the forest. They are browsing on natural regeneration and planted seedlings, in some cases even debarking trees and creating severe erosion especially on hillsides. In all those countries I worked with (Mongolia, Tajikistan, Ethiopia and Georgia), politics addressed this problem only halfhearted or not at all. Herders are voters and it seems nobody dares to tell them how many livestock they can keep. A lot of development aid projects have worked on this subject but most of them came up with solutions very difficult to implement. Pasturable lands of Tajikistan are strongly subject to erosion - with 89% of the summer pastures and 97% of winter pastures suffering from medium to strong erosion (Saigal 2003). In some parts of Mongolia a country with a population of 3 Million and a livestock population of up to 60 Million, the forests are diminishing since investors have realized that the steppe is suitable for agriculture. Huge crop fields can be found and the pressure on the forest by livestock has increased tremendously. In Georgia the number of private, meaning roaming livestock has increased after the breakdown of the Soviet Union, but its management is much poorer. In Ethiopia a GIZ project has initiated a "Cut and Carry" system with good results. At least some of the herders are fencing their livestock and feed them. Thus, the livestock do not create any erosion any more, gaining weight much faster and the dung can be collected for fuel much easier. On the same grazing area the threefold number of livestock can be kept. Surprisingly only a few herders are following this project. This shows that without political support and enforcement, the impact will remain very small.

Of course, this problem cannot be solved by setting regulations only, but governments have to show alternatives to these livestock keepers to give them the chance to generate sufficient income. The crucial fact is the determination of the livestock bearing capacity for a particular area.

All the following text is either directly copied or derived from the GIZ project paper, "Community based pasture management in Kyrgyzstan" by Stefanie Bussler, August 2010.

2. Management of pastures and forest areas

2.1 Multi-level-stakeholder participation

To solve problems and to seize opportunities an improved participation of different stakeholder categories at all levels of interaction is required. Stakeholders include those from a community level up to those from regional, national and even international level. Informational meetings have to be carried out at different stakeholder levels. These meetings inform partners dealing with the management of natural resources at national level and allow a discussion of possibilities of joint co-ordination of activities related to pastures issues. In some cases, even the development on a new law on pastures might become necessary.

2.2 Collecting initial data

To gain initial data relevant for pasture management a baseline study should be conducted. Among the collection and analyses of official data (maps, statistical data, reports, etc.) complementary data should be collected in the field. The main objectives are:

- To collect information regarding past and current land use and land legal and institutional management conditions.
- To assess the current condition, productivity and economic aspects of pastures
- To describe and document the current pasture occupation and livestock herding system including the composition of livestock and their spatial distribution
- To assess the current animal health and veterinary service situation
- Assessment of the grazing value of different forage species. The plants were ranked for their biomass potentials and preference by livestock.

2.3 Assessment of grazing area and number of livestock

The first step is the assessment of the total area of grazing land, the forest area suitable for grazing or collection of forage and the number of livestock in this respective area. Whenever in the following the term pasture is mentioned, it includes even forest stands suitable for grazing. All these areas have to be separated into summer- and winter pastures if required.

2.4 Awareness building

Meetings, workshops and specific trainings give the herders themselves the opportunity to express their different points of view on specific matters. Awareness building is one of the most important approaches. The focus lies on making the people conscious of the situation and the need to act. But it is not just awareness of the problems and the necessary measures that need to be understood. The most important aim is to make herders aware that they themselves are the ones who need to act and solve their problems.

Trainings should be based on active involvement of the participants including different role-playing games and the distribution of tasks to the participants. Group work and plenary discussions are important components of the workshops. The moderator gradually involves the participants in interactive discussions. The main objective is to support a self-learning process based on individual experience and leading to an increase in competence and knowledge. It is a "first step" for creating village partnership and activation of initiative groups.

A workshop titled "Learning for Sustainability on pasture management" is available and described in detail in this GIZ project paper, "Community based pasture management in Kyrgyzstan" by Stefanie Bussler, August 2010.

2.5 Institutional development

To achieve an efficient and sustainable pasture management, responsible institutions have to exist. Such institutions with different stakeholders responsible for the different tasks of pasture management are responsible for the planning and monitoring of pasture use, the collection of charges and taxes and the responsible use of their incomes for improving pasture quality and infrastructure.

2.5.1 Pasture User Association

From each village representatives of pasture users have to become members of a Pasture User Associations. They are elected at circle administration level management. They are composed of the head of the administration (government representative), representatives from each village administration, specialists (for example veterinarians), Head of the respective Forest District, pasture users and other stakeholders. These Pasture User Association are the decision making body for pasture management in the circle administration area. They are responsible for the overall planning of pasture use and monitoring the Pasture Committees.

2.5.2 Pasture Committees

The Pasture Committees are elected and working in each village and closely connected to the Pasture User Association. They consist mainly of villagers but additionally of one representative of the respective administration and Forest District. These committees have to be provided with the necessary information and instruments for a sustainable pasture management.

These Pasture Committees are the decision making body for pasture management of the village pasture. They are responsible for the planning of pasture use, monitoring the state of the pastures, selling the pasture tickets, administrate the revenues and maintaining pasture infrastructure.

2.5.3 Placement of Field-Manager

Additionally a Field Manager, who is the elected Head of the Pasture Committee, should be installed into the management area of each village. He lives with the herders in the villages. He is the representative of the herders and thus the direct contact person of the local population.

He has a mediating role between local population and circle and village administration.

The tasks of the field manager are:

- • To provide information about the plans of the Pasture User Association.
- • To find out about the problems in the villages
- • To support the people with their new challenge of conducting a communal pasture management
- • To keep in touch with relevant local institutions
- • To pursue organizational responsibilities, e.g. organization of local workshops and implementation of technical support measures.

The permanent presence on site provides a better information exchange, which strengthens the trust of the village population. It simplifies matters to gain truthful and dependable information about the situation and problems in the project area.

The close contact with the local population provides steady information about all activities and achieved results for the herders and gives the possibility to gain information about the progress of activities, and can, if applicable, adapt approaches and methods.

3. Implementation strategies and applied methods

Besides the pasture use plans there are different measures necessary to achieve a sustainable pasture management. The state of pastures needs to be monitored to ensure that there is no deterioration and

to provide the base for pasture planning. A monitoring system adapted to the possibilities and skills of the Pasture Committees and the herders has to be developed.

The use of pastures also relies on infrastructure. Therefore the improvement and maintenance of pasture infrastructure is inalienable from achieving a sustainable pasture management as pastures are only used if they are accessible and offer a water supply. Some pastures might not be used because of destroyed or missing water points and many remote pastures cannot be reached because of poor road conditions. Maintaining infrastructure has to be introduced into the annual pasture management plan by the Pasture Committee.

A further aspect of pasture management is the production and storage of winter fodder. To decrease the burden of overstocked village pastures during winter time, winter fodder production and storage needs to be improved.

Since pasture and winter fodder resources are limited, the Pasture Committees have to monitor the development of herd growth closely. Livestock numbers must not exceed the pasture capacity and the additional amount of harvested winter fodder over the seasons. Herd management is necessary to control the herd size and quality. With the improvement of veterinary services and regular vaccinations, the first steps towards quality improvement can be taken.

The livestock carrying capacities of pastures vary according to seasons in the temperate zones, the same applies to rainy- and dry seasons in the tropical and sub-tropical zones.

3.1 Determination the number of livestock per ha.

Determination the number of livestock per ha, requires all information about ecological and economical features.

The participants in the planning process have to find out about relevant factors concerning pasture management. To these belong livestock units (LU), approximate carrying capacity of pastures, dynamics of livestock development and its forecasting and quantity of produced winter fodder. For the estimations real village data are applied in order to achieve primary data for the respective villages. For each calculation the respective data of the villages are collected and discussed by the participants.

3.1.1 Livestock Unit

For planning pasture use sustainability, it is essential to know the meaning and calculation of livestock units. In many countries herders own sheep, cattle and horses, grazing on the same pasture plots. These different species graze different amounts of grass and need to be equalized to assess the overall grazing effect on pastures. One livestock unit is usually the grazing equivalent of one adult cow. All other livestock needs to be converted into livestock units. The factors listed in table 1 have to be applied for these calculations:

Table 1: Livestock Units of different livestock

Livestock	Livestock Unit	Coefficient
Cow	1	1
Sheep/goat	0,2	5
Horse	1,2	0,84
Camel	1,5	0,67
Donkey	0,5	2

3.2 Carrying capacity of pastures

The pasture capacity expresses the amount of livestock units that can be fed on a pasture for a defined time span. It is important for planning pasture use as it gives the information about the maximal stocking without ecological damage to the pasture.

To get data of the approximate capacity of the pastures of the respective village a greatly simplified method is applied. It is assessed by observing the

Table 2: Example of approximation of pasture capacity

Factor	Condition of pasture area	Required additional space	Increase in ha	Carrying Capacity LU
*Vegetation **cover**	50%	240%	2.4	0.3
Precipitation	500 mm	0%	0	1
Altitude	1800 m	100%	1	0.5
Exposition	south	30%	0.3	0,8
Slope	15°	0%	0	1
Season	summer	50%	0.5	0.7
Total		420%	4.2	0.2

Adjust the coefficients according to table 2. Multiply your pasture area (ha) by these coefficients to achieve the number of livestock you can keep for 90 days.

* Calculating the Carrying Capacity per LU: 1 ha for 1 LU for 90 days; here 240% more area required = 1 ha + 2,4 ha = 3,4 ha; Carrying capacity = 1 : 3,4 = 0,3.

different factors influencing pasture productivity and hence also its capacity.

In average (estimation!) one LU needs 1 ha of pasture ground in a time span of 90 days.

Of course, factors such as altitude, vegetation cover, slope, exposition and precipitation and season of use change this situation and can lead to an increase in the required pasture ground to feed one LU.

(see Table 2)

3.3 Calculation of available winter fodder

During the winter, pasture capacity is very low and many of the pastures should not be used because of the weather conditions. Although herders sell some livestock in autumn, most of the time there are still too many animals left, which cause a high overstocking of the near village pastures. The result is not only degradation of the pastures but also a suffering or even a high mortality rate amongst the animals due to starvation. Thus it is important to produce the required amount of winter fodder. Ideally the amount of produced winter fodder should compensate the missing productivity of the pastures needed to feed all livestock. As there is only a limited area of arable land, winter fodder production however has its limits. The amount of LU also needs to be adjusted to the maximal possible amount of produced winter fodder and pasture capacity of the near village pastures. In many countries, most herders produce only a little winter fodder, if any at all. By increasing winter fodder, the herders can add to a sustainable use of their pastures. In order to do that, the farmers need to know how to calculate the amount of necessary winter fodder to feed their own livestock, which they keep in winter time.

