
Training module
Cartography in Reduced Impact Logging

Integral Module



PREFACE

The application of Reduced Impact Logging (RIL) techniques is one of the important requirements for the certification of sustainable forest management. However, considerable effort still has to be taken before the RIL practises will be operational on a large scale in the region.

Previous experiences have already demonstrated the necessity and feasibility of the training in Reduced Impact Logging (RIL) techniques in the Congo Basin.

Notwithstanding the considerable differences between the different countries of the Congo Basin we are of the opinion that by introducing the RIL practices in Gabon we can investigate at first hand the impacts of the conventional logging and demonstrate the advantages of RIL techniques for the enterprise and for the environment of all of central Africa.

This because Gabon still accommodates a rich and very much varied patrimony of fauna and flora, which is not only like elsewhere, seriously threatened by the logging and mining industries and by the progressing demography, but also still very much susceptible to methods that might avert these threats.

As the logging techniques in tropical countries can differ from country to country, and even from region to region and all the more as there are not yet sufficient data on RIL in Africa, it is still difficult to convince foresters of the advantages of the application of RIL.

The RIL training courses aim at teaching logging staff and workers these specific techniques and to optimize their skills.

The following modules have been composed to form a package of instruction covering most of the aspects of logging techniques under RIL methodology:

- Cartography
- Forest inventory
- Road planning
- Road construction
- Controlled felling
- Planning of skid tracks and tracing
- Planned extraction
- Log landing operations
- Post-harvest operations
- First aid in the forest
- Operational management in RIL

ACKNOWLEDGEMENT

This task could never have been accomplished without the generous support of the persons mentioned hereunder.

Our first concern was the accommodation of the project with a logging company that was already well ahead on the way to sustainable forest management.

We found the directorate of the Société des Bois de Lastourville (SBL), in the persons of Messrs. Pierre et Stéphan Vergnaud, willing to lodge us and to assist us with all their facilities, their equipment and their work force. SBL is already well advanced on the way to certification of sustainable forest management and its concession has ideally helped us as experimenting field. Furthermore, the forest put aside for us by SBL is perfectly suitable for the execution of the training. We owe Pierre and Stéphan Vergnaud a great debt of gratitude.

I am also very grateful to Mr. Frank Stenmanns, sustainability manager of SBL, for his patience, his collaboration and his tireless assistance, that he give me aside from his daily tasks, with the preparation of the compartments for the project, the discussions on the inventory, the mapping and the road planning.

A great many thanks also to the management of the company CEB-Thany à Bambidie, Messrs. Jean-Marie Pasquier et Philippe Jeanmart, the real pioneers of RIL in Gabon, for their hospitality, their advising and their very valuable ideas about subjects such as cartography, construction of roads and bridges and extraction techniques. The exchanges of experiences often took place during delicious lunches at the swimming pool in Bambidié, but were nevertheless very instructive for me.

The editing of the modules by Dr. Peter van der Hout, founder of the RIL training centre of TFF in Guyana and his incomparable knowledge of RIL have guarded me from too many blunders. Moreover, his visit to Lastourville was very pleasant and far too short.

Hattem, the Netherlands, July 2010

Mans Vroom

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1. INTRODUCTION

For the management of a logging company the cartography is the most important tool for the budgeting, planning and monitoring of the operations, because without the maps the management would neither know where to find his trees, nor how to get there, nor how many there are and even less how to harvest them in an efficient and ecological way.

It has been proven that with today's modern and efficient, but very expensive equipment, harvesting of the tropical forest without any preparation entails such high costs that already in the short run it turns out to be economically totally unjustifiable and all the more so on the environmental plan.

For these reasons the cartography of the logging operation must be seen as an essential instrument for the establishment of the Sustainable Forest Management Plan (SFMP), that will soon be compulsory for concessionaries in all countries of central Africa and that will have to be integrated in the entity of subjects of the Reduced Impact Logging (RIL).

The software of the Geographical Information System (GIS) not only considerably simplifies the processing of the different inventory data for the establishment of maps and summaries, it also allows a multitude of registration and processing possibilities of these data into products that are indispensable for an efficient production and commercialization of the timber.

Its investment, comprising a computer, GIS software and a printer for the formats A2 or A1 (ideally even A0) is totally justified by the increase of efficiency that it entails with its correct application.

Anyway, without cartography created by the GIS and representing all data from the management inventory, a Management Plan would not be sufficiently complete to successfully pass a certification audit.

However, as elaborate operation instructions are available with the authors of systems like MAPINFO and ARC VIEW, the GIS will only be treated summarily in this module. We will concentrate on the manual establishment of maps.

Mans Vroom
Emile Ditsougou

2. OBJECTIVES

The cartography module aims at teaching forest managers, foremen and workers that are qualified for forest inventory, road tracing, log tracing, felling and extraction to make optimal use of the modern cartography and its software, the GIS.

3. CONTEXT

Cartography is an entity of studies and scientific, artistic and technical operations realized by the results of direct observations or the use of documentation in order to produce maps, plans, and etcetera as well as to demonstrate their utilisation.

In the sphere of logging cartography is a very important tool for decision making, especially where budgeting, planning and monitoring of the operations in the annual coupes are concerned.

There are several types of maps in forestry, classified according to the following aspect:

- Scale
- Legend
- According to the basic documents and accuracy of the information
- According to the nature of the editing (basic map, compiling map, adapting map, etcetera)
- According to the contents and type of information, the topographic map that represents the surface on the ground and that is only descriptive and the thematic map that is used as support of the topographic map.

The information science has considerably transformed the cartography practices. This current revolution covers all stages of the production of cartographic images, its conception, its design and its propagation.

To connect with the respective target groups we divide the cartography in 7 different categories :

Basic cartography, posted in the sustainable management office and the forest manager's office, gives a general overview of the operation and serves as quick orientation. It can, where needed, be extended with recently updated maps (« pocket »- or compartment maps), notably on inventories, planning and road construction.

Inventory cartography, posted in the sustainable management office and the forest manager's office, hold all progress of the inventory and has to be updated on a daily basis, both manually and in the software.

Planning and road construction cartography, posted in the sustainable management office and the forest manager's office, allows to project on the map, trace and finally open the main roads, secondary roads, side roads, log landings and main skid trails according to the inventory data concerning stock, topography and hydrography. The definitive track of the opened road is digitalized and transferred to the basic cartography.

The cartography of skid tracks and tracing registers on the digitalized inventory map of the pocket or compartment the selection of trees to be felled with their species and felling number and an indication for the type of engine (skidder or track type tractor) to be used. A copy of this inventory map is handed over to

the tracing foreman and the prospectors of the tracing team. These men apply the felling numbers on the trees and add their observations (change of direction, obstacles) on the map. The map also shows the tracing of the secondary tracks leading from the main track to the trees to be felled. The map is subsequently handed over to the sustainable management office to be further digitalized.

The felling cartography shows on the digitalized map of skid tracks and tracing the log landing, the main skid track and the trees to be felled according to the indications by the tracing foreman. Then the feller indicates on the map the trees actually felled, butted and topped (and eventually crosscut, with the number of logs) and preferably with the felling direction. This manually filled-in map will be digitalized and entered into the software.

The extraction cartography indicates on the digitalized felling map the tracks towards the felled and numbered trees, these trees themselves and the type of engine to be used. The extraction foreman or the operator of the engine marks on this map the trees and/or logs actually extracted. After completion, digitalization and entering in the software, this map will be used with the post-harvest inspection (felling quality, search for abandoned logs, damage to trees to be saved, etcetera)

The cartography for the post-harvest operations:

The set of updated and digitalized maps of:

- The inventory of the Allowed Annual Coupe
- The inventory of the pocket or compartment
- The Felling
- The extraction

will serve the forest manager as basis for the execution and monitoring the post-harvest operations.

With a GIS system a basic map is used on which one can project all maps mentioned in this module with variable scales at ones choice

4. TARGET GROUPS AND COMPETENCES TO BE TAUGHT

4.1 Target group 1: Specialists

Positions: Inventory team leader, inventory clerk

Position profile:

- Leadership over an inventory team during line-cutting of the compartments, enumeration of harvestable, future crop trees or otherwise protected or seed trees and registration of the characteristics of the terrain.
- Establishment of precise inventory maps carrying the whole of the gathered data.

Requested knowledge and competences:

- Literate
- Ability to orientate himself in the forest
- Skilled in the use of a compass
- Capable to judge the nature of the terrain in relation with the capacity of the extraction engines
- Reasonable knowledge of cartography

Competences to be taught:

- Increased cartography knowledge
- Practical application of cartography during the execution of their tasks.

Position: Tracer for roads, landings and main skid tracks

Position profile:

- Tracing on the ground of roads, log landings and main skid tracks following the directives given on a map by his superiors
- Adaptation of the tracks following the conditions on the ground, whilst respecting the principle of the shortest distances.

Requested knowledge and competences:

- Literate
- Ability to orientate himself in the forest
- Skilled in the use of a compass
- Capable to judge the nature of the terrain in relation with the capacity of the extraction engines
- Reasonable knowledge of cartography

Competences to be taught:

- Increased cartography knowledge
- Practical application of cartography during the execution of their tasks.

