THEMATIC MAPPING OF THE FLEMISH FOREST COVER USING AERIAL PHOTOGRAPHY

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Abstract

As old forest inventory methods, based on questionnaires, become obsolete, a new procedure using remote sensing techniques has been developed.

The objectives are fourfold :

1. Analysis of the forest situation in Flanders
2. Forest inventory methodology development
3. Creation of a forest management data bank
4. Production of base maps with high planimetric accuracy

Basic material consists of colour infrared 1/30000 transparencies. Photo interpretation and processing is carried out using a Wild Aviopret APT-1 stereoscope and a Bausch & Lomb Zoom Transfer Scope.

The legend features species composition, development stage, ground cover percentage, management practice and ownership.

Data from interpretation, field work and supplemental sources are presented as a series of thematic overlays on a 1/5000 colour infrared orthophotomap.

Numerical processing is executed on a PDP 11/44 microcomputer. A Wild interactive graphic system (Synercom) is used for digitizing and area calculation. Automatic map production is performed on a Wild TA 2 drawing table.

Availability of stand boundaries in digital form enables generation of thematic computer maps.

1. Introduction

According to the decenial national forest survey (1970) the area under forest cover in Belgium totals 616.918 hectares, representing about 21% of the country. Forest units are unevenly dispersed and mainly concentrated in the southern part of the country.

About 44% of the forest area is state-owned or belongs to various civil administrations. Up to now, the public forest estate has been managed by the central forest administration as prescribed in the 1854 forest code. This set of laws and regulations unequivocally defines the role of the administration with respect to management, exploitation and conservation of all forests on public land. It has, however, no force of law within the private forests, representing the other 56% of the forest area scattered over more than 103.000 owners.

Within the decentralization policy of the national administrations it was decided in 1979 to transfer the authority on forests and inland water resources to the newly established regional ministries. This entailed the possibility to create different forest policies for the different geopolitical regions of Belgium (the Flemish, the Walloon and the Brussels region), in order to respond better to the local situation and requirements.

In compliance with this decentralization policy, a commission was formed in 1980 to formulate a new forest code for the Flemish region. A main difference between the existing legislation and the proposed forest code is that the latter will cover both public and private forests. A detailed inventory of all private forests, non-existing today, will be required by law. A management plan will be imposed when the area exceeds 5 hectares. Exploitation quota will be prescribed for private forest blocks of more than 50 hectares.

To alleviate the additional burdens of this policy for private owners, free technical advice and assistance can be requested from the forest administration.

Due to the dispersed character of the forest estate and the lack of information about the private forests, representing almost 70% of the Flemish forest cover (table 1), no global assessment of the forest resources is available. In view of the practical consequences of the forest code, a standardized survey of all areas under woody vegetation in Flanders is deemed of uttermost necessity.

Table 1 : Geographical distribution of the Flemish forest area based on ownership classes (in hectares)

Province	Ownership				
	State	Province	Munici-palities	Public Institu-tions	Private
Antwerpen	3234	243	3766	1586	27988
Brabant	8433	72	869	1314	23040
W-Vlaanderen	982	57	112	474	5680
O-Vlaanderen	453	141	160	772	11801
Limburg	3366	759	12108	804	18611
Total ha	16468	1092	17015	4950	87120
Total %	13.0	0.9	13.4	3.9	68.8

Source : " Een bos voor uw gemeente "
Stichting Leefmilieu
Documentatie no.8. pag.11.

In late 1981, the Ministry for the Flemish community, formulated a request for a pilot study on the methodology of such a venture. Within the framework of an IWONL (1) project, the resource assessment section of the remote sensing firm EUROSENSE BELFOTOP (2), in close cooperation with the Laboratory of Remote Sensing and Forest Management of the State University of Ghent, developed the practical approach. The Hallerbos (left-most top quarter of Belgian ordnance map sheet no.39/2-2 scale 1 : 10.000) was the pilot study area.

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(1) IWONL : Institute for Scientific Research in Industry and Agriculture.

(2) EUROSENSE BELFOTOP : Eurosense Belfotop NV. Vandervekenstraat 158, 1810 Wemmel.

Methodology and results were discussed with the forest administration. A project proposal for the thematic mapping of the Flemish forest cover was a brought up to ministerial level, as a first step towards a global assessment of the region's forest resources.