7.5 kg of dry high-quality fodder is the resting metabolic rate to keep 1 LU.

This includes even a slight feeding for performance. Each additional level of performance requires 1-2 kg more good dry quality fodder. According to this data one can calculate the amount of winter fodder needed.

3.4 Creating pasture use and management plans

The aim of creating pasture use plans is to achieve a balanced allocation of livestock on the pastures over the seasons. The allocation is based on the qualitative state of the pastures. Livestock has to be reallocated between current overstocked pastures and underused pasture units. As pasture use depends on the carrying capacity of the pasture, regular monitoring is necessary. Here again, the planning of pasture use needs participation of all stakeholders involved.

The plan has to be created each year and its fulfilment needs to be monitored closely by the Pasture Committee. In addition, the state and the yield of the pastures needs to be assessed and monitored each year. The corresponding data of the monitoring and assessment data as well as experiences of possible conflicts, problems and successes, will serve as a base for the following year's plan.

Pasture management is complex, dealing with many different factors and problems concerning pasture use and livestock.

As a first step to develop a pasture management plan it is advisable to create a pasture use plan. To avoid further overstocking, livestock needs to be allocated to pastures with suitable carrying capacities in the different seasons. By planning and discussing the yearly pasture use, different problems concerning pasture state, accessibility or related use limiting factors as well as user conflicts can be identified. This information can then serve as a base for further management measures to be added in the management plan.

To create a sustainable pasture use plan it is necessary to have a basis of information about the pastures and the livestock of the respective village. As the collection and preparation of these data falls under the responsibilities of the Pasture Committee, they are strongly involved with this process. They determine pasture borders of pasture units, collect data of real livestock and herd composition and assemble the current pasture occupation. They have to produce the necessary maps, if possible in a digital format. To determine the defined borders of the pasture units, the Pasture Committee, together with the Field Manager, makes an inspection of the pasture area of the respective village. The total pasture area of the circle administration is then determined by the Pasture User Administration. This pasture area is divided into different pasture plots, which are mainly defined through traditional use habits, well known by the herders and the members of the Pasture Committee. The borders of most of these units are defined through natural barriers like creeks, hedges, roads or mountain slopes.

The Pasture Committee draws these borders onto a topographical map on a scale of 1:25.000 of the village pasture area, adding the traditional names.

To achieve a real occupation plan representing the current allocation of livestock, the Pasture Committee collects data of the number and composition of the herds and currently used pasture units of each herder. From these data, a real occupation plan of each season can be made.

All these information are entered then onto a Result Map (1:25000), which shows the different pasture types with its specific attributes within the pasture units. For each pasture unit the total carrying capacity is calculated then. To achieve the carrying capacity of the pasture units during the different seasons, the total capacity is multiplied by defined factors for each season (example see below). The results are projected on four single maps, representing potential carrying capacity of the pasture units in the seasons spring, summer, autumn and winter.

The current livestock occupation of the pasture units should be opposed to the respective carrying ca-

Table 3: Actual stocking

Name of pasture unit	Carrying Capacity LU	Herder name	LU	Herder name	LU	Herder name	LU	Actual Stocking %	Actual Stocking No.
Khulo	25	A	22	B	15	C	9	184*1	+21*2
Batumi	46	D	33	G	28	H	57	257*1	+72*2
Kobuleti	88	E	36	F	68	L	45	169*1	+61*2
Ozugeti	74	M	22	N	15	P	18	0,74*1	-19*2

*1: Calculation: Sum of LUs of all herders divided by Carrying Capacity
*2: Calculation: Sum of LUs of all herders minus Carrying Capacity

pacity within a table. The factor of the actual stocking and the real carrying capacity assesses the current capacity utilization. The factor indicates to how many % the pasture unit is overstocked (factor > 100%) or understocked (factor < 100%) respectively. The actual stocking No. shows if there are too many LU (+) or how many LU could be added (-).

This information is the basis for the further planning process.

(see Table 3)

The herders distribute cards with big letters on the seasonal capacity maps of the respective pasture unit corresponding to the actual pasture occupation with their livestock. The result provides a clear overview of the spatial distribution of the livestock on the pasture units and allows recognizing to which intensity a pasture unit is used. By comparing the LU with the potential carrying capacity on the pasture unit they are placed on, over- or understocking can easily be identified.

Additionally, all this data presented in an excel table (see table 3). The members of the Pasture Committee then try to allocate the stocking between overused and underused pastures by moving the cards in between the pasture units. The data have to be matched on the excel table according to the new occupation suggestions of the herders. The aim is to achieve a coefficient close to 100%.

During the discussion of the possible allocation of the livestock on the pastures it might turn out that the balancing between over- and under-stocked pastures is not totally possible, as many pastures are not accessible or have no water resources. These problems need to be remedied to achieve sustainable pasture use plans and have to be a further component in the pasture management plan. The planning process results in a current best-possible allocation of livestock units on the pastures. The result represents the first pasture use plan.

To complete the planning process the created pasture use plan needs to be approved by all respective herders and the Head of the local Administration. The Pasture Committee concludes a contract with each single farmer on the adherence and compliance to the pasture use plan.

3.5 Livestock development

Livestock development plays an important role in pasture management, as pastures can only carry a limited number of LU. Thus far, most of the herders are intending to increase their herd sizes. The aim of a respective training is to show the participants the consequences of uncontrolled herd growth and to introduce initial aspects of herd management. There is a need to balance between the amount of livestock and the available fodder sources. The fodder basis includes the productivity of pastures and the amount of fodder from hayfields, cultivation of fodder crops and forest areas. Pasture and livestock management are closely linked and need to be understood. If the farmers continue with their actual habits of not managing the number of their livestock, the capacity of the pastures will soon be not sufficient.

Without further management, herd growth is influenced only by animal reproduction and purchase of additional animals which leads to a steady growth of the herd size each year. To regulate the herd size additional management efforts need to be undertaken. The herders have to be introduced to important information, which is required to calculate the development of the livestock population. This information includes the age of the first calving of female animals, at what age dams are slaughtered and natural loss rate. Reproduction rates vary according to the type and breed of animal and the respective environment.

Under Kyrgyz conditions for example, the approximate annual reproduction rate amounts to 0.7 for cattle, horses, camels and 1.2 for sheep and goats. For the calculation it is defined, that every year a certain number of the oldest cows are slaughtered and all male and 60-90% of female young animals are sold at the age of six months. To increase the herd size, up to 40% of young female animals are raised during the first years. This percentage is steadily reduced in the following years, and stabilized at the level of this amount of animals which are necessary to replace the slaughtered cows each year.

3.6 Results

As a result of the trainings the actual situation of the pasture capacity and livestock development of the respective village is analyzed. Initial estimated data of

the respective village have to be revised according to real conditions.

The carrying capacity of the pastures during the course of the year has to match with the predicted respectively desired livestock development. These data are essential for the further Pasture Committees course. The herders have to be aware of their current situation and the necessity to manage their pasture use.

3.7 Monitoring of pasture use plans

The occupation of the pastures by the herders is defined through the pasture use plan. This plan needs to be monitored due to its compliance by the Pasture Committee. This can be made through regular observations of the respective pastures during the year. Members of the committee visit the pasture units in the different seasons to control the adherence of the herders to the pasture use plan. If herders do not adhere to the plan the reasons need to be identified to avoid such discrepancies for the next pasture use plan.

3.7.1 Implementation of monitoring system

Planning the use of pastures is based on their carrying capacity in the single seasons. The carrying capacity varies between the seasons and can change during the course of time due to utilization and climatic conditions. Hence it is important to regularly assess the quantity (yield) and quality (composition of species) of the pastures to avoid degradation.

A simple pasture monitoring system, adapted to the skills and opportunities of the members of the Pasture Committee is needed. To have a reference of the potential capacity of the pastures, demonstration plots are set up on different pasture types, each measuring 25 m^2. To keep these safe from grazing, they are fenced with mesh wire, fixed on small stems of the local vegetation. Additionally the yields of different pasture types are monitored. The monitoring is jointly conducted by herders and the Pasture Committee and takes place in spring (May/June) and autumn (September), and on intensively used pastures even in summer (July/August).

Applied method:

a) Location
Representative locations are chosen on a foregoing inspection of the pasture area. Monitoring points are set up on different vegetation types which are typical in between the pasture area.

b) Geographical data
On each monitoring point coordinates and altitude are saved using a GPS. Additional geographical data like exposition and slope are documented.

c) Photo documentation
For the Photo documentation a digital camera should be used. A 1m^2 frame is delineated on the ground and photographed from both a bird's eye perspective and from the front. For the latter the exposition is documented.

d) Vegetation assessment
Within the 1m^2 frame vegetation cover and vegetation height are defined. The plant species are determined, dividing them into the two categories - palatable and not palatable plants. Not palatable plants include poisonous, harmful or ligneous plants.

e) Collecting phytomass
Phytomass is picked on 5 m^2. For that the frame is moved to four other spots which are radiating located 5 m away from the corners of the frame on the initial position. The plants are picked by hand and put into separated cotton bags for palatable and not palatable plants.

f) Determining dry-weight
Palatable and not palatable phytomass is air-dried and the dry mass weighed

g) Digitalization of data
The monitoring points are transferred from the GPS gear into shape files. The points are marked on a map and the data entered into an excel table. This step is conducted by the Pasture committee to create a map showing the determined monitoring points on the pasture area. This map can serve as orientation for the further monitoring years.
Posters and a small brochure showing common pasture plants and their different characteristics such as palatable, poisonous, shrubs etc. should be made available. A good knowledge of plant species is important as not all of them are suitable fodder plants and some of them can even harm or kill livestock.

The phytomass is weighed in fresh mass and converted into approximate dry mass by subtracting the percentage of water contained in the vegetation at this time of the year. With the received weight the approximate pasture capacity of the monitored pasture section can be calculated.