Positions: Tree grader, controller and tree tracer

Position profile:

- Selection of trees to be felled following directives of the management
- Marking of these trees on a copy of the inventory map

- Tracing and beaconing on the ground of the secondary trails leading from the tree to be felled to the main track respecting the principle of the shortest distances
- Tracing of these very trails on the map.

Requested knowledge and competences:

- Literate
- Ability to orientate himself in the forest
- Skilled in the use of a compass
- Capable to judge the nature of the terrain in relation with the capacity of the extraction engines
- Reasonable knowledge of cartography (locating the trees and recognition of obstacles following the map)

Competences to be taught:

- Increased cartography knowledge
- :Practical application of cartography during the execution of their tasks

Positions: Fellers, skidder operators

Position profile:

- To fell trees assigned for the production or extract the felled trees towards the landing

Requested knowledge and competences:

- Ability to orientate himself in the forest
- Skidder operators : Capable to judge the nature of the terrain in relation with the capacity of the extraction engines
- Reasonable knowledge of cartography (locating the trees and recognition of obstacles following the map)

Competences to be taught:

- Increased cartography knowledge
- Locating trees following the map
- Practical application of the cartography in the execution of their task.

4.2 Target group 2: Persons concerned

Management staff (directors, forest managers) officials (MINFOR), researchers (university), teachers (forestry school), environmental NGO's.

Presentation of the following subjects:

- Importance and purport of cartography
- Distinction of the various maps and their objectives
- Lecturing and utilisation of the various maps

5. THE FORESTRY MAP

5.1 Concept of a forestry map

A Forest Management Unit (FMU) is subdivided into 30 Allowable Annual Coupes (AAC) that are regrouped in quinquennial blocks of 5 AAC. Each AAC is subdivided in compartments or pockets. In hilly terrain the natural boundaries (contours, ridges, streams, roads, tracks) make a division in pockets much easier than a division in square or rectangular compartments. These different subdivisions of a forest are made to know the potential in wood of every area. Each subdivision is constitutes a map. These different maps are called thematic, because they all treat a single theme: **the logging operation**.

5.2 The generalization of a forestry map

The generalization is the substantiated schematization of the design of the essential elements of the map. On a forestry map one finds only the representations that are useful for the needs of the forester:

- Contours
- Hydrography
- Roads and tracks of the concession

The GIS is an integral geographic information system based on cartographic data obtained with the help of specific software such as ARCVIEW and MAPINFO regularly used in forestry units. This software treats and visualizes the information.

This software is capable to digitalize and track each chosen spot by means of géoreferential co-ordinates.

5.3 Harmonization of a map

The adoption of the conventional symbols and signs enlarges the apparent dimensions of objects in varying proportions: on a basic map of 1/1000.

All information and the exact position of certain objects, trees, all sensibly chosen, streams, mountains, different types of soil (loamy, rocky, sandy), are geographically positioned on a map, on which the relief is indicated by contour lines and the different environments by colors. The precision of the reflection of the data is defined by the scale of the map.

5.4 Contour lines

The contour line is the geometrical place of points that have a common altitude. It is also the projection on the map of the intersection of the terrain by the surface of a certain elevation

The contour lines are chosen at equal vertical distances, they are « vertically equidistant ». The equidistance is chosen subject to the scale.

Depending on the slope of the terrain, the equidistance is five (5) meters on flat terrain and ten (10) meters in mountains.

Main contours are mentioned in bold each 5 contours. Those in between are called intermediate contours.

5.4.1 The purpose of contour lines

The contour lines help to identify the terrain or the environment where the operator intends to go. The disposition of the contour lines allows him to know whether the terrain is flat or whether there are (steep) slopes.

We recognize a flat terrain on a map by the regularity of large distances between the contour lines (equidistance).

A hilly terrain is recognized by the very small distances between the contour lines. They indicate the presence of hills, valleys, streams and the direction of slopes.

5.4.2 The equidistance

A map of mountainous terrain will only be readable if the contour lines are more than 2 – 2.5 mm apart, which represents a scale of 1/20.000 or 7 meters on the ground. In case a slope amounts to 100 %, the spot is marked with a sign of a rock.

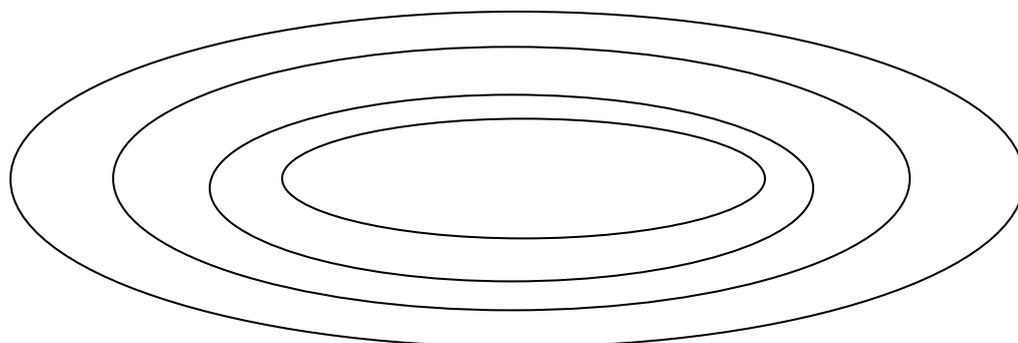
5.4.3 Main contours, inserted contours

Main contours: To simplify the reading of maps every fifth contour line is marked in bold

Inserted contours: It is traced at $\frac{1}{2}$ the equidistance to indicate shifts of the terrain beyond the normal contours. Inserted contours are traced with a dotted line.

Basin: Indicated by an arrow on the main contour line.

Main contour



5.4.4 Noting values and colors of contours

Generally main contours are marked with their altitude and certain reliefs or soil types that do not figure clearly by the contour lines are colored.

- Blue in different shades for glaciers
- Brown in different shades for rocks.

5.4.5 Calculation of slopes

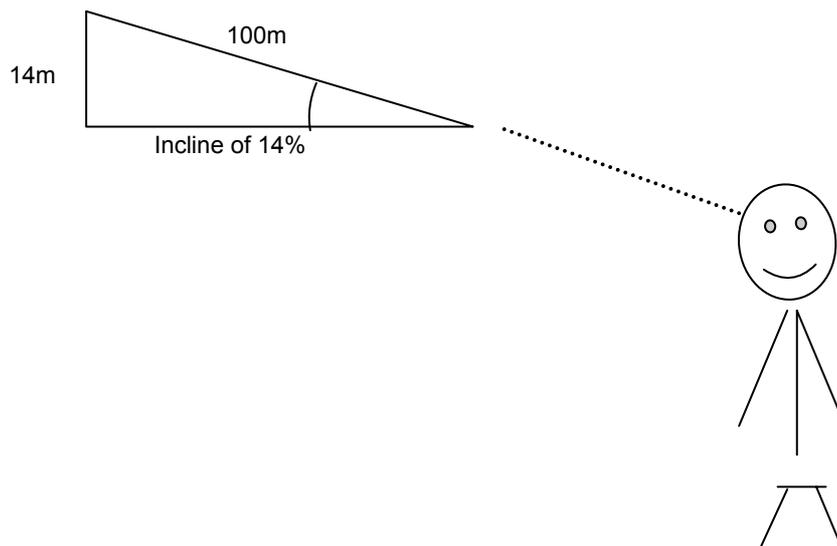
A slope or incline is the angle of inclination (gradient) of the terrain on the horizon expressed by its tangens.

Example:

If the scale of the map is 1/1000:

On the terrain $AB = 3,4 \cdot 1000 = 3400\text{cm} = 34\text{ m}$

Incline $AB = \text{equidistance} / \Delta(\text{interval}) = \text{tgi} \Rightarrow \hat{i} = \text{ctg} AB = 5\text{m}/34\text{m} = 0,14\text{ m}$, whence $\hat{i} = 0,14 \text{ ctg} = 8,86 \text{ gr}$



The incline of the terrain is often expressed in percents, i.e. $\text{incline} = AB = 0,14 = 0.14$, in other terms $\text{Incline} = 0.14 \times 100 = 14\%$.

5.5 The scale of a map

The scale is the reduction ratio between a length measured on a map and the real measurement on the terrain. The scale is expressed by a fraction of which the numerator is a length unit on the map and the denominator is the corresponding distance on the terrain.

A scale of 1/100000 means that 1 cm on the map represents 10000cm or 1 Km on the terrain.

There are two distinguishable types of scale :

- The numerical scale
- The graphic scale

5.5.1 The numerical scale

The numerical scale is recorded as a fraction. It is calculated as follows:

Example:

a) If one measure a distance of 2.5 cm on a map and the distance on the ground is 2.5 meters, the scale is

$$2,5/2500 = 1/1000$$

b) If one measures a distance of 7,4 cm on a map and the scale is 1/500, the real distance will be:

$$7,4 * 500 = 3700\text{cm} = 37\text{m}$$

c) Inversely, if a length measured on the ground is 8.5 meters, it will be represented on a scale of 1/200 by:

$$85/200 = 0,425\text{m} = 42,4\text{cm}$$

The scale on a plan or a map is a fraction. It will be larger as its denominator will be smaller. On a map the scale is often noted as a fraction, for example: 1/20000.