It should be clear that the project's task is to produce thematic forest maps, not only representing valuable working tools for the forest management, but also functioning as base documents for a continuous forest inventory. The purpose of this paper is to document background and approach of this mapping project.

2. Forest survey of the Flemish region

2.1. Existing cartographic documents

A multitude of detailed thematic maps could be expected in a small country as Belgium. However only an incomplete, heterogeneous and mostly antiquated package of cartographic information on the forest cover is available.

Although the forest administration has published a small manual on forest mapping with standardized instructions, making of large-scale forest maps is restricted to important forest units only.

Apart from such occasional large-scale forest maps and outdated hand-drawn documents, foresters in Belgium find their cartographical information sources limited to non-forest thematic maps (ordnance maps, ecological maps and regional planning maps). Moreover the forest type descriptions including symbols, colour codes and scales are non-uniform and inadequate for forest management purposes.

Ordnance maps are published by the NGI (3) at scales of 1/50000, 1/25000 and 1/10000 and encompass forest area delineation, distinguishing only 5 classes of woody vegetation :

- broadleaved forest and thicket
- coniferous forest
- poplar plantations
- tree orchards
- tree nurseries

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(3) NGI : National Geographic Institute (Belgium)

This classification permits a preliminar assessment of the available resources but does not provide the forester with enough information.

Top-soil maps, produced by the NGI in cooperation with IWONL, are at a 1/20000 scale. These show a very detailed soil classification, in fact much too detailed for practical use in forestry.

Ecological maps are rather rare and exist only for specific ecological entities. They are published under different formats and tend to view the forest resource from a purely biological point of view.

Regional planning maps are another source of information. They introduce vaguely defined and disputable vegetation classes as :

- forest
- nature preservation zones
- green belts
- buffer zones
- parks

2.2. The national forest enumeration

The latest assessment of the Belgian forest cover dates from 1980 and was carried out in the traditions of the 1950, 1959 and 1970 national forest enumerations. A discussion of the methodology falls outside the scope of this paper. Nevertheless it is thought relevant to summarize its most important characteristics, to illustrate the different approach as compared with the actual proposal.

The 1980 enumeration was meant to cover all broadleaved and coniferous tree populations. Included were all poplars, even roadside row plantations and single trees. Also waste land and areas larger than 0.02 hectares forming an integral part of a forest complex, although having no timber production at all (lakes, ponds ...), were included.

A questionnaire to all Belgian municipalities, requesting cadastral certificates and owner's identification for all forest lands, initiated this first phase of the nation-wide exercise. Answers had to be sent back to the N.I.S. (4), which in turn passed on a compiled

(4) N.I.S. National Institute for Statistics.

list of the received data to the concerned forest district offices. It was the task of the latter to ascertain the data according to the provisions of the forest code, for the publicly owned forest lands.

In a second phase, municipalities sent another questionnaire to all owners of forest lands not falling under the custody of the forest administration. Apart from requests for further administrative information, they contained questions about total forest area by species and management class for broadleaved units, by species and age class for coniferous stands, by plantation mode and age-class for poplars and by utilization class for non-productive forest lands. The addressees had the obligation to return the answers to the N.I.S. through the municipal enumerators.

The forest district offices were also requested to estimate the standing volume and the actual value of their properties as correctly as possible. Moreover, they were also asked to verify the questionnaires received from the other forest landowners, mostly private, within their district.

Once all data controlled and approved by the forest administration's inspectorate, the N.I.S. produced enumeration lists at different levels (municipality,forest district etc.) based on legal status and ownership class. As such, an assessment of the Belgian forest resource became available.

It should be said however that many of the parameters this enumeration is based on, as arbitrarily data entered by the forest land owners, are unacceptable in modern survey techniques. Hence one may conclude that the methodology of the ten yearly forest enumerations has proved to be too unreliable, inaccurate and slow for present day survey requirements.

3. The use of aerial photography for forest survey purposes

3.1. Advantages of remote sensing techniques

Remote sensing, in this case small-scale colour infrared aerial photography, was selected to assess the Flemish forest cover for the following reasons :

(I) The old survey method by questionnaires has proved to be inaccurate, incomplete, slow and therefore unreliable.

(II) Most forest entities are small sized, particularly the private forests. This implies intensive fieldwork resulting in high costs when inventoring without the use of remote sensing techniques.

(III) Aerial photography permits continuous updating of the documents.

(IV) Comparative cost-benefit studies between classical survey approaches and survey by means of aerial photography revealed the latter to be more cost advantageous.