3.8 Support on winter fodder production

During winter time pasture capacity is low and the winter pastures are heavily overstocked. Production of winter fodder is often too low and there are additional losses due to bad storage. To preserve the quality of the harvested winter fodder an adequate method of storage is necessary. Usually, hay is stored outside, where it is exposed to all weather conditions. Improved storage facilities as roofed shelters can be highly recommended.
(see Table 4)

Table 4: Example of calculation of pasture ticket per LU according to the respective season

	Winter pasture	Spring pasture	Summer pasture	Autumn pasture	Total per year
Number of grazing days	**145**	**40**	**110**	**70**	**365**
Number of grazing LU	110	45	38	77	270
Price for pasture ticket per season and LU ($)	**47**	**6**	**19**	**15**	**87**
Total amount of money paid per season ($)	5170	270	722	1155	7317

As the longest season is winter, the pasture tickets will be most expensive at this time. This might motivate herders to increase winter fodder production and keep more of their animals in stables than buying the expensive pasture tickets. With this method the pasture ticket serves as a sustainable economic instrument of pasture management.

3.9 Animal health

Animal health plays an important role in herd management. Regular vaccination and timely identification of animal diseases is important to avoid financial losses. In cooperation with the respective veterinary department seminars on animal health should be conducted to improve the herder's skills on animal diseases and its prevention.

3.10 Breed

The productivity of livestock can be increased by improvement of breed through insemination.

4. Livestock in the forest

Livestock inside the forest should be herded at all times to secure that no harm comes to regeneration and trees. In general, herders have to be always responsible for the damage their livestock causes. Unfortunately in some countries, the landowners have the duty to protect their land against roaming livestock which is nearly impossible to do. Here, the respective laws should be revised accordingly.

No livestock should live permanently in the forest. This would create severe damage on regeneration, trees and the environment at all. Preferable older stands with sufficient undergrowth are suitable for grazing as long the particular stand is not going to be rejuvenated. Approximately two decades before the end of a stand's rotation period no livestock should be permitted to enter to guarantee the germination and growth of natural regeneration. In young stands grazing becomes possible again when the trees have grown out of the reach of the livestock's mouth. Weeding of plantations can be carried out even by driving for example a herd of sheep with a certain speed through a plantation. If the speed is adjusted correctly, there is no browsing on seedlings, but weeds are eaten up or trampled down by the hoofs.

A very interesting video about grazing of cattle and its impact one can find in the internet: http://vimeo.com/8239427

In areas where forest management is largely affected by roaming livestock the same procedures as mentioned above for pastures should be carried out. Thus, a grazing plan for the entire forest area and each sub-compartment should be developed incorporating all duties and restrictions for the herders. Contracts with the herders should be made, stating the price for grazing of each LU for a certain period, the timeframe of the grazing period, a list of penalty costs and the procedures to terminate the contracts in case of violation by herders of set regulations.

For all these duties the respective Forest District administration is responsible.

As usual even the best trainings and awareness building might not reach every herder. At the end the respective government is responsible for a sustainable pasture management. After all these efforts carried out, giving each herder the chance to understand and to adapt, enforcement has to come in even some of the herders might not like it.

5. References

Bussler, Stefanie 2010; "Community based pasture management in Kyrgyzstan; GIZ Kyrgyzstan"; Project Report

XI. Guidelines for Ergonomics and Work Safety in Forestry

Glossary

Cm . . . . . Centimeter
EU. . . . . European Union
FD. . . . . Forestry Department
FPA. . . . . Forest technical testing Committee
FW . . . . . Forest Worker
Kg . . . . . Kilogram
KWF . . . . . Board of Trustees for Forestry Work and Technology
TO. . . . . Tractor Operator

1. Ergonomics

Ergonomics is the science related to human work. It is based on research on human peculiarity and individuality and can be considered the prerequisite to adapt work to human requirements as well as to enable workers to carry out their respective work (e.g. motivation of staff, training). In this humanization of the working world mankind stands in the focus of attention. Research in ergonomics developed a lot of recommendations to reduce stresses and strains for workers in the modern working world and how to get the biggest advantage out of their abilities.

Forest workers should be obliged to retain their physical and mental strength to stay safe and healthy and to avoid an early retirement. Knowledge about their human body and its reactions give them the chance to work accordingly. FD / contractor can assign workers with dangerous work in the forestry sector only, if they have no physically or mentally deficiencies, which could put themselves or others in danger. The qualification has to be assessed by a doctor.

A balanced rest- and nutrition system is a prerequisite for a good performance and health of the forest worker. Information about nutrient content and composition of local food are available by the respective Ministries of Health.

Inadequate performance requirements can lead to enormous performance pressure and finally to the refusal to work at all. Taking rests regularly is highly influencing the performances.

The ability to perform is depending on:

- abilities (physical and mental)
- training
- experience
- motivation
- time of the day
- day of the week
- season of the year
- age

The highest performance can be achieved in the morning time, at the beginning of the week and at an age of 20 – 35 years.

The following body parts are subject to severe injury in forest work and have to be checked regularly by a doctor. (see Table 1)

2. Work Safety

2.1 Introduction

Work in the forestry sector is besides mining and oil drilling the most dangerous operation worldwide. Statistics from Germany show that even in a country with a well-established training and accident prevention system, accidents occur quite frequently as the following figures show (source “Der Forstwirt” 1991-1995):

89573 accidents (including 228 deadly accidents) in 5 years, = 17915 accidents per year.

Approximately 120 accidents per 1 Million operating hours or every 8333 hours 1 accident!

That means that, in case a company employs 20 workers, there is **every 52 days 1 accident**! In countries without appropriate accident prevention regulations, accidents appear 2 to 3 fold. Each accident has beside the harm to the casualty an economic implication. 33% of all accidents (source KWF 2011) in Germany resulted in a loss of more than 20 working days (= 1 month) of the worker, which has a considerable business and national economically impact.

Table 1: Endangered body parts in forest work

Body part	Endangered by	Counter-measures
Back bone and intervertebral discs	Lifting of weight Static work Severity of forest work	Correct way of lifting (s. App. Fi. 10 and §II.2,2) Frequently changes in working cycles Training Keeping the normal weight (s. App. Fig. 9) Keeping correct work posture (s. App. Fig 8)
Extremities	Chain saw Axe Falling	Working according to safety standards Wearing protection gear Good boot treads (s. App. Fig. 7)
Eyes	Saw dust Sliding branches Chemicals	Use of visor (s. App. Fig 6) Use of helmet (s. App. Fig. 6) Use of respiratory mask (s. App. Fig. 11)
Ears	Chain saw Machinery Frost	Use of ear protection (s. App. Fig 6) Wearing cap or hat
Skin	Chemicals Weather conditions	Use of appropriate gloves (s. App. Fig. 5) Protective hand cream
Mental and emotional strain	Noise Heat Frost Conflicts	Use of required protection gear (s. App. Fig 6) Establish good working atmosphere

The following guidelines can serve as accident prevention regulations and if final endorsed by the respective Government one day, adherence to it has to become compulsory for everybody involved.

2.2 Safety Regulations

§ 1. General Behaviour

In general, the contractor/employer is responsible for the compliance to all safety regulations, for himself and his staff.

- Everybody has to perform in such a way, that sufficient safety is assured for himself and anybody else.
- The contractor/employer has to provide First Aid courses for his staff.
- The contractor/employer has to provide First Aid equipment for each working group of his staff. This equipment has to be controlled annually and supplemented if necessary.
- The contractor/employer has to develop Emergency Plans. These plans have to state the procedures in case of accidents and list all important emergency-Tel. No. They include maps, showing meeting points with ambulances, fire brigades and police.
- In case of more than 20 staff members a **Safety Officer** has to be employed. This person has to undergo special trainings (training modules available with the author) and be in charge of all safety related issues.
- During operations alcohol and other drugs are prohibited. Everybody has to be clean before starting work.

§ 1.1 Special responsibilities of the contractor/employer:

- The contractor/employer has to cease all operations under bad weather conditions
- It is in the responsibility of the contractor/employer that only certified equipment and tools are used (e.g. EU, FPA, KFW, s. App. Fig. 14)
- It is in the responsibility of the contractor/employer that nobody is working alone with chainsaws, winches or during tree climbing operations. A second person has to be in shouting- or sight distance. At least radio or permanent telephone connection is required. In exceptional cases only, operations are permitted when the worker has consulted a control person.
- Similar arrangements have to be made for the trip to and from work and for the expected arrival time at home.
- Instruction of all staff concerning this safety regulation once a year. Confirmed by each staff member through signature.
- Before felling operations commence in the vicinity of power lines, the contractor/employer is responsible for all arrangements with the power line operating company.
- Provision of protection gear
- Training of new working techniques
- Allocation of clear work orders and work flows

§ 1.2 Special responsibilities of the employee (FW)

- Safe standing during the entire operation (strong foothold).
- Use of machinery and tools only when technically faultless, permanent maintained, correct transported and set aside.
  - All spiky and sharp machinery and tools are protected by a cover.
  - Working and maintaining of machinery and tools according to manuals.
  - Disposing of machinery and tools that no one can be harmed (fallen over).
  - Repair or maintenance of machinery with appropriate tools only and when engine is cut off, except carburettor adjustment.
  - Removal of jammed chainsaw bar only when engine is cut off.
- Working with machinery and tools, keep always sufficient distance to other persons.
- No use of iron or steel wedges for felling operations with chainsaws. When using a felling lever, apply appropriate cutting technique (refer to Harvesting Guidelines).
- Splitting operations by hammer: no use of iron or steel wedges.
- Use of protection gear is compulsory.

§ 2. Employment

§ 2.1 Dangerous Work

The contractor / employer can assign workers with dangerous work in the forestry sector only, if they have no physically or mentally deficiencies, which could put themselves or others in danger. The qualification has to be assessed by a doctor.

Exceptions: People who produce their own firewood

§ 2.1.1 Dangerous work in the forestry sector is:

- Tending and cutting of trees
- Working with chainsaws or string trimmer (FW has to be older than 18 years, or for training purposes in the presence of the trainer)
- Harvesting of windfall, wind- broken or snowfall trees
- Bringing down of hanging trees
- Climbing on trees
- Handling of dangerous working substances (chemicals)
- Yarding operations with winches (FW has to be older than 18 years, or for training purposes in the presence of the trainer)

§ 2.2 Lifting and carrying of loads

(see Table 2)

§ 3. Working on Slopes

- Delimbing, debarking and cutting into pieces of logs on slopes only when they are secured, e.g. no slipping or rolling down is possible.
- Working only from the upper hillside.
- No working below each other, e.g. working sideward relocated only, so workers at the lower hillside are not endangered by rolling logs or stones.