5.5.2 Graphical scale

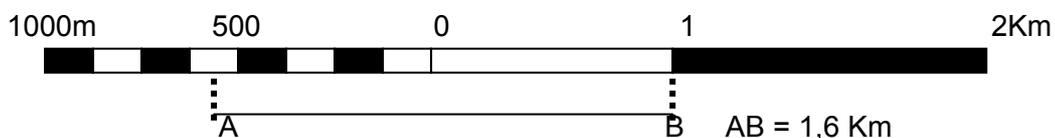
The graphical scale consists of a straight horizontal bar divided in equal segments. Each segment is limited by a small vertical line. The figures are written straight above these lines and are round figures.



The distances on the graphic scale are those on the mapped space.

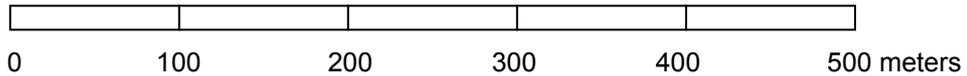
On topographic maps and all maps on which the determination of the distances is essential, the graphic scale is extended left from the zero by a graded segment with more precision, called the talon.

The talon is graded in the opposite direction of the scale.



Measurement of a distance AB by means of a talon.

The graphic scale can be completed by the design of an area unit. This is a useful indication in the case of land registry, agricultural or village properties where the assessment of the surfaces is primordial.



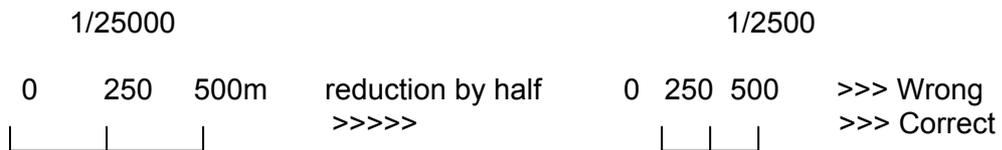
The visualization of the distances on a map is immediate with the use of the graphic scale

If one does not dispose of a numerical scale, such distances are assessed by calculation.

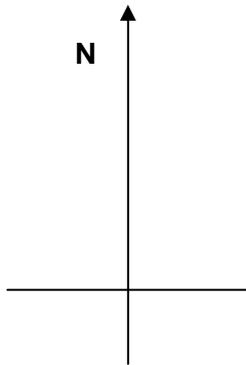
The graphic scale must be applied with documents that are to be enlarged or reduced as this scale will undergo the same variations as the entire image. It is indispensable on cartographic documents produced on a computer that easily reduces and enlarges images, especially when the right format of reproduction is required.

On the other hand, a numerical scale becomes wrong and must be recalculated when the document undergoes such modifications.

One has to be very observant with the numerical scale on a document that seemingly is not original (for example in case of an enlargement or reduction by photocopier :



5.6 Bearings



The four (4) points of the compass, North, South, East and West define the bearings all over the world.

The North must always point at the topside of each map. The letter **N** is marked above an arrow that indicates the North.

Symbol for the orientation on each map.

5.7 The legend of a map

In the case of complex maps the accurate display of a legend is essential for the readability of the entire document. The legend is placed in a frame on the edge of the map.

The various themes of the legend are displayed and classified in an order that takes the issue of the subject into account. Each feature carries a clear description. The legend is arranged in features.

Environment et soil use	
	Forest with cultivation gaps
	Farming region
	Mining industry
	Charcoal

Legend

5.8 Magnetic variation

A compass is the best instrument to define one's bearings. However, its needle is not drawn towards the **true North** (the geographical North Pole), but to a very magnetical point situated about 800 Km, the **magnetic North** pole. The difference of the angle between the true North and the magnetic North is called the **magnetic variation**.

The magnetic variation changes according to the place on earth and on a given place with the time. The magnetic variation, that is always faint between the tropics, is indicated on good maps, with a description of the speed and amplitude of its change.

When using a compass it is important to take the magnetic variation into account. A small difference of angles at the starting point has very important consequences over large distances. So, one has to take this magnetic variation into account if one has to follow an exact direction over a longer distance or if long sections (for example a long transect or a boundary of a reserve) has to be mapped.

However, when walking shorter distances or not using a map (for example: when one uses a compass to reach a remote summit), one can ignore the magnetic variation. The magnetic variation can also be ignored with the design of a small scale map (for example: the map of an annual coupe).

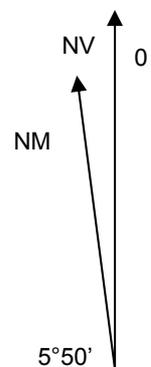
When the magnetic variation is ignored around the equator, it will cause errors of 50 to 100 meters per kilometer (about 17 meters per degree of variation and per kilometer distance).

To rectify the magnetic variation of, for example : the magnetic North is at $5^{\circ}50'$ East of the geographic North, the magnetic variation can be corrected by using a compass in one of the following ways :

The rose of the majority of compasses is fixed with a small screw that can be loosened, which allows to change its bearings to rectify the variation. In this case the dial must be placed in such a way that the needle and the red arrow of the dial are aligned so that the course read will be $360^{\circ} - 5^{\circ}50' = 354^{\circ}10'$.

If your compass cannot be adjusted in this way, you can add $5^{\circ}50'$ to the course that you want to follow. For example: If you want to walk plain eastward (90°), you follow the course $95^{\circ}50'$ indicated on your compass.

The magnetic variation in relation to the true North on January 1st, 1985 decreases with $6'$ each year.



5.9 Cartographic projections

The earth is a sphere, the map is a plane. How to flatten a curved surface?

Such an operation cannot be done without some distortions. It is important to have an idea of the scope of the alterations to choose the type of map that is best adapted to them.

5.9.1 Different projection systems

A projection system or more precisely, a **flat reproduction system**, are operations allowing to pass from the spherical shape to the flat representation of a map.

The geoid is the theoretical shape that approaches most the real surface of the globe. Apart from the geoid, it is necessary to calculate a regular mathematical surface called the **Reference Ellipsoid**.

Many different ellipsoids can be adjusted to the surface of the earth:

- Local ellipsoids for the local determinations
- Global ellipsoids for the mondial systems
- The Clark's ellipsoid (1880) is applied for the Gabonese topographical maps
- The Hayford's ellipsoid (1909) is reserved as international ellipsoid.

A certain point on the surface of the globe is located by its longitude (East or West of the Greenwich meridian and its latitude (North or South of the equator), expressed in degrees.

A **flat reproduction system** establishes through a calculation a correspondence between the points of an ellipsoid and those of the plane of a map. This operation describes on the plane the transformation of surfaces, distances and directions. The flat representation systems are classified according to the alterations and the construction mode.

5.9.2 The choice of projection

The calculation of the projections is irrefutably the task of specialists. For the geographer the choice of projection is based on various circumstances:

- For large scale plans and maps the problem is negligible, the rounding of the earth hardly being perceptible
- At the scale of continents, the transformations become considerable. The planispheres show the most important transformations
- Two maps that have not been drawn up in the same projection system cannot match
- Certain projections are preferred in relation to the latitude, the extent or the shape of the area to be depicted
- To convey the signs of distribution or intensity, one has to choose equivalent projections that retain the surfaces
- For example with navigation maps (marine or aviation maps) identical projections are used that maintain the angles, so also the directions
- The projection must be adapted to the treated subject. The projections aimed at the strategic region. In Gabon these are the Clark system (1880) and the UTM (universal Transverse Mercator)
- For the maps at small scale, the transformations can be considerable and very much different in relation to the projection system applied.

6. THE MAP IN ITS PROPER SENSE

A map is a conventional flat representation in relation to concrete or abstract phenomena locating in the space. The map can also show variations and developments of phenomena in time as well as their factor in changes and positions in space.

The elements of a map are:

- The scale (numerical or graphical)
- The grids giving the geographical co-ordinates of a point : latitude, longitude
- The « kilometrical », giving the rectangular co-ordinates X_a and Y_a in a MTU projection system on a Clark (1880) ellipsoid
- The relief : represented by contour lines and gradients, which is the co-ordinate Z_a
- Special lines (slopes and escarpments)
- The planimetry (physical biological or human phenomena, either natural or artificial)
- The magnetic variation (with regard to place and time)
- The legend that gives the meaning of the conventional signs used
- The date of publishing and indication of survey and source of the data.

7. USE OF THE MAP

7.1 The cartographic communication

In the cartographic communication nature or the environment is the source of information, the registrator is the symbolic of the map (conventional signs: the signal is the design in two dimensions, created by the human brain)
The connection is now the map or plan, the signal and the deciphering.

If a map is not comprehensible for its user, it has not fulfilled its functions.

The ideal cartographer must psychologically understand the users of the maps and also must he master the cartographic techniques and their symbolics.