§ 4. Working with Chainsaw

- Chainsaws have to be supported and hold tightly during starting operations. Chainsaw bars and chains should have no contact with other items.
- During Delimbing operations, the chainsaw should be supported by resting on the log.
- Sawing with the tip of the chainsaw bar: do not use the so called "12 to 2 o'clock range".
- The contractor / employer has to provide the protection gear for his workers. It consists of helmet with visor and ear protection, gloves, protection trousers and boots, especially designed for operation with chainsaws.
- While cleaning with compressed air make use of respiratory mask.
- While sharpening with grinding machine make use of safety classes.
- While sharpening by hand make use of gloves.
- No chainsaw operations without completion of a chainsaw course, certified by the respective FD.

§ 4.1 Felling and Processing of Timber

- Felling of trees at daylight only without hindrance by fog, smoke, heavy rain, heavy snowfall or hail.
- Felling operations have to cease when strong winds divert the direction of fall.
- Operations on frosty, icy or snowy slopes only as long a firm stand can be guaranteed.
- The contractor/employer is responsible for the fencing off of the entire harvesting area. He has to assure that nobody is inside the felling range (= 2 trees lengths) who is not engaged in the actual felling operation. Exceptions only during training or presentations. (s. App. Fig. 2).
- The contractor/employer is responsible that his staff set up a safe retreat pass.
- The retreat pass shows normally diagonal backwards.
- The FW is responsible that the log is free of any hindering material.
- Appropriate felling techniques, e.g. scarfing, have to be applied. Before the operation commences, a warning cry has to be given by the feller. During the fall of the tree everybody has to move backwards following the retreat pass, watching the tree falling and waiting until the tree crowns have stopped shaking. Never work below hanging branches or crown parts.

Appropriate felling techniques:

- Scarfing in a right angle of the direction of fall and horizontally. Lower and upper scarf cut in an angle of 30° to 45° to each other. Deepness of lower scarf cut 1/5 to 1/3 of the stem diameter (s. App. Fig. 1).
- Final cut minimum 3 cm higher than the lower scarf cut, preferable 1/10 of the stem diameter higher. Leave a safety band of 1/10 of the stem diameter. (s. App. Fig. 1).
- Other special felling techniques are possible.
- Give a warning shout before the final cut: "Tree falling"

Refer to Harvesting Guidelines

- Each tree has to be brought to the ground before starting with felling of the next one. This does not apply for pre commercial cuts (DBH < 20 cm) and winch supported felling techniques.
- Hanging, leaning or cut trees have to be brought to the ground immediately or the dangerous area has to be fenced by a coloured ribbon. Dangerous area is the double tree length.
- After appropriate training of winch supported felling techniques, trees can lean at each other for a short period but must be brought to the ground before the next tree felling starts. (s. App. Fig. 3).
- Appropriate techniques to bring trees to the ground are:
  - Turning down with felling lever or Sappi
  - Lifting of the stem foot with rods or Sappi
  - Winching down. In this case the cable has to be fixed at the tree before the felling operation starts. The winch has to be stationed outside of the dangerous area. (s. App. Fig. 4).
- Hanging or leaning trees **cannot** be brought to the ground by climbing on them, cutting off supporting branches, felling of the tree the other is hanging or

Table 2: Lifting and carrying of loads

Age	Weight (kg)			
	Occasionally (less than 3 times per hour)		Frequently (more than 3 times per hour)	
	Female	**Male**	**Female**	**Male**
15 - 18	15	35	10	20
19 - 45	15	55	10	30
Older than 45	15	45	10	25

leaning on, nor dropping other trees on the hanging or leaning one.
- Except in pre-commercial cuttings (DBH < 20 cm), bringing trees to the ground by cutting piece by piece is prohibited.

§ 5. Working with Axe

During Delimbing of trees by axe, the FW has to have a strong foothold and positioning himself on the opposite side of the stem, meaning the stem is between himself and the branches to be cut. Exceptions only by working on steep slopes or on big or high laying trees.

§ 6. Processing of Trees from Windfalls and broken Trees

- Before the processing of trees from windfalls and broken trees starts, the contractor/employer is responsible for an appropriate training of his staff and determination of work sequences.
- Except for fixing of cables, climbing on high laying trees is absolutely prohibited.
- First step of operation: release the tension in the tree. Always carry out the first cut from the pressure side.
- Before cutting of upright standing roots, they have to be secured to prevent rolling and tilting. The feller has to assure that nobody can be hit by the falling roots.

§ 7. Tree climbing, working at the standing Tree and in the Crown

- Climbing only when light and weather conditions are appropriate and with professional climbing gear.
- Professional climbing gear according to German safety classification DIN 7478, DIN 7470, DIN 7471 and DIN 23326
- During the cutting of crown parts or branches, only necessary staff is allowed to stay in the dangerous zone.

§ 8. Working with String Trimmer

- Screw for fixing the cutting blade has to be tight firmly
- Only permitted blades and cutting devices for the respective machine
- When engine is idling, no turning of the blade or cutting devices by hand.
- Double shoulder carrying strap for machine > 7,5 kg and in proper condition.
- Operating by FW older than 18 years only except for training and presentation.

§ 9. Yarding Operations

The contractor/employer is responsible for appropriate equipped machinery.
Equipment:

- Cabin protected against rolling over, back- and side wards
- Tractor equipped with winch, logging arch, piling devise and protection grid.
- Winches should have the German or European test seals (s. App. Fig. 14).
- Winches must be equipped with self-braking brakes, meaning the load is still fixed even the engine cuts off.
- Winch controls must have joy-sticks switching back into the neutral position immediately, the moment they are released (“Dead-Man-Position”).
- Winches must have protection devices at the rope inlet to prevent pulling in of hands and gloves.
- Winches have to be checked annually by a certified workshop.

The TO has to adjust the load and speed according to his tractor’s facilities, soil conditions and steepness of the terrain. He has to assure that steering and braking is possible at all times.
- The tractor has to be parked in a position that during winching operation it cannot be moved.
- The TO has to monitor the winching operation permanently.
- The TO should not walk or stay during the winching operation beside the log, in between log and tractor or in the “dangerous triangle” when using a pulley (s. App. Fig. 15). Only by using a remote control for the winch, the TO can walk along the log, in that area where the cable is fixed.
- Damaged cables cannot be utilized. Reeling the cable on the winch drum cannot be supported by hand.
- No movement of logs by hand, only with appropriate tools, e.g. felling lever, Sappi
- Carrying loads by 2 persons: the rear one has to signal when the load has to be lifted or dropped. The load has to be carried either on the left or right side by both persons. Dropping the load over the head is prohibited.
- Logs and log pieces can be slipped or rolled downhill only when nobody is endangered.
- Only professional cable connections are permitted.
- All cables used must have minimum the threefold tear strength than the average pulling capacity of the winch.
- Choker-cables must have minimum the double tear strength than the maximum pulling capacity of the winch. (s. App. Fig. 13).
- No use of damaged cables (s. App. Fig. 16).
- Cables have to be connected at least with 5 rope clamps. (s. App. Fig. 12).

§ 9.1 Yarding Operations with Log-Lines

- Log-lines have to be constructed that no logs are catapulted outside. In steep terrain braking devises have to be constructed.
- It is prohibited for staff to cross the log-line during operation.

- 1 log only can be slipped down at a time, exception: logs up to 3 m length

§ 10. Pruning

The following subjects require attention:

- Keep your work place free of all hindering materials
- Use of fully functional tools
- Foot-and hand protection
- Head- and eye protection

In the area where pruned branches can fall nobody should stay beside the cutting staff. During strong winds, rain, snow fall, fog etc. the work has to be ceased. Climbing on trees with appropriate gear only.

Hereto the following items belong:

- Light and tight clothes
- Working boots
- Safety belt with rope

3. Attachments:

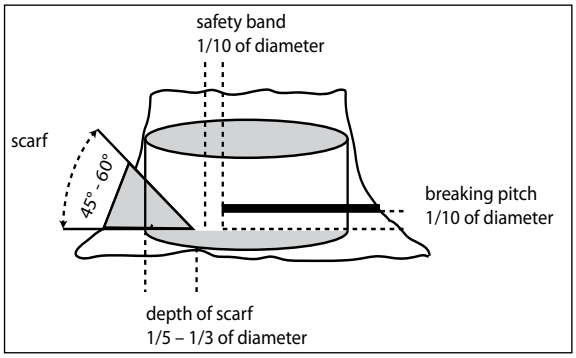


Figure 1: Felling operation

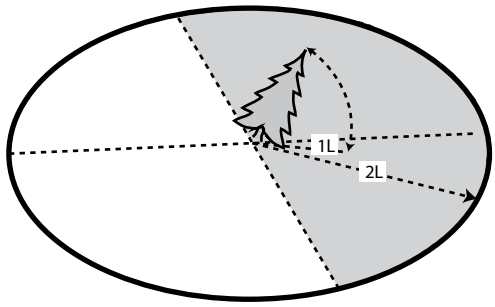


Figure 2: Danger Zone

(Photo: unknown)

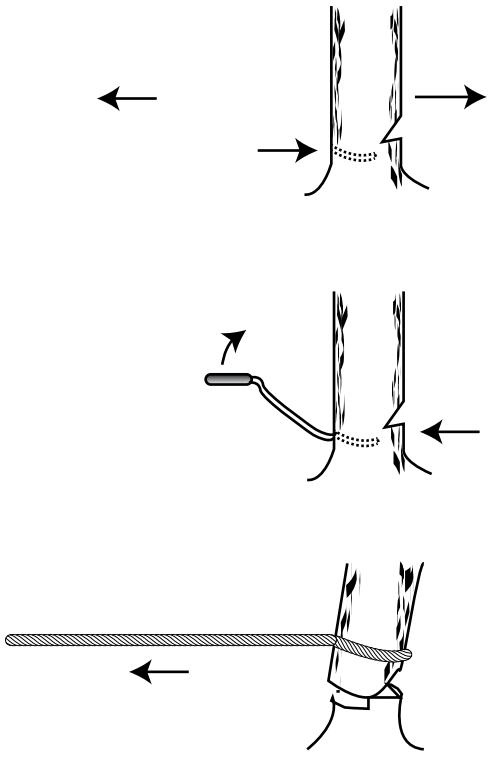


Figure 3: Felling operations supported by winch and felling lever

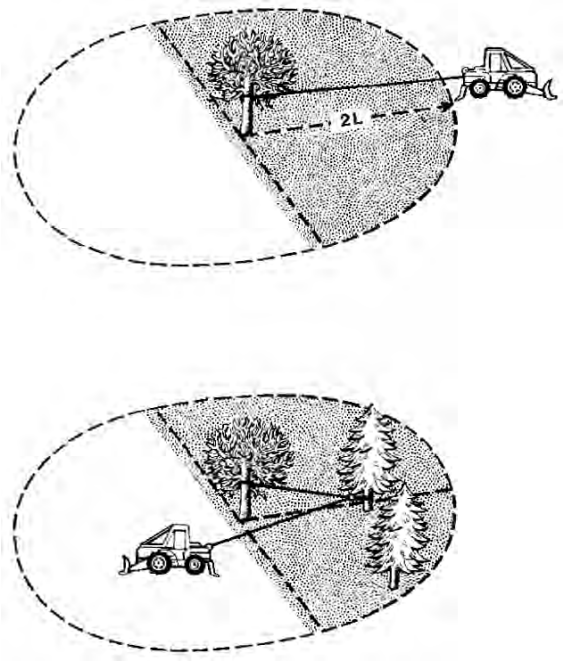


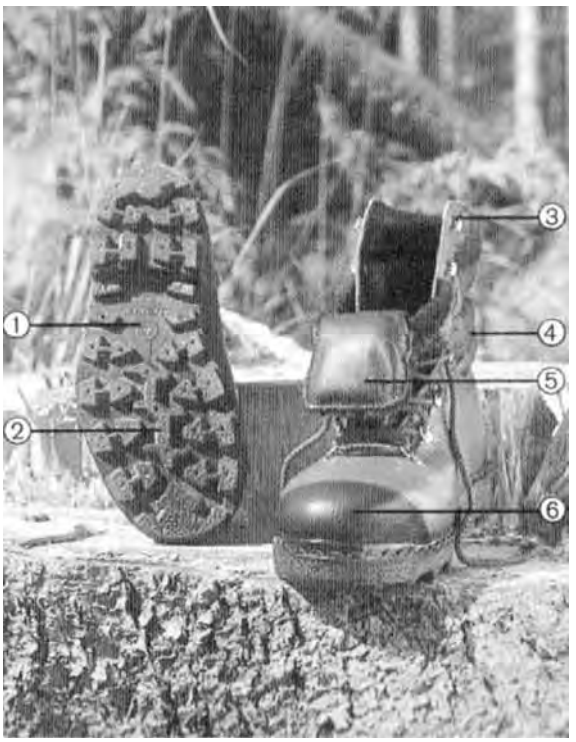
Figure 4: Danger Zone during winching operations

Picture 1: Safety gloves

(Der Forstwirt, 2000; 3. Auflage, Ulmer Verlag Stuttgart, Germany; Helmut Flebacher, Fellbach)

Picture 2: Helmet with visor and ear protection

(Der Forstwirt, 2000; 3. Auflage, Ulmer Verlag Stuttgart, Germany; Helmut Flebacher, Fellbach)



Picture 3: Safety boots

(Der Forstwirt, 2000; 3. Auflage, Ulmer Verlag Stuttgart, Germany; Helmut Flebacher, Fellbach)

1 Tread min. 1,5 mm
2 Tread min. 6 mm
3 Upper shoe
4 Ankle protection
5 Cutting protection
6 Steel toe-cap

Wrong **Correct**

Picture 4: Work posture

(Der Forstwirt, 2000; 3. Auflage, Ulmer Verlag Stuttgart, Germany; Braun,W., Itzelberg)

Picture 5: Respiratory masks

(Photos: Der Forstwirt, 2000; 3. Auflage, Ulmer Verlag Stuttgart, Germany; Fa. Grube, Hützel)

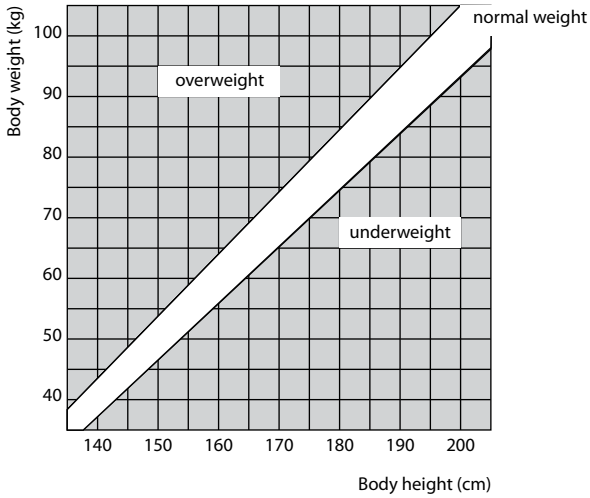


Figure 5: Body weight

(Der Forstwirt, 2000; 3. Auflage, Ulmer Verlag Stuttgart, Germany; Helmut Flebacher, Fellbach)

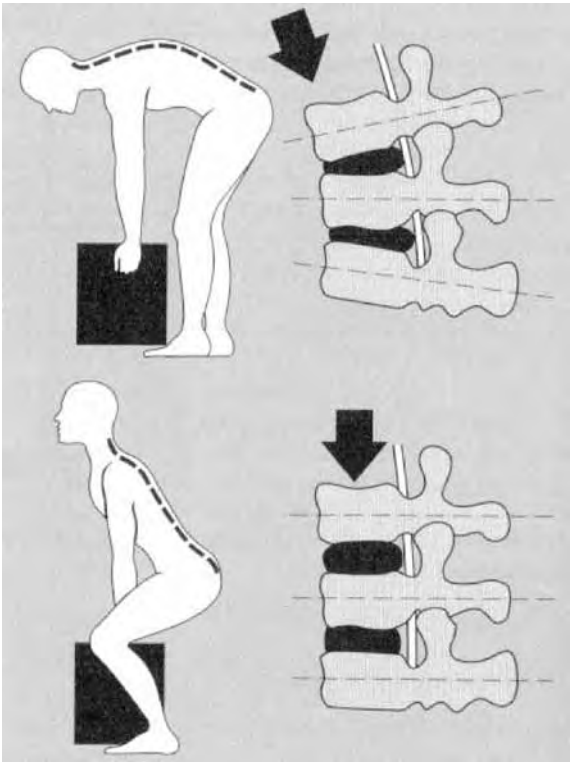


Figure 6: Change of intervertebral discs during lifting of weight

(Der Forstwirt, 2000; 3. Auflage, Ulmer Verlag Stuttgart, Germany; Helmut Flebacher, Fellbach)

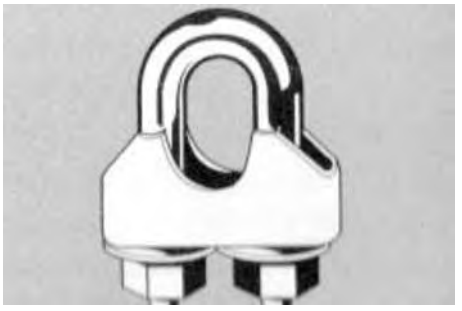


Figure 7: Rope clamp

(Der Forstwirt, 2000; 3. Auflage, Ulmer Verlag Stuttgart, Germany; Helmut Flebacher, Fellbach)

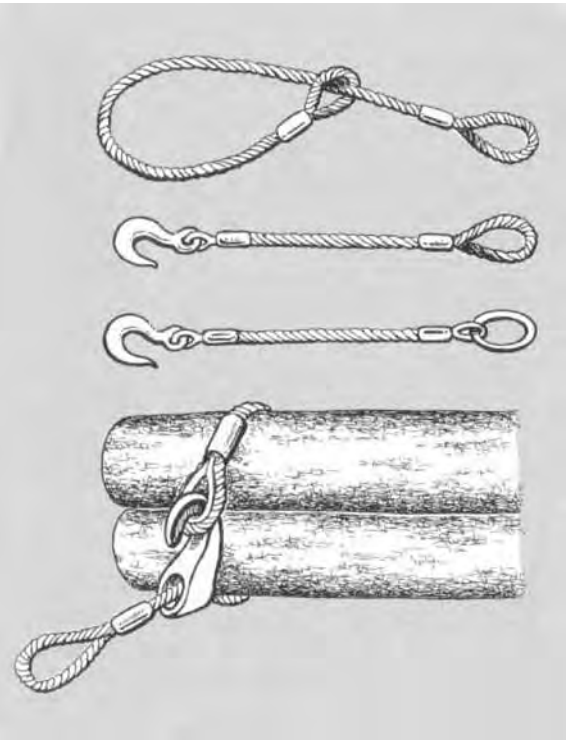


Figure 8: Choker cables

(Der Forstwirt, 2000; 3. Auflage, Ulmer Verlag Stuttgart, Germany; Helmut Flebacher, Fellbach)

Figure 9: German and European test seals

(Der Forstwirt, 2000; 3. Auflage, Ulmer Verlag Stuttgart, Germany; Helmut Flebacher, Fellbach)

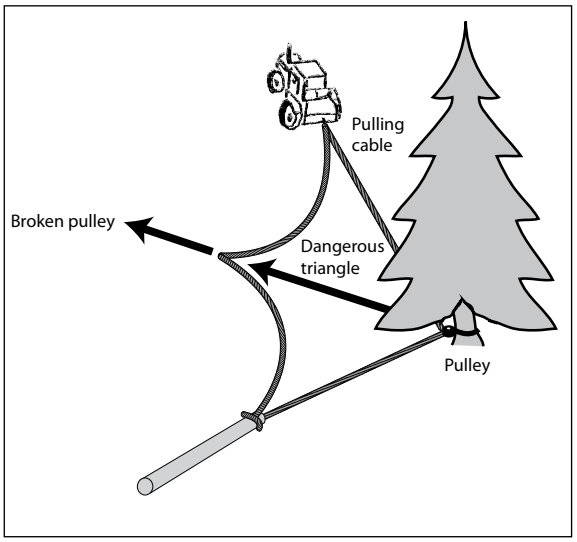


Figure 10: „Dangerous Triangle“

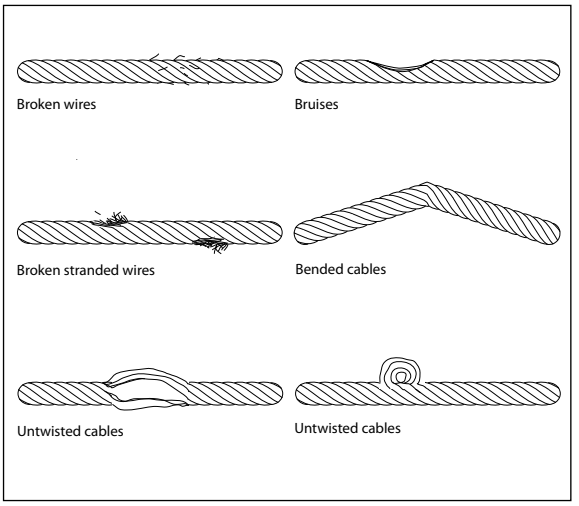


Figure 11: Damaged cables

4. References

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Kuratorium für Waldarbeit und Forsttechnik e.V. „Prüfsiegel“, Internetrecherche