7.2 Use of a forestry map

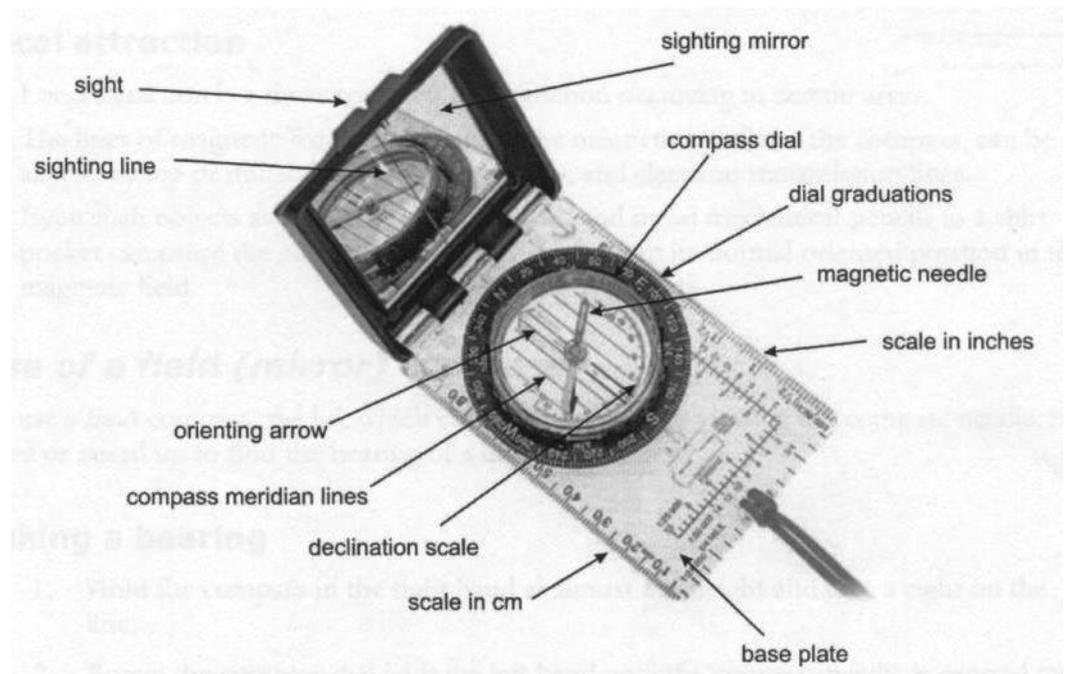
The grid at the bottom of the map is a support to materialize the position of objects on the ground.

8. THE COMPASS

A compass is an instrument composed of a compass rose in the centre of which a movable magnetic needle is fixed. It shows us the direction on a horizontal level starting from the North. Describing a full circle, it is divided into 360 equal sectors, called degrees. These degrees are numbered starting from the North ($0^\circ = 360^\circ$) following the circle in the clockwise sense.

8.1 Characteristics of the compass

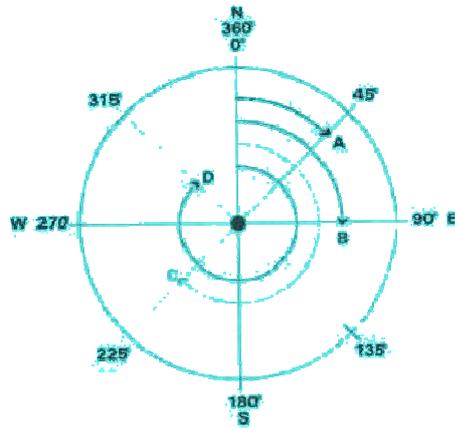
- A rotating compass rose to indicate the wanted quarter
- A sight to aim the compass straight at the object in question
- A sighting line to align the compass towards the object in question
- A magnetic needle with a red point that always points towards the North and that can freely pivot when the compass is held horizontally
- The needle is enclosed by a liquid that buffs the vertical and horizontal movements of the needle
- An arrow for the orientation is marked on the compass rose that can direct the compass towards the object in question.



8.2 Reading the marks on the compass

8.2.1 The azimuth

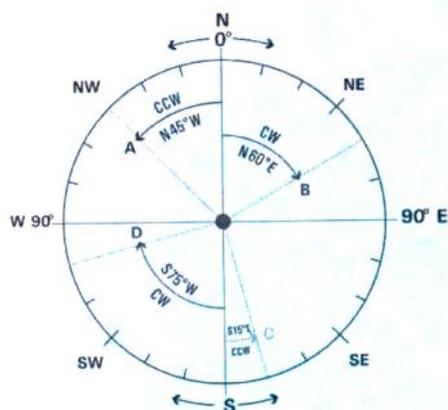
Supposing the user or a point on the map is in the middle of a circle, the direction is measured by following the circle clockwise going from 0° to 360° . The direction is then called « azimuth x° ».



Some compasses have sighting mechanisms or mirrors that allow to see at the same time the object and the numbers on the rose. This gives a more precise reading.

8.2.2 The quarters of the compass

The quarters of the compass are the rectangles related to the quarters of a circle. A quarter can not be larger than 90° and they are always measured starting from the line North – South. They are for example called: N45E or S30W.



- Apart from the 4 quarters (North, East, South and West) the compass indicates the directions in degrees ($^\circ$). There are 360 degrees in a circle. North is always 0° or 360° . East is 90° , South is 180° and West is 270°
- The circle can even be subdivided: North-East is exactly in between North and East at 45° , North-North-East and East-North-East are exactly in between North, North-East and East at respectively $23,5^\circ$ and $68,5^\circ$, etcetera.
- The other directions are generally described by their number (or course), for example 49° .

8.3 True readings and magnetic readings

- The magnetic reading is the angle of the reading line with the magnetic North – South line.
- In case the magnetic variation is indicated on the compass by setting of the rotating dial, all readings have become the true readings.
- If, however, the magnetic variation has not been set with the dial, all reading are magnetic readings.

8.4 Local force of attraction

- Local force of attraction is a common phenomenon in certain areas
- The lines of magnetic force that orientate the needle of the compass scan be modified by deposits of iron ore, iron fences or high-tension cables.
- Oven objects like cutlasses, gun barrels, skidding wires or metal pens can cause a compass to deviate from its normally oriented position in the magnetic field.

8.5 Use of the compass

8.5.1 Reading

1. Put the compass horizontally on your hand or on a picket, so that the needle can turn around freely and almost on the level of your right eye and aim at the chosen object
2. Turn the dial with your left hand until the magnetic needle is centered on the orienting arrow
3. When the needle is stabilized, align the « N » on the dial with the red or dark side of the needle. When the « N » for North is on its place, you can read the other directions (South, East or West) on the dial
4. Determine the reading on the index of the dial.

8.5.2 Moving in a given direction

1. Turn the dial until the arrow points in the chosen direction
2. Hold the compass right in front of your chest
3. Pivot your body until the magnetic needle has aligned itself on the arrow
4. Choose a bearing point in line with the chosen direction and aim at that point through the sight
5. Whilst aiming at the bearing point, look at the needle in the mirror to assure that the needle converges with the arrow.

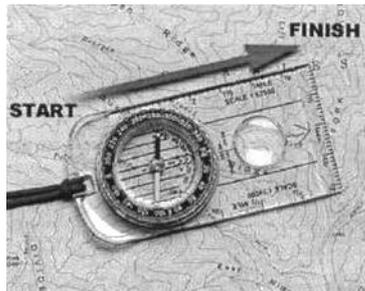
8.5.3 To locate your position in the forest

1. Choose two bearing points on your map
2. Aim your sight at one of these bearing points on the ground
3. Turn the dial until the magnetic needle aims at the N at the dial
4. Read the bearing on the index
5. Place the compass on the map with the alignment touching the bearing point

6. Turn the compass until the orientating arrow is in line with the North magnetic lines
7. Draw a line on the map from the bearing point along the alignment of the compass
8. Repeat this process with the other bearing point
9. The intersection of the two lines indicates your position

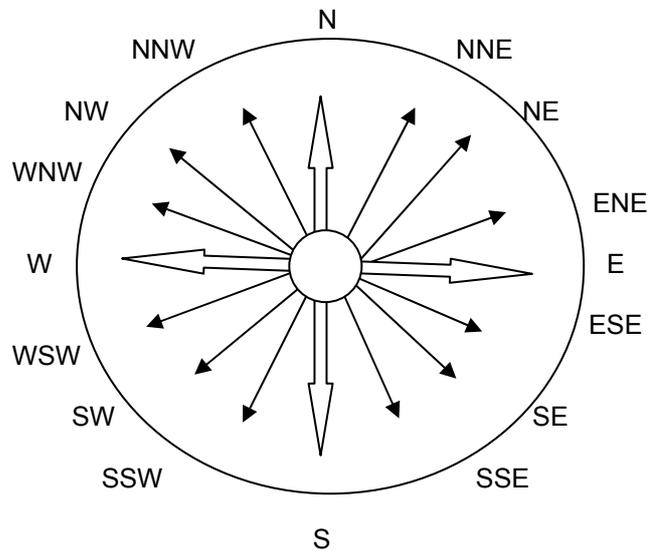
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8.5.4 To determine your direction with the use of the compass and the map



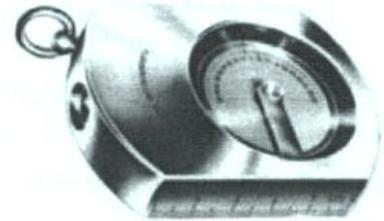
1. Place the compass on the map with its alignment connecting your actual position (start « A ») with your goal (picture 8)
2. Turn the dial until the « N » is aligned with the magnetic North on the map with a compass without corrected variation and with the true North on the map with a compass with corrected variation (picture 9)
3. Hold the compass in front of your breast with the sight in straight ahead direction (picture 10)
4. Pivot yourself until the magnetic needle points in the same direction as the orientation arrow

5. Raise your eyes and find a bearing point on the ground in exactly that direction
6. Direct yourself in that direction and repeat these actions until you have reached your chosen destination.