Forest Road Construction, Sabah, Malaysia
(Foto: W. Benneckendorf)

XII. Set-Up and Duties of Forestry Departments

Glossary

AAPO . . . . . Form for Annual achievement of Plan of Operations
APO . . . . . Form for Annual Plan of Operations
BSc. . . . . Bachelor of Science
CF. . . . . Community Forest
EU. . . . . Engineering Unit
DDFO . . . . . Deputy District Forest Officer
DFD . . . . . Director of Forestry Department
DFO . . . . . District Forest Officer
Dipl. . . . . Diploma Holder
DSFO . . . . . Deputy Senior Forest Officer
FD. . . . . Forestry Department
FDis . . . . . Forest District
FDisO . . . . . Forest District Office
FE. . . . . Forest Enterprise
FMP . . . . . Forest Management Plan
FO. . . . . Forest Officer
For.Mgt.Form Forest Management Form
FR. . . . . Forest Ranger
Fra . . . . . Forest Ranges
FTC. . . . . Forest Training Centre
FU. . . . . Forest User
FW . . . . . Forest Worker
IaD . . . . . Form for Implementation and Documentation
Insp.O. . . . . Inspection Officer
ID . . . . . Implementation Division
IU . . . . . Inventory Unit
M&E . . . . . Monitoring & Evaluation
MSc . . . . . Master of Science
PD. . . . . Planning Division
PF. . . . . Private Forest
Rad. . . . . Regional Administration
SFM . . . . . Sustainable Forest Management
SFO . . . . . Senior Forest Officer

1. Introduction

There are many different names used, e.g. Forestry Department, Forest Department, Forestry Authority or Forest Agency, for an administration with the task to manage a country's forests. Whatever it is named, these administrations are fully responsible to their governments and the public for the sustainable management of their forests. Outsourcing of certain tasks or even privatization of forest land cannot take this responsibility away. If this is the real situation in a country, the respective FD has to be in the position to control and monitor these private companies closely. The following numbers of staff have to be seen as a recommendation only since the quantity of staff depends very much on the intensity of the management of forests and other obligations, e.g. sovereign functions.

2. Forest Department Staff

Any forest management requires a certain amount of staff. A well trained and equipped Forest Ranger (FR), (Diploma holder or BSc) can carry out all kind of forest management options on forest land up to 4.000 ha. Each FR should be assisted by at least 4 FW. These FW can assist during all implementation work, as inventory, tree marking, forest road closure, etc. The remaining time can be used for timber or firewood production. For 10 FR one District Forest Officer (DFO) should function as supervisor and superior to whom the FR report directly. These DFO s working under the supervision of the Regional Administration (RAd). The DFO office (FDisO) should be headed by 1 DFO, plus 1 DDFO and 2 clerks. This team is capable to handle all necessary work and reports to the RAd. The RAd office consists of 1 SFO (Head), 1 DSFO (Deputy) and 1 clerk. A driver is not necessary since a RAd has normally a pool of drivers and vehicles.

Beside a.m. staff no additional staff is needed in the field. The actual work in the field, as logging, planting of trees, etc., is carried out either by contractors or own FWs. FD Headquarter should provide professional input for all Management Planning subjects. They are responsible for state wide M & E, implemented through frequently inspections in the field.

From the authors experience it is very important that the idea of SFM is understood and well "digested" on all levels of intervention. Each level should be in-

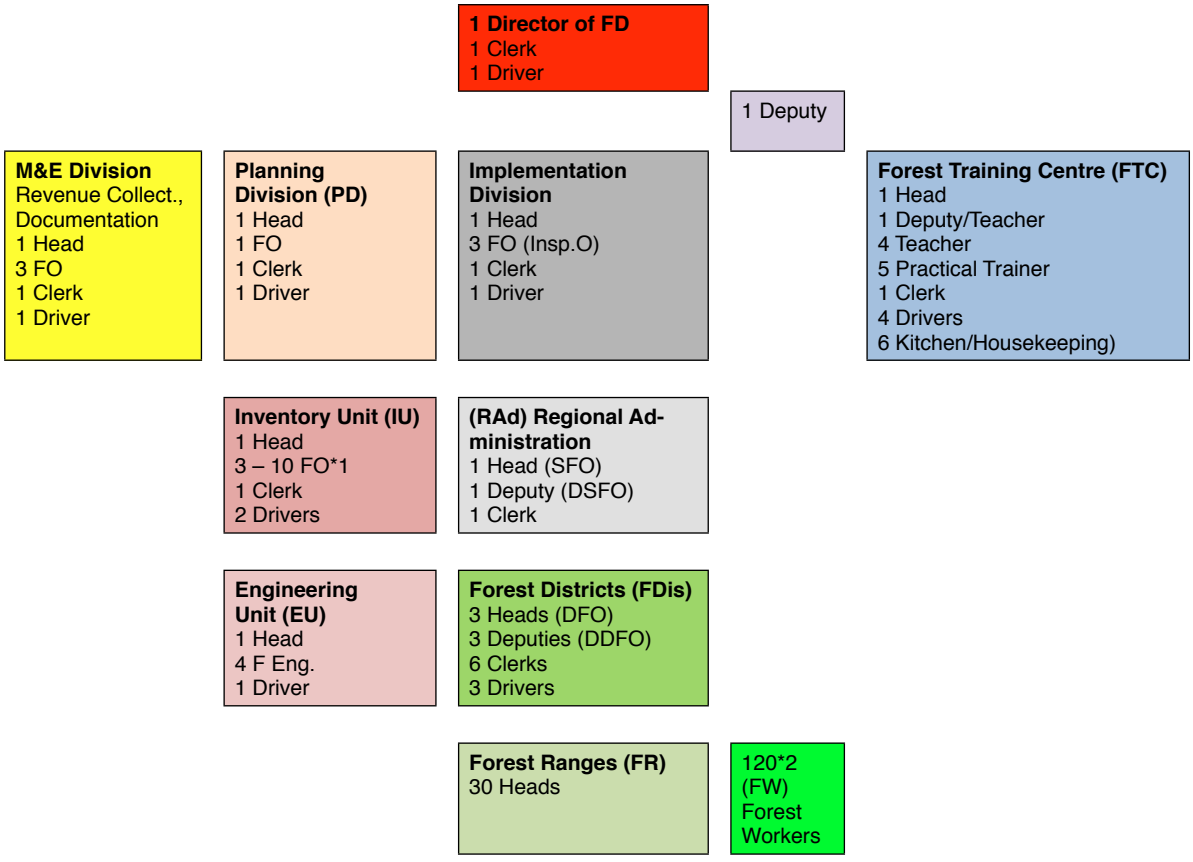

Figure 1: FD Set-Up

*1 = up to 10 FO for the initial management inventory in all FDis. At a later stage 3 FO are sufficient.

*2= only in case all operations in the field are carried out with own FWs.

Table 1: FA Staff

For 120.000 ha Forest Land	Total Staff No.	(MSC, BSC) No.	FO (Dipl. Or BSC) No.	Clerks	Driver	Forest Worker FW	Others No.
FD Headquarters	4	2	0	1	1	0	0
M & E Division	6	1	3	1	1	0	0
Implementation Division (ID)	6	4	0	1	1	0	0
Planning Division (PD)	4	1	1	1	1	0	0
Inventory Unit (IU)	6	1	3	1	1	0	0
Engineering Unit (EU)	6	1	4	0	1	0	0
Regional Adm. (RAd)	3	1	1	1	0	0	0
District Forest Office (FDis)	15	3	3	6	3	0	0
Forest Ranges (FRa)	150	0	30	0	0	120	0
Forestry Training Centre (FTC)	22	2	9	1	4	0	6
Total	**222**	**16**	**54**	**13**	**13**	**120**	**6**

For cost calculation just refer to the chapter VI. Economics. Enter staff figures into the Excel software.

volved. Of course, in some cases one could jump the level of Rad, but from my experience this can cause a lot of trouble if they have not been involved from the beginning.

The following tables give an overview of all required FD staff for about 120.000 ha of forest, their respective positions and related duties. Again, the figures given here have to be seen as an example only.

Since the forest inventories should proceed step by step, meaning FDis by FDis, completing one FRa after the other, the number of FD staff can increase parallel according to education and practical trainings.

The workflow inside a FD is mentioned in Table 3.

Table 2: Set colors according to specific activities

10 year Forest Mgt. Plan (FMP)	
Annual Plan of Operations (APO)	
Implementation, Activities	
Revenues, Licenses	
Documentation In AAPO and IaD, M&E	
Reporting	

2.1 FD Staff, Duties and Responsibilities

The activities mentioned below, of course, can only show part of the duties of the staff. It should serve as a guide for a documented workflow inside a department, where everybody involved knows what he has to do until what time. Everybody involved has to copy his chapter only to know until what date he has to deliver or receive a report or carry out a certain task.

Each different color below refers to a specific duty. So, this duty can be followed through all levels of intervention in a FD. Only if everybody involved is carrying out his duties according to set time frames, the forestry sector can develop and a SFM can be achieved.