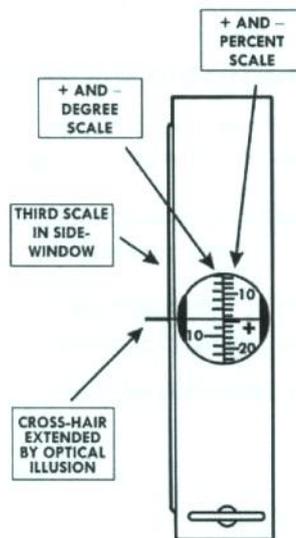
9. THE CLINOMETER

The clinometer is an instrument to measure the vertical angles of a line of sight above or under the horizontal. The instrument is used in the forest to measure the height of trees and the angle of slopes.



9.1 Use of the clinometer

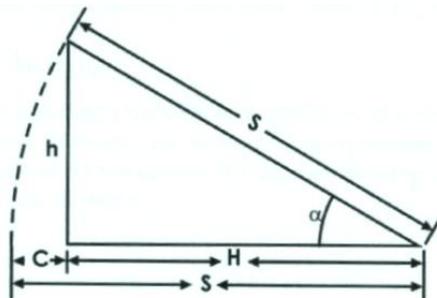
- There are two scales:



- The left scale indicates the angle of the slope in degrees taken from the horizontal position at eye level.
- The right scale indicates the height of the sighting point taken from the same horizontal position at eye level expressed in percentage of the horizontal distance.
- Step-by-step use :
 1. Read the scales with your right eye
 2. Keep both eyes open
 3. The supporting hand shall not obstruct the sight of the left eye
 4. The instrument is held in front of the reading eye (right eye) so that the scale is readable through the optical with the round window towards the left
 5. The clinometer is aimed at the object
 6. Looking with your right eye through the ocular you will see the slope measuring scale and a horizontal line



7. Aim with your left eye at the object to be measured (like the top of a tree)
 8. Because of an optic illusion the line seems to continue outside the frame and is therefore easy to be seen in combination with the scale and the object
 9. Next the instrument is lifted or lowered until the horizontal line is seen against the point to be measured
 10. When the horizontal line is aligned with the top of the tree you read the scale to find the angle in degrees or in percentage
 11. To measure a slope you have to aim at an object at the same level as your eye
 12. Take 3 times again your measurements and calculate the average of the 3 results
- Calculation of a height :
The calculation of the difference in height between two points is easy as soon as the percentage of the slope and the horizontal distance are known:



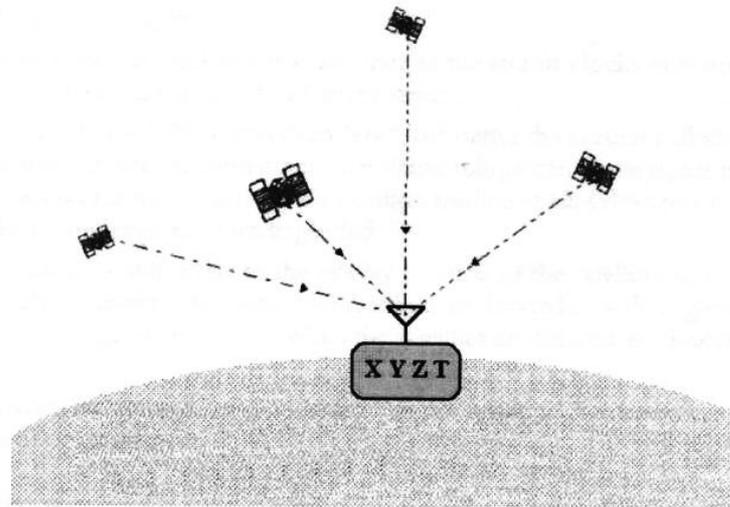
S	=	slope distance
h	=	difference in elevation ($S \times \sin \alpha$)
H	=	horizontal distance ($S \times \cos \alpha$)
C	=	correction or ($S - H$)

1. The horizontal distance is calculated as $H = S \times \cos \alpha$ or read in the slope correction table
2. The given percentage ($h/H \times 100\%$) is multiplied by the horizontal distance H and gives the difference in height h.
3. **Add the difference in height to the known height of your departure point.**

10. THE GPS

10.1 The functioning of the GPS

- The Global Positioning System (GPS) is in fact a composition of 27 satellites turning around the earth and communicating with receivers on the ground or in the air.
- The GPS satellites turn around the earth and transmit information signals
- GPS receivers catch this information and calculate the exact position of the user
- Essentially the GPS receiver compares the moment that a signal has been transmitted by a satellite with the moment that signal has been received. The difference in time between the two moments indicates for the GPS the distance at which the satellite is located
- The position of the user is determined by the distance measurements from several satellites and is depicted on the electronic map on the screen
- A GPS receiver must follow the signal of at least 3 satellites to calculate a bi-dimensional position (latitude and longitude) and the movement of the track
- The receiver can determine the tri-dimensional position (latitude, longitude and altitude) of the user with the signal of at least 4 satellites



- As soon as the position of the user is determined, the GPS can calculate other information, like the speed, the direction the track, the distance of the trip, the distance to the destination, the time of sunrise and sunset, etcetera.

10.2 The system of the GPS satellites

- The 27 satellites that form the segment of the GPS space turnaround the globe at an altitude of about 19,000 kilometers
- They complete two tours around the globe within less than 24 hours
- They advance at a speed of about 11,000 Km per hour

- They are propelled by solar energy
- The GPS satellites transmit 2 radio signals at low power. These signals. These signals advance by visibility lines, meaning that they pass through clouds, glass and transparent plastic, but not through most of the solid objects like buildings and mountains.

10.3 Sources of error of GPS signals

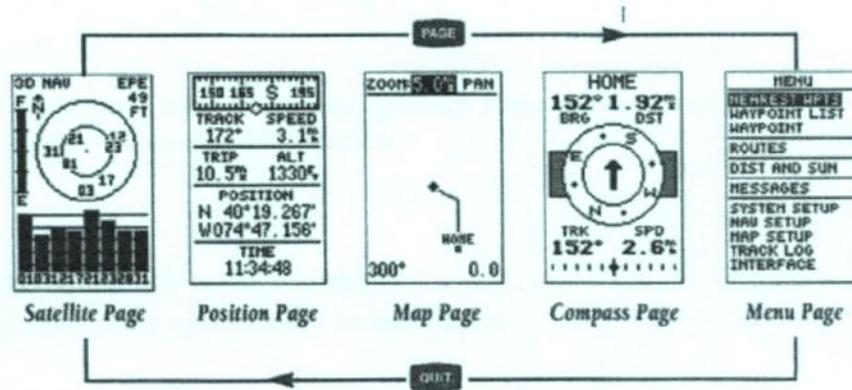
Factors that can degrade the quality of GPS signals and consequently affect their precision include the following:

- The signal of the satellite slows down whilst passing through the atmosphere. The GPS system used a modulator that calculates an average of the delay to partly rectify this kind of error. The total of errors can amount to 10 meters.
- « Multipath » of the signal means that the GPS signal is reflected against massive objects like large buildings or rock formations before reaching the receiver. This fact increases the advancing time of the signal, which causes errors.
- The clock incorporated in the receiver is not as precise as the atomic clocks on board of the GPS satellites. The clock errors can result in errors of one meter
- The more satellites the receiver can catch, the better its precision will be. Buildings, landscape, electronic interference or even sometimes the foliage of a forest can block the reception, causing errors in the positioning or even no indication at all. GPS does not function in the interior of buildings, underground or under water.
- The shadow of satellites relate to their relative position at any given time. An ideal geometry of the satellites exists when the satellites are positioned in relatively large angles. Poor geometric results occur when the satellites are aligned or in a close group.

Other errors, including a selection of geodetical dates, can cause errors of between one and one hundred meters.

10.4 The GPS receiver

- As soon as the receiver has been started up, one has to check if the almanach is updated and if necessary, if it updates itself automatically. Next, it searches and enters into satellites in sight and thereupon calculates a cross location of the satellites by using the parameters of the receiver.
- The receiver has been developed to catch, to stock and to manipulate data within certain limits, to present these data visually and often to download them onto a computer.



Most of the GPS receivers have problems receiving through forest canopies, which make a reliable use dependent of the use of gaps in these canopies.

10.5 Use of the GPS

The GPS is very useful to precisely locate the position of an object. This facility is amply used in the forest. Some of these applications are:

- The collection of data on the positions to be introduced into maps. This can vary from drawing up a map and the positioning of limits / boundaries to the positioning of individual trees.
- The provision of data to find back a position. This is specifically useful when searching Permanent Sample Plots, that are only being visited once every five years or so.
- The navigation, either by referring to data that are stocked in the receiver, or by co-ordinates on a map. This is specifically useful with the back-tracing of a road.

10.6 « Waypoints »

The receiver registers an actual position when the button « Waypoint » is pushed. A series of these points can be made up along a road, which makes back-tracking easy. Some receivers give directives to return to a given reading point by showing a compass reading and a distance.

10.7 « Track » (continuous map)

The Track registers and shows a digital map of a road that has been followed. The biggest disadvantage of this hand-held instrument is its high battery consumption. The data can be down-loaded onto a computer and applied onto a map (SIG).

It is difficult to operate a GPS receiver in a dense forest. The vegetation can interfere with the signals sent by the satellites, so if you are in the forest, you have to look for gaps in the canopy allowing to catch the satellites.

In lower vegetation, you can try to fix your GPS receiver on a long pole and lift it to above the foliage.

There are today 24 navigation satellites in orbit at 17,500 Km altitude.

The position given by a GPS is shown in geographical co-ordinates or in UTM and can be transferred onto a map, which allows you to know what your

location is. That location will not be completely exact, but generally at 100 meters near.

Yet, the GPS receiver must at all times be started up in an open area and be left switched on to avoid it losing contact with the satellites. If you do not immediately receive a signal, try to move 10 – 20 meters, which might allow you to receive the signal. You can also wait 10 – 20 minutes for the satellites to change position.

All foresters and sustainability managers must have a GPS receiver at their disposal.

11. BASIC CARTOGRAPHY (SUSTAINABILITY MANAGEMENT)

Sources: National Institute for Cartography, documentation on remote sensing (satellite images, aerial photography), compass readings, GPS readings.

11.1 Map I. National map of Forest Concessions under Sustainable Management

Handed out by the Ministry of Forestry, featuring:

- Topography
- Hydrography
- Road network
- Waterways network

The national map of forest concessions allows the forester to identify the boundaries of his concessions with his neighbors, the infrastructure of the country (roads, railways, waterways) and the position of their mutual work areas and in relation to the destination of his products (factory, harbor). It also allows him to plan the procurement of other concessions and to plan at long term the production programme of his enterprise.

11.2 Map II. Management map of the Concession under Sustainable Management (CSM)

Scale 1/200.000, format A2, NIC or LANDSAT, featuring:

- Boundaries of the concession, the FMU's and their quinquennial plans
- Other management series (protection and conservation, agro-forestry)
- Human settlements
- Topography
- Hydrography
- Contour lines (or isohypse lines) or
- Images of the relief

The map of the Concession under Sustainable Management (CSM) displays the exact boundaries, according to the readings indicated in the official allocation by the Forestry Ministry. This very map serves for the location of the Forest Management Units (FMU) and the Quinquennial Units (QU).

Featuring the boundaries of the FMU, this map serves as base for the establishment of the planning of the Sustainable Management Inventory (sample survey planning, etcetera), next the subdivision in Quinquennial unit and finally the subdivision of these QU in Annual Coupes (AAC) consisting each of 1/25 or 1/30 of the surface of the FMU.

The provisory planning of the access roads and main roads can also already be made in this stage with the help of this map.

11.3 Map III. Map of the FMU and its QU

Scale 1/50.000, format A2, NIC or LANDSAT maps, featuring:

- Boundaries of the FMU and its QU
- Existing and planned roads and constructions
- Human settlements
- Topography
- Hydrography
- Contour lines

The map of the FMU and its QU show on a scale of 1/50.000 the boundaries of the QU, of the AAC and the contour lines, which allows for a provisional planning, but more precisely the tracking of the access and main roads according to the topographic and hydrographic data.

11.4 Map IV. Map of the QU and its AAC

Scale 1/125.000, format A3, NIC or GIS map, featuring:

- Boundaries of the QU and its AAC
- All existing access roads, main roads, secondary and side roads, as well as the hydraulic constructions such as bridges and important culverts
- Planned road network (access roads, main- and secondary roads and bridges)
- Human settlements
- Topography
- Hydrography
- Contour lines

The map of the QU and its AAC serves for the planification of the road network, (access roads, main- , secondary and side roads, bridges and log landings. It serves also to plan the inventory by projecting the first base lines across the AAC (see Cartography of the Logging Inventory here below).

Once this inventory has been completed for half of the surface of the AAC, the side roads and log landings can also be tracked.

12. CARTOGRAPHY OF THE LOGGING INVENTORY

12.1 Map III. Map of the FMU and its QU

Scale 1/50.000, format A2, NIC or LANDSAT maps, featuring:

- Boundaries of the FMU and its QU
- Existing and planned roads and constructions
- Human settlements
- Topography
- Hydrography

Based on the sustainable management inventory data (zoning according to human settlements, protected areas, different types of vegetation, hydrography), the first inventory plan is established. The zoning allows already to decide on the intensity of the inventory in the different areas.

Areas that are recognized as poor or hard to reach do not need an intensive inventory, whilst areas with more important stands will require an intensity of 100% of harvestable individuals.

12.2 Map V. Map for the inventory line cutting plan of the AAC

Scale 1/50.000 or 1/30.000, format A4 or A3, reduction of map IV, drawn by GIS or by hand, featuring:

- Boundaries of the AAC
- Principal numbered lines
- Subdivision in compartments or pockets
- Numbering (identification) of the lines
- Topography
- Hydrography

On this map will be projected the lines of the compartments or pockets and their designation (in figures and letters for the latitudinal and longitudinal lines) for the inventory.

This map will be used by the line cutting team to open the boundary lines of the compartments or pockets.

12.3 Map VI. Inventory map of the AAC

Scale 1/10.000, format A0, drawn by GIS or by hand, featuring:

- Boundaries of the AAC
- Subdivision in inventory parcels
- Topographic, hydrographic and relief data (according to GIS and enumeration sheets)
- Identification (numbering) of the parcels or compartments
- Location of the harvestable trees, future crop trees and trees to be protected per species and per DBH group (according to GIS and enumeration sheet)
- Existing main and secondary skidding tracks
- Buffer zones

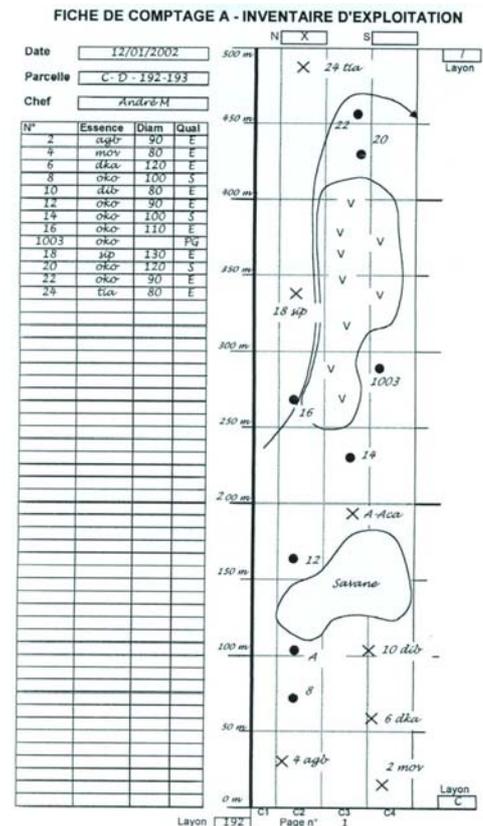
- Topography
- Hydrography

The completed inventory map of the AAC is fixed at the office of the forest manager and serves as an outline of the situation in the AAC under operation with its constructed and planned roads and tracks, the enumerated and still to be enumerated parcels or compartments.

12.4 Enumeration sheet

One for each enumeration strip of the parcel or compartment. Scale 1/1.000 – 1/2.000, format A4, folded by hand, featuring:

- Number of the parcel/enumeration line in the compartment
- Grid on which the sketch of the strip on scale 1/500 for each 50 meters
- Identification and location of all trees (harvestable, future or to protect), per species and DBH group
- Summary of the enumerated trees (on the side of the grid or on the back of the sheet)
- Data on topography, hydrography and relief and soil characteristics
- The enumeration and data on topography, hydrography and relief and soil characteristics are integrated by hand or by GIS into the inventory maps of the compartment or parcel and of the AAC



Enumeration method by CEB

- A multitude of systems to divide the AAC is used :
 - Square compartments of 50 – 100 hectares, divided into strips of 100, 125 or 200 x 500 -1000 m
 - Parcels in strips of 200 x 500 – 2000 m
- The efficiency of each technique depends on the number of tree enumerators engaged.

12.5 Map VII. Inventory map of the compartment or pocket

Scale 1/3.000 – 4.000, format A4, drawn by GIS or by hand, featuring:

- Inventory of the trees, eventually in sequence per AAC and location per species and per DBH group of each encountered harvestable, future crop tree or tree to be protected
- Summary of the enumerated trees (besides the grid or at the back of the sheet)

- Topographic, hydrographic and relief data according to the enumeration sheet
- Buffer zones

The enumeration sheets are collected at the inventory office and all their data are transmitted into the GIS software or by hand on the inventory map of the compartment or pocket.