Table 3: FD Staff duties and responsibilities

FD Staff, others	Responsibilities, Action	Time Frame
Forest User (FU) Enterprises (FE) Community Forests (CF) (Forest Worker, FW)	Contribution to FMP	Ongoing (with FR)
	Receiving of final FMP from DFO	Until 30th of Oct., 9th year, valid for the next period
	Contribution to APO	Ongoing (with FR)
	Receiving of final APO from DFO	Until 30th of Sept. each year for the following year
	All activities (planting, maintenance, harvesting, fire protection etc.)	Ongoing, if needed or by request of the FR Reporting to FR about all activities
	Contribution to harvesting assessment	Set by FR
	Payment of revenues (harvesting and transport license)	After harvesting, set by FR
Forest Ranges (FRa) Forest Ranger (FR)	Contribution to FMP and submission to DFO	Every 10 years, until 31st of Dec., 7th year
	Receiving approved FMP from DFO	Until 15th of Oct., 9th year
	Submission of FMP to FU, FE CF	Until 30th of Oct., 9th year
	Finalizing APO (with FU, FE, refer to FMP)	Until 15th of Jul. each year for the following year
	Submission of APO to DFO	Until 31st of Jul. each year for the following year
	Receiving of final APO from DFO	Until 31st of Aug. each year for the following year
	Submission of APO to FU, FE, CF	Until 30th of Sept. Each year for the following year
	Harvesting and other activities (s. above)	Supervision, advise & control of licenses.
	Assessment of harvested volumes	1 week after harvesting completed
	Documentation of all activities in “Annual Achievement of Plan of Operations” (AAPO)	Until 31st of Jan., of next year
	Submission of all AAPO’s to DFO	Until 15th of Feb., of next year

District Forest Office (FDisO) District Forest Officer (DFO) Clerks (CL)	Disciplinary head of all FRas staff	Ongoing
	Conducting monthly office meetings with FR and DFO (using Office Record Form)	monthly
	Responsible for all activities in the field	Control checks in each FRa min. 1 day each month
	Receiving payment of revenues from FU, FE, CF, PF	After harvesting
	Transfer of payments to Gov. Bank account	Immediately after reception of money
	Sending accounts to M&E	Until end of each month
	Receiving FMP contributions from FR	Until 31st of Dec. of 7th year
	Commenting on FMP contributions & submission to RAd	Until 31st of Jan. 8th year
	Receiving final FMP from RAd	Until 1st of Sept., 9th year
	Submission of final FMP to FR	Until 15th of Oct., 9th year
	Receiving APO contributions from FR	Until 31st of Jul. each year for the following year
	Approval of APO & submission to FR	Until 31th of Aug. each year
	Receiving of all AAPO's from FR	Until 15th of Feb., of next year
	Entering of AAPO data into FMP page 3	Until 31st of March of the next year
	Submission of copies of AAPO and FMP page 3 to Rad	Until 15th of April of the next year
	Receiving documented FMP from M&E	Until 31st of Jul., 11th year
	Receiving Forestry Sector Report from DFD	Annually until 31st of March
Regional Administration (RAd) Senior Forest Officer (SFO)	Disciplinary head of all DFO and RAd Staff. Guaranteeing that all measurements carried out in consultation with other RAd Departments.	Ongoing
	Conducting monthly office meetings with DFO (using Office Record Form)	monthly
	Receiving FMP contributions from DFO	Until 31st of Jan. 8th year
	Contribution to FMP and forwarding to IU	Until 28th of Feb. 8th year
	Receiving final FMP from IU	Until 15th of Aug., 9th year
	Submission of final FMP to DFO	Until 1st of Sept. 9th year
	Receiving AAPO's and FMP page 3 from DFO	Until 15th of April of the next year
	Submission of AAPO's and FMP page 3 to PD, M&E	Until 30th of Apr., of the next year
	Receiving of documented FMP and evaluation report from M&E	Until 31st of Jul., 11th year
	Receiving Forestry Sector Report from DFA	Annually until 31st of March

Inventory Unit (IU)	Receiving FMP contributions from RAd	Until 28th of Feb. 8th year
	Carry out forest inventory (site classification, increment assessment, determination of AAC) Collection of all data for FE, CF, PF Writing FMP and incorporating all contributions.	Has to be completed latest 30th of Jun. in the 9th year
	Finalizing FMP and submission for approval to Head of PD	Until 15th of Jul., 9th year
	Receiving final FMP from PD	Until 31st of Jul., 9th year
	Submission of final FMP to RAd	Until 15th of Aug., 9th year
Engineering Unit (EU)	Responsible for the Opening Up systems in forests Evaluation of Harvesting systems Training in harvesting techniques (in collaboration with Forestry Training Centre)	Ongoing
Planning Division (PD) Head of Planning Division	Disciplinary head of all Inventory and Eng. Staff	Ongoing
	Receiving FMP from IU	Until 15th of Jul., 9th year
	Contribution and approval of FMP & Submission of final FMP to M&E, IU and DFD	Until 31st of Jul, 9th year
	Receiving copies of AAPO and FMP, Page 3 from RAd	Until 30th of Apr., next year
	Receiving of documented FMP and evaluation report from M&E	Until 31st of Jul., 11th year
	Receiving Forestry Sector Report from DFA	Annually until 31st of March
Implementation Division (ID)	Disciplinary head of all SFO at RAd and DFO.	
	Responsible for contemporary implementation of FMP. Each FO is responsible for 1 FDis and functions as an Inspection Officer.	Inspections twice a month to each FDis.
	Keeping contact to universities, research stations etc. Transferring all innovations and knowledge (e.g. new harvesting systems, new pesticides, etc.) to Rad and FDis.	
M&E Division (M&E)	Receiving final FMP from PD	Until 31st of Jul, 9th year
	Receiving copies of AAPO and FMP, Page 3 from RAd	Until 30th of Apr., next year
	Carry out M&E activities referring to FMP, Page 2 and 3 of AAPO	Until 30th of Jun., 11th year
	Submission of documented FMP and evaluation report to FDisO, PD, RAd (“Evaluation Report”: Planning / Implementation, e.g. deviation from planning, reasons etc.)	Until 31st of Jul., 11th year
	Receiving accounts from DFO	Until the end of each month
	Elaboration of Financial Report	Until 31st of March of the following year
Dir. Forest Department (DFD)	Receiving of documented FMP and evaluation report from M&E	Until 31st of Jul., 11th year
	Receiving FMP from PD	Until 31st of Jul, 9th year
	Elaboration of “Forestry Sector Report” and submission to the respective Ministry of and all FD offices	Annually until 31st of March

3. Monitoring and Evaluation (M&E)

Following the workflow in Table 3 strictly and comparing the planned activities according to chapter IV. Inventory, "For.Mgt.Form 2" and "For.Mgt.Form 3" (refer to Inventory Guidelines) for implementation, the M&E Division can easily monitor the progress of implementation and all possible deviations annually. Since the Forest Mgt. Plan is valid for 10 years, there is sufficient time to interfere to assure that planning and implementation are balanced at the end.

4. Fighting illegal Logging

Illegal logging can be minimized only when at the same time sufficient wood, commercial timber and firewood, is legally produced or imported. Focus should be given on following activities:

4.1 Licenses for logging operations

- Issuing of harvesting and transport license (1 document) on request for each m^3 of commercial timber and firewood by FDis. All licenses are available until 31.of Dec. for the following year. Each license has to be paid before it is issued and entered into a database with the FDis.
- The licenses have to be approved through stamp by FRas before the logging operation commences and is valid for a certain time period only. After logging is completed the transport has to be approved again by stamp by FRa. In case of railway transport the customer has to report latest 1week or in case of truck transport after 1 day to the FDis that the timber or firewood has reached its final destination. The arrival has to be entered into the database. So, this license cannot be used again.
- The license has to follow the timber / firewood at all times up to the final destination (end consumer).
- The transport can be followed at check points, FDis or RAd offices.
- In case the arrival is not reported in set timeframe to the FDis, the FDis or FRa has to check where the timber or firewood got stuck. According to the quantity of the timber or firewood, the customer has to pay a fixed surcharge. Police has to assist if required. Each FDisO can check via the database the final destination of licensed wood.
- The FDisO has to keep record of each m^3 produced, transported and sold.
- The end consumer has to keep the license or part of it and to show on request.
- Control by all stake holders involved, especially frequently controls of end consumers by police, DFO or FR will have the effect that only legally produced wood is bought.
- Each wood dealer has to have a selling license and is eligible to book keeping. He has to enter all data of each license and each m^3 bought and sold into a "Timber Receiving Book" and a "Timber Selling Book". Beside this he has to keep a copy of each license. This will assure an easy wood tracing process.

4.2 Action Plan fighting illegal logging

Table 4: Action plan for fighting illegal logging

Topic	Action	Person in Charge	Time Frame
Fighting illegal logging	• Start intensive co-operation: Ministry, FD, Rad, FDis, FE, Courts and Police! • Set dates for regular meetings		
Database	• Development of central data base where all timber and firewood and all violations are recorded and to which all stake holders have access (Police at check point by Mobile Phone or PC)		
Telephone network	• Development of telephone network, • Issue telephone number for reporting of illegal logging country wide, • 24 hours service		
License system	• Change present license system accordingly		
Check points	• Review of present check points • Construction of new check points if required.		
Information policy	• Information of population about consequences of illegal logging, • TV spots, newspapers, posters, schools,		
Selling of commercial timber and firewood	Establishment of an internet platform: • Availability of products • Advertisement		

5. Appendix

5.1 Tender for Logging Operations

The Forest Department: .....
represented by: .....
tenders out a logging operation as mentioned below in detail:

1. Venue

The logging operation takes place in
Forest Department: .....
Forest Range: .....
Compartment / Sub-Compartment: .....

2. Tree marking

Tree marking will be carried out and skid-trails pre-laid by Forest Department Staff in the respective sub-compartments before the actual logging operation commences.

3. Contractor

3.1 The contractor is fully responsible for his staff and operates on his own risk at all times.
3.2 He has to ensure that his staff is working according to set standards listed in the "Harvesting Guidelines", especially chapter 2.3.2 Safety Regulations, 2.3.3.2 Felling Operations and 2.3.3.3 Yarding Operations and the respective Harvesting Plan.
3.3 He has to present a list with all names and positions of his staff involved.
3.4 He ensures with his signature on this contract, that he will pay all taxes and fees according to the respective laws and regulations for his staff and himself.
3.5 He presents a list with all tools and equipment (brand, model, horsepower, etc.) he intends to use in this operation.
3.6 He is liable for all damages caused by himself or his staff.

4. Staff

4.1 All staff involved has to be in good physical condition and fit for the required tasks.
4.2 All staff involved in cutting operations has to present a certificate which assures the participation in a chainsaw training course.

5. Equipment and tools

5.1 All equipment and tools have to be suitable for the job and certified with the CE and/or CF (European Certification Scheme) or KWF sign.
5.2 All staff involved has to wear a complete set of safety equipment, as helmet with ear protection and visor, protection trousers and boots. The staff has to wear this equipment at all times.
5.3 All staff involved has to be equipped with chainsaws, measurement tapes, crayon and caliper.
5.4 The tractor for yarding operation has to be equipped with a winch with a pulling capacity of min. 4 t and a 50 m cable of min. 11 mm diameter. A fully equipped forest tractor with respective tires and all other safety equipment will be considered an asset.

6. Operations

6.1 All cut trees have to be brought to the ground, meaning at the end of the day there are no leaning trees in the stand.
6.2 All timber has to be delimbed parallel with the bark, meaning no snags are remaining at the trunk.
6.3 All center cuts have to be straight and cut in a right angle.
6.5 All mid-diameters below 20 cm have to be measured with a caliper once. From 20 cm and above, the mid-diameter has to be measured twice, the second measurement relocated at 90°. Another possibility is the measurement of the big and the small end of the stem. Both measurements have to be averaged. The diameter of the respective bark, as indicated below, has to be subtracted. For each meter of stem-length 1 cm has to be added but min. 10 cm has to be added for each piece (E.g.: 8m stem-length add 10 cm = cut by 8,10 m; 14 m stem-length add 14 cm = cut by 14,14 m). Length and mid-diameter have to be written with crayon at the front face of the trunk.

6.6 Bark diameters for subtraction

Species	Measurement place	Subtraction cm
Pine	Lower part, thick bark	2
Pine	Upper part, thin bark	1
Oak	For each mid-diameter class	1
Beech	-	1
Hornbeam	-	1
Norway Spruce	Below 30 cm mid-diameter	1
Norway Spruce	Above 30 cm mid-diameter	2
Other species	-	As required

6.6 All timber has to be piled and stacked into woodpiles and at places indicated by Forest Department Staff.
6.7 For forest protection purposes all logging waste has to be cut into pieces smaller than 50 cm to increase the drying process and the decay.
6.8 After the entire operation is completed, the contractor is responsible that all garbage lying in the forest is collected into plastic sacks and stored at a place indicated by Forest Department Staff.

7. Grading rules and Bidding Prices for Logging Operations (Example!)

Comp	Ha	M^3	Assort-ment	Length m	Min. Top-Diam. cm	Quality	Bidding Price per 1 m^3, $	
							Cutting	Yarding total costs
15.3	114	Appr 2850	Comm. timber	6,10	12	Straight, no decay		
		Appr 1450	Fire-wood	1,00	7			

Volumes indicated in this table are estimates only, the exact volumes and qualities will be assessed during/after the operation.

8. Volume assessment, prices and payment
8.1 The contractor has to indicate his bidding price in the list above (No. 7) for the production of 1 m^3 of timber (commercial timber and firewood), cut, measured and piled, and separately for yarding as required by Forest Department Staff.
8.2 The total volume will be finally assessed by Forest Department Staff after the operation is completed, confirmed in a protocol and reported to the contractor. The contractor can participate in the assessment. The contractor accepts the protocol by his signature. The assessment has to be completed and the protocol signed latest after 7 working days after the completion of the operation by the contractor. On request of the contractor, partly payments are possible according to the work progress.

8.3 The Forest Department pays to the contractor's bank account:

Bank swift code: ..... Bank account: .....

the total sum after the operation is completed, quality and quantity assessed and approved by both sides in above mentioned protocol. The payment has to be accomplished latest after 7 working days after the protocol was signed.

Date:
Signature Forest Department Signature bidder / contractor

....

5.2 Timber Sell Bid

The Forest Department: .....
represented by: .....
tenders out a timber sell as stated below in detail:

1. Venue

The timber to be sold is piled and accessible for trucks in
Forest Department: .....
Forest Range: .....
Compartment / Sub-Compartment: .....

The timber can be inspected by the buyer on:
Date: Time: Venue:

2. Bidder

2.1 The bidder is fully responsible for his staff at all times and operating on his own risk.
2.2 He has to ensure that his staff is working according to set standards listed in the "Harvesting Guidelines", especially chapter 3. Loading and 4. Hauling.
2.3 He has to present a list with all names and positions of his staff involved.
2.4 He ensures with his signature on this contract, that he will pay all taxes and fees according to the respective laws for his staff and himself.

3. Volume and prices

The volumes are listed in the attached "Volume Assessment Sheet" and differentiated according to species, diameter classes, quality, quantity and batch.
The bidder has to enter his prices in the table below accordingly.

Price List, Bidding / Contract

Species	Quality class	Dia. Class	Batch	Volume M^3	Price for 1 M^3, GEL	Total Price

With his signature the bidder participates in the above mentioned bidding and accepts the bidding and selling regulations of above mentioned Forest Department. The bidding has to be delivered to this Forest Department either to the "Bidding Internet Platform" or in an sealed envelope, until the
Date: **Time:**

The bidder will be informed about the acceptance of the tender by the Forest Department, until the

Date:

Furthermore, the bidder accepts with his signature the quantity and quality of a.m. timber. The participation in the tender is not revocable, meaning after submission and acceptance of the bidding, the bidder has to buy the timber.

4. Place of jurisdiction

The place of jurisdiction is…….

Date: ..... Date: .....

Signature Buyer Signature Seller

....

5.3 Timber Sell Contract

The Forest Department,
Adress: .....
represented by: .....
sells timber as stated below in detail to the Buyer:
Name: .....
Adress: .....

1. Venue
The timber to be sold is piled and accessible for trucks in
Forest Department: .....
Forest Range: .....
Compartment / Sub-Compartment: .....

2. Buyer
2.1 The buyer is fully responsible for his staff at all times and operating on his own risk.
2.2 He has to ensure that his staff is working according to set standards listed in the “Harvesting Guidelines”, especially chapter 3. Loading and 4. Hauling.
2.3 He has to present a list with all names and positions of his staff involved.
2.4 He ensures with his signature on this contract, that he will pay all taxes and fees according to the respective laws for his staff and himself.
2.5 The buyer is liable for all damages caused by himself or his staff.

3. Volumes and prices

3.1 The volumes are listed in the attached “Volume Assessment Sheet” and differentiated according to species, diameter classes, quality, quantity and batch.
3.2 The Forest Department is liable for obviously timber qualities only, meaning not liable for defects inside the wood. Timber defects have to be claimed immediately during the inspection (s. 4.).
3.3 In case the timber is sold batch by batch, all following chapters below are effective for each of them.

Price List, / Contract

Species	Quality class	Dia. Class	Batch	Volume M^3	Price for 1 M^3, GEL	Total Price

4. Inspection
4.1 The timber can be inspected by the buyer on:

Date: ..... **Time:** ..... **Venue:** .....

The date of this contract can be relocated by the buyer only once, but not longer than 10 days after a.m. date.
4.2 Seller and buyer have to sign a protocol stating that the timber quantity is available and the quality is accepted by the buyer.
4.3 In case the buyer does not make use of this inspection or does not show up at a.m. date, he accepts the quantity and quality of the timber and has no right of reclamation afterwards.

5. Payments

5.1 The “Timber Sell Contract” has to be send by the Forest Department to the buyer latest 3 days after the date of inspection. The total sum of sell has to be on the Forest Department’s account latest 10 days after the date of inspection.
5.2 In case the money has not reached the account in time, the Forest Department can charge **Interest Rates of ..... %**

6. Assignment of property

6.1 With the date of inspection and after signing of the inspection protocol, all risks, e.g. loss of quantity, damage by people, fire etc., are at the buyer’s risk. The Forest Department cannot be made responsible for any of those damages.
6.2 The timber stays in the forest and remains the property of the Forest Department until the total price (or for the respective batch), is paid by the buyer and the respective amount has reached the Forest Department’s account.

7. Transport

7.1 After receiving the total sum (or for the respective batch), the Forest Department will send within 3 working days, the permission for the transport of the timber, stating all log-numbers and quantities. This permission has to accompany the timber at all times.
7.2 All timber has to be transported out of the forests latest within 3 months after the date of the permission for transport was issued (7.1).
7.3 In case the timber is not transported in time, the Forest Department will remind the buyer in written form. The buyer has now 2 weeks time to transport the timber.
7.4 In case the timber is not transported in time again, the Forest Department can arrange the transport or any other operation on the buyer’s costs, especially to prevent danger of forest diseases or forest fires. Latest 12 months after the date of the first reminder, the property of the timber goes back to the Forest Department and can be sold to anybody.

8. Place of jurisdiction

The place of jurisdiction is…….

Date: ..... Date: .....

Signature Buyer
.....

Signature Seller
.....

6. References

Benneckendorf W., 2013: Concept for Forestry Sector Development in Georgia, Project Report, Tbilisi City Hall, CIM Advisor

Benneckendorf, W., 2014: Sustainable Firewood Production, CENN, Leaflet, Tbilisi, Georgia

Damage Assessment after a Forest Fire, Thunkel, Mongolia (Foto: K. Schmidt-Corsitto)

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Born in 1952 in the “Harz-Mountains”, Lower Saxony, Germany. Study of forestry at the Lower Saxony Forestry College, “Düsterntal”, degree: Dipl.-Eng., Forestry (BSc) from the University for Applied Science (Fachhochschule Hildesheim / Holzminden) in Göttingen, Germany. He has worked in Germany as a specialist for forest road construction, as Forest Range Officer and as a teacher at the “Lower Saxony Forestry Education Centre Münchehof” and the Vocational Training Centre in Northeim, Germany. At the same time he was Coordinator for placement projects in the EU programme “Leonardo da Vinci“ and flew as pilot for the Lower Saxony Fire Brigade. In 2004 he was trained in pedagogics and didactics for teachers by the Lower Saxony Ministry of Science and Education.

From 1982 onwards he worked altogether 15 years as a Forestry Advisor in Liberia, Malaysia, Ecuador, Ethiopia, China, Mongolia, Tajikistan and Georgia. He gave advice in the fields of Nursery & Plantation, Sustainable Forest Management, Opening-Up and Harvesting Systems, Sustainable Utilization of Natural Resources, Production and Marketing of Firewood and Management Planning. He finally retired at the end of 2017.