A summary of the enumerated trees per species and per DBH group is drawn besides the map or at its back.

12.6 Map VIII. General map of the AAC

Scale 1/30.000, format A3, drawn by GIS or by hand, featuring:

- Hydrography
- Existing roads and skidding tracks
- Subdivision, boundaries and designation of the compartments (of 25, 50 or 100 ha) of the AAC **or** :
- Subdivision, limitation by natural boundaries and designation of the pockets (between 10 and 100 ha) of the AAC
- Inventory of the trees, each tree eventually numbered in sequence per AAC and location per species and DBH group
- Codified summary of the number of trees per species to be felled in each compartment or parcel.

This map serves for the forest manager, his deputy and the foremen of the road tracking and tree sorting as means of orientation and memorizing with their daily work in the field. It can also be used as sketch for road planning, etcetera.

13. CARTOGRAPHY OF ROAD PLANNING AND CONSTRUCTION

13.1 Map II. Management map of the CSM

Scale 1/200.000, format A2, NIC or LANDSAT, featuring:

- Boundaries of the concession, the FMU's and their Quinquennial plans
- Other management series (protection and conservation, agro-forestry)
- Human settlements
- Topography
- Hydrography
- Contour lines (or isohypse lines) or
- Images of the relief
-

The map of the CSM serves as overview of the entire CSM permitting to reckon with the position of the roads and other infrastructures existing in and around the CSM during the planning of the road network and its connections inside the CSM

Updated with the data of maps III, IX and XI, map II will serve as road map of the CSM.

13.2 Map III. Map of the FMU and its QU

Scale 1/50.000, format A2, NIC or LANDSAT maps, featuring:

- Boundaries of the FMU and its QU
- Existing and planned roads and constructions
- Human settlements
- Topography
- Hydrography

Updated with the data of map IX, map III will serve as road map of the FMU.

13.3 Map IX. Map of the QU

Scale 1/125.000, format A3, drawn by GIS or by hand, reduction of map III, featuring:

- Boundaries of the CSM, the FMU's and QU's
- Existing and planned road network and constructions
- Boundaries of the concession and its FMU and QU
- Human settlements
- Topography
- Hydrography

The road tracking team can inspect and, where necessary, rectify this track on the ground, after which the road opening can start.

Such a map can eventually feature several QU, which has the advantage of a clear overview on the middle term planning.

Updated with the data of map XI, this map can also serve as road map of the QU.

13.4 Map X. Extract of map IX. Map of the QU

Scale 1/125.000, format A3, drawn by GIS or by hand, reduction of map III, featuring:

- Boundaries of the CSM, the FMU's and QU's
- Existing and planned road network and constructions
- Boundaries of the concession and its FMU and QU
- Human settlements
- Topography
- Hydrography
- Width of the roads and water ways with their buffer zones on a correct scale

After final location on the ground with the GPS the tracing on the map will have to be rectified!

Updated with the data of maps V and VII this map can also serve as road map of the QU.

13.5 Map XI. Inventory map of the AAC

Scale 1/7.500, format A4, reduction of map VI, drawn by GIS or by hand, featuring:

- Topography
- Hydrology
- Boundaries of the AAC
- Subdivision in inventory parcels
- Topographic, hydrographic and relief data according to GIS and enumeration sheets
- Designation of the parcels
- Location of the harvestable trees, future crop trees and trees to be protected per species and DBH group, according to GIS and enumeration sheets
- Net work of existing and newly constructed roads and skid tracks
- Buffer zones

After final tracking of the roads on the ground: rectification of the tracks on the map!

Updated with data of the GPS, this map serves as road map of the AAC.

13.6 Map XII. Extract of Map XI. Inventory map of the AAC

Scale 1/7.500, format A4, reduction of map VI, drawn by GIS or by hand, featuring:

- Topography
- Hydrology
- Boundaries of the AAC
- Subdivision in inventory parcels
- Topographic, hydrographic and relief data according to GIS and enumeration sheets
- Designation of the parcels

- Location of the harvestable trees, future crop trees and trees to be protected per species and DBH group, according to GIS and enumeration sheets
- Net work of existing and newly constructed roads and skid tracks
- Buffer zones
- Width of the roads and water ways with their buffer zones on a correct scale

NB: After final location by GPS of the roads: rectification of the tracks on the map!

This map is used by the road tracers and clerks for the sketches and planning of the roads, side roads, log landings, main skid tracks and side tracks.

13.7 Map VII. Inventory map of the compartment or pocket

Scale 1/3.000 – 4.000, format A4, drawn by GIS or by hand, featuring:

- Inventory of the trees, eventually in sequence per AAC and location per species and per DBH group of each encountered harvestable, future crop tree or tree to be protected
- Summary of the enumerated trees (besides the grid or at the back of the sheet)
- Topographic, hydrographic and relief data according to the enumeration sheet
- Buffer zones
- Roads and skid tracks already constructed

The width of the roads and waterways with their buffer zones are to be projected on the correct scale

NB: after locating the roads, tracks and landings by GPS: rectification on the map!

Copy of this map will serve for the Post-harvest inspection (abandoned trees or logs, quality of the selection, topography, etcetera).

14. CARTOGRAPHY OF THE SELECTION

14.1 Map VII. Inventory map of the compartment or pocket

Scale 1/3.000 – 4.000, format A4, drawn by GIS or by hand, featuring:

- Inventory of the trees, eventually in sequence per AAC and location per species and per DBH group of each encountered harvestable, future crop tree or tree to be protected
- Summary of the enumerated trees (besides the grid or at the back of the sheet)
- Topographic, hydrographic and relief data according to the enumeration sheet
- Buffer zones

The inventory map will guide the selector (or verifier of logs to be harvested) towards the enumerated trees for a selection according to species, quality and DBH.

On this inventory map the trees declared unsuitable for harvesting are erased.

The approved trees are marked on the map with a selection number, which in some countries will be used as the permanent identification number of the tree and its logs

The selector and his helper indicate the shortest way between the approved trees by a pencil stripe on the map and by a line marked on the ground with pickets.

Very large trees or trees that are in a very difficult situation to extract are marked on the map with a B (for Bulldozer).

After completion of the selection the map is handed over to the sustainable management office to be digitalized and entered in the GIS.

The map is from now on called: Map XIII Tree selection map.

CEB Tree selection and monitoring system:

The approved trees are provided with a set of 3 metal tags bearing the inventory number as well as the selection number or permanent ID number. These trees are marked on the tree selection map by their inventory number.

14.2 Map XIII. Tree selection map of the compartment or pocket

Scale 1/3.000 – 4.000, format A4, drawn by GIS or by hand, featuring:

- Location of the selected trees for felling with their selection number (= permanent ID number), species and DBH group
- Summary of the selected trees (besides the grid or at the back of the map)
- Topographic, hydrographic and relief data (according to the enumeration sheet)
- Buffer zones
- All data and sketches of the map

The selection map on A4 format will be distributed to the felling operators and clerks and also used for the drawing of map XIV. Selection map of the AAC.

Copy of this map will be used for the Post-harvest inspection (abandoned trees, quality of the selection, respect of the trees to be saved, etcetera).

14.3 Map XIV. Selection map of the AAC

Scale 1/7.500, format A0, drawn by GIS or by hand, adaptation of map VI, featuring:

- Boundaries of the AAC
- Subdivision in inventory parcels
- Topographic, hydrographic and GIS data (according to GIS and enumeration sheet)
- Designation of the parcels or compartments
- Location of the trees to be harvested, future crop trees and trees to be protected, by species and by DBH group (according to GIS and enumeration sheet)
- Summary of all trees located and codified in DBH groups
- Existing and planned roads and main skid trails
- Buffer zones
- Topography
- Hydrology

The inventory map of the AAC is fixed at the forest manager's office and updated; it serves as overview of the situation in the AAC under operation with its planned and constructed roads and tracks, the harvested parcels and compartments and for the adapted and more precise planning of the side roads, log landings and skid tracks.

15. CARTOGRAPHY OF THE FELLING

15.1 Map XIII. Tree selection map of the compartment or pocket

Scale 1/3.000 – 4.000, format A4, drawn by GIS or by hand, featuring:

- Location of the selected trees for felling with their selection number (= permanent ID number), species and DBH group
- Summary of the selected trees (besides the grid or at the back of the map)
- Topographic, hydrographic and relief data (according to the enumeration sheet)
- Buffer zones
- All data and sketches of the map

A copy of the tree selection map is handed over to the felling clerk or to the felling operators, who mark on it the trees felled with the falling direction.

After completion of the felling the updated tree selection map is handed over to the sustainable management office for digitalization and entering in the GIS.

15.2 Map XV. Felling map of the compartment (or pocket)

Scale 1/3.000 – 4.000, format A4, drawn by GIS or by hand, featuring:

- Location of felled and bucked trees with their permanent ID number, species and DBH group
- Summary of the selected trees (besides the grid or at the backside)
- Topographic, hydrographic and relief data (according to the enumeration sheet)
- Buffer zones
- Marking of the felled trees with an arrow indicating the falling direction
- Marking of the crosscut and bucked trees with a line on the arrow.

Copy of this map will serve for the post-harvest inspection (abandoned logs, respect of trees to be saved, etcetera).

16. EXTRACTION CARTOGRAPHY

16.1 Map XV. Felling map of the compartment (or pocket)

Scale 1/3.000 – 4.000, format A4, drawn by GIS or by hand, featuring:

- Location of felled and bucked trees with their permanent ID number, species and DBH group
- Summary of the selected trees (besides the grid or at the backside)
- Topographic, hydrographic and relief data (according to the enumeration sheet)
- Buffer zones
- Marking of the felled trees with an arrow indicating the falling direction
- Marking of the crosscut and bucked trees with a line on the arrow.
- Provisory tracing of tracks towards the felled trees

The trunk of trees to be protected during extraction (to be by-passed during the opening of the track) must be marked with paint or tape.

This map will be used by the clerk in charge of the planning and tracing of the skid tracks on the ground to orientate himself via the shortest and most efficient distance towards the felled trees. He marks the main and secondary tracks on the map and on the ground in a way that is clearly visible for the operator of the skidding engine, seated on his engine. It serves as sketch for the establishment of map XVI here below. After completion it will be deposited at the sustainable management office for digitalization and introduction in the GIS.

16.2 Map XVI. Extraction map of the compartment (or pocket)

Scale 1/3.000 – 4.000, format A4, copy of map XV, Drawn by GIS or by hand, featuring:

- Location of the trees selected for felling with their permanent number, species and DBH group
- Buffer zones
- Marking of the felled trees by an arrow indicating the direction of the fall
- Final tracing of the tracks towards the felled trees.

A copy of the extraction map will be handed over to the extraction clerk or to the skidder operators, who will use it to find the position and the number of logs. They will cross the extracted logs on the map.

After completion of the skidding, a photocopy of the map will be handed over to the sustainable management office for digitalization and introduction in the GIS.

Copy of this map will serve for the post-harvest inspection (abandoned logs, respect of trees to be saved, etcetera).

17. CARTOGRAPHY OF THE POST-HARVEST OPERATIONS

17.1 Map XI. Inventory map of the AAC

Scale 1/7.500, format A4, reduction of map VI, drawn by GIS or by hand, featuring:

- Topography
- Hydrology
- Boundaries of the AAC
- Subdivision in inventory parcels
- Topographic, hydrographic and relief data according to GIS and enumeration sheets
- Designation of the parcels
- Location of the harvestable trees, future crop trees and trees to be protected per species and DBH group, according to GIS and enumeration sheets
- Net work of existing and newly constructed roads and skid tracks
- Buffer zones

This map that will serve as road map will guide the responsible person for the post-harvest operations along all primary, secondary and side roads, log landings, skid tracks and water works to inspect the quality of felling, extraction, landings, their state of cleanliness (removal of offal, wires, filters, etcetera), maintenance, drainage capacity and, where necessary, blockage of side roads, leveling and drainage of landings, etcetera.

17.2 Map VII. Inventory map of the compartment or pocket

Scale 1/3.000 – 4.000, format A4, drawn by GIS or by hand, featuring:

- Inventory of the trees, eventually in sequence per AAC and location per species and per DBH group of each encountered harvestable, future crop tree or tree to be protected
- Summary of the enumerated trees (besides the grid or at the back of the sheet)
- Topographic, hydrographic and relief data according to the enumeration sheet
- Buffer zones
- Width of roads and streams with their buffer zones on the correct scale

The Inventory map of the compartment or pocket, the felling map (map XV) and the extraction map (map XVI) will guide the responsible person for the post-harvest operations, together with the logging register in comparing and verifying on the ground:

- The position of the enumerated and actually felled and extracted trees
- The applied felling technique

- The damage to the remaining stands
- The eventually abandoned trees and/or logs and the reasons behind it
- The eventual waste of wood during bucking, crosscutting
- The tracing after the harvest of the future crop trees, the seed trees or trees to be protected otherwise.

17.3 Map XV. Felling map of the compartment (or pocket)

Scale 1/3.000 – 4.000, format A4, drawn by GIS or by hand, featuring:

- Location of felled and bucked trees with their permanent ID number, species and DBH group
- Summary of the selected trees (besides the grid or at the backside)
- Topographic, hydrographic and relief data (according to the enumeration sheet)
- Buffer zones
- Marking of the felled trees with an arrow indicating the falling direction
- Marking of the crosscut and bucked trees with a line on the arrow.
- Provisory tracing of tracks towards the felled trees

17.4 Map XVI. Extraction map of the compartment (or pocket)

Scale 1/3.000 – 4.000, format A4, copy of map XV, Drawn by GIS or by hand, featuring:

- Location of the trees selected for felling with their permanent number, species and DBH group
- Buffer zones
- Marking of the felled trees by an arrow indicating the direction of the fall
- Final tracing of the tracks towards the felled trees.

18. SUMMARY OF THE MAPS

	Title	Scale	Form	Indications
I	National map of Forest Concessions under Sustainable Management	?	?	Issued by MINFOR-All concessions in the country
II	Management map of the Concession under Sustainable Management (CSM)	1/200.000	A2	Boundaries of the concession, FMU and QU, topo, hydro, etcetera
III	Map of the FMU and its QU	1/50.000	A2	Boundaries of FMU, QU, AAC, roads, topo, hydro, etcetera
IV	Map of the QU and its AAC	1/25.000	A3	Road net and planning, topo, hydro, etcetera
V	Map for the inventory line cutting plan of the AAC	1/30.000-50.000	A3 or A4	Reduction of map VI, division of AAC into compartments or pockets
VI	Inventory map of the AAC	1/10.000	A0	Identification and location of all enumerated trees in the AAC
VII	Inventory map of the compartment or pocket	1/3.000-4.000	A4	Identification and location of all enumerated trees in the compartment
VIII	General map of the AAC	1/30.000	A3	Topo, hydro, roads, compartments , enumerations
IX	Map of the QU	1/125.000	A3	Topo, hydro, roads, boundaries
X	Extract of map IX. Map of the QU	1/25.000	A3 or A4	Existing and planned road net
XI	Inventory map of the AAC	1/7.500	A4	Reduction of map V : line cutting
XII	Extract of Map XI. Inventory map of the AAC	1/3.500	A4	To be used for road planning, sketches, etcetera
XIII	Tree selection map of the compartment or pocket	1/3.000-4.000	A4	Tracing of the main tracks, tracing towards the stumps
XIV	Selection map of the AAC	1/7.500	A0	Overview of the situation in the AAC being harvested, updating
XV	Felling map of the compartment (or pocket)	1/3.000-4.000	A4	Adaptation of map XIII
XVI	Extraction map of the compartment (or pocket)	1/3.000-4.000	A4	Copy of map XV with tracing of tracks

19. STRUCTURE OF THE TRAINING

Theoretical training

- In a hall
- Seating places for the participants
- Blackboard or flip board with markers
- Maps (see 18. Summary of the maps)
- Text as under chapters 5 - 17
- Compass, clinometer
- Question round

Practical training

- Chapters 6, 7, 8, 9 and 10 will be demonstrated and discussed on the sites of the roads under construction
- Several compasses, clinometers and GPS
- Maps VI and XI in several copies.

Conditions to be fulfilled

- Availability of a hall with seating places, etcetera
- Situation on the ground as represented on the maps.

Tasks to be fulfilled by the instructor

- Lecturing of the theory concluding with a question round
- Explanation of the importance of each activity concluding with a question round and an open discussion.

Necessary instruments and material

- Several compasses, clinometers and GPS
- Maps VI and XI in several copies.

Personnel

- 1 instructor

Duration:

- 1 full day

20. CONCLUSION

As discussed here above, the development of the cartography of a logging operation proceeds step-by-step, all maps with their accumulated data resulting in new maps to be used in a next phase of the operation.

Costs and time invested in a clear and exact cartography are rapidly recovered.

A set of all maps explained here above in clean copies is to be kept in the software and in the files of the operation.

It will serve as a reference and consultation tool at any moment for the operation's management.

Saved like that it will avoid much double work and expenses with a next similar operation

21. SELECTED REFERENCES

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22. ABBREVIATIONS

AAC	Annual Allowable Cut, 1/5 of a Quinquennial Unit (QU)
ARCVIEW	A brand of geographic information system
CSM	Concession under Sustainable management
CITES	Convention on International Trade in Endangered Species
DBH	Diameter at Breast Height
DMA	Diamètre Minimum d'Aménagement
DME	Diamètre Minimum d'Exploitation
FMU	Forest management Unit : forestry unit for which a SFMP has been established for one rotation of 25 or 30 years or longer, divided into 5 or 6 or more QU
GIS	Geographic Information System, such as ARCVIEW or MAPINFO
GPS	Global Positioning System
MAPINFO	A brand of geographic information system
MINFO	Ministry of Forestry of any given country
NGO	Non-governmental Organization
QU	Quinquennial Unit, 1/5th of a FMU, divided into 5 AAC
RIL	Reduced Impact Logging
SFM	Sustainable Forest Management
SFMP	Sustainable Forest Management Plan