(V) Remote sensing documents (orthophotomap/thematic overlays) provide a detailed geographic image. The database contains a quantitative approach of the forest cover.

3.2. Colour infrared aerial photography

Advantages of colour infrared aerial photography (CIR) for vegetation studies have been well documented in the professional literature, and should only be summarized here.

Tonality of the image, on CIR photos or transparencies, depends on both the reflected visible light (wavelenght 500 to 700 nm) and the reflected near-infrared energy (700 to 900 nm). Measurement of the reflectance characteristics in the 500-900 nm wavelength range corresponding with CIR film sensitivity, gives a specific curve including possibilities for vegetation identification.

Spectral reflectance of a green vegetation, is low in the blue and red (5%), high in the green (20%) and highest in the near-infrared (60 %) part of the electromagnetic spectrum. Low reflectance of blue and red light is a direct consequence of the absorption of these wavelenghts by chlorophyl a and b. High green reflectance of these leaf pigments results in plant populations appearing green to the eyesight. Because of the specific leaf structure, causing reflections in the multiple refraction-planes of the spongy parenchyma, near infrared reflection is very high.

Since the reflectance curve depends on the morphological structure and the physiological condition of the leaves, the former represents a kind of " fingerprint " or specific signature of the vegetation. Careful interpretation allows for stress-detection, such as pollution-damage, insect-attacks or other diseases.

CIR aerial photography covers the 700 to 900 nm part of the electromagnetic spectrum, wavelenghts forwhich the human eye is not sensible. Hence CIR images have an unusual colour, explaining the common name " false colour " photography.

While normal colour images depict all forests as green, CIR photography permits a direct visual delineation between broadleaved and coniferous trees. Nowadays, more detailed classification methods are available through refined image analyzing techniques. Pioneering work in this field has been carried out by CEVA (5) in Ghent, where an IWONL-backed research project on these items is still continuing.

3.3. The aerial photocover of Flanders

Although research revealed a photoscale of 1/20000 more optimal for a forest survey, financial considerations led to a 1/30000 scale.

CIR aerial photographs are taken from a twin-engined aircraft, characterized by high stability at low speed, to restrict photographic distortion to a maximum of 15 micron. The plane is equipped with 2 WILD RC cameras with WILD UAG II lenses (focal distance f = 15 cm) and sandwich filters to obtain a normalized colour balance. Optimal film exposure results from on lineshutter speed regulation through WILD PEM photoelectrical cells.

Polyester based Kodak Aerochrome 2443 infrared film is used for this forest survey. Colour balance discrepancies of different films are sensitometrically tested. Sensitometrical strips are exposed on the film to study the behaviour of the emulsion under specific development conditions, the ultimate purpose being the optimal adaptation of exposure time and sandwich filtering during the photoflight. This is essential to obtain a normalized colour balance for different films, necessary for a trustworthy and efficient photointerpretation.

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(5) CEVA : Centre for Vegetation Studies with Remote Sensing Techniques. State University of Ghent - Belgium

The Kodak Aerochrome 2443 film is developped in a Kodak Colour Versamat Roller Transport Processor 1811 with continuous monitoring of all development parameters. Development is carried out within 24 hours after photoflight, as to avoid fading of the latent image.

3.4. Production of the colour infrared orthophotomaps

All CIR orthophotomaps are produced by EUROSENSE BELFOTOP.

To obtain the topographical information required to produce an orthophotoplan, CIR stereo transparencies are scanned line by line on a Wild A 10 Aviomap restitutor, connected to a 128k memory PDP-11/44 minicomputer. The resulting tridimensional terrain model is further modified through an appropriate software to digital terrain data that are directly accessible to the Wild OR 1 Avioplan orthophotoprojector. The digital model serves as the main steering computer input, to produce a geometrically correct ortophoto-transparency on the ortphophotoprojector, at the same 1/30000 scale.

To obtain an optimal quality, each orthophotomap is produced with only one CIR transparency. In this way colour tonality within one ortophotomap remains uniform. If colour compensation is necessary, because of inferior quality of the original aerial photography, a Miligan colour compensator, adapted for automatic colour correction, it used.

The orthophoto-transparency of the Wild Avioplan is further enlarged to the desired 1/5000 scale via a Zeiss SEG rectifying enlarger, and centered out within the predefined orthophotomap frame.

Colour infrared orthophotomaps at a scale of 1/5000 are the base documents for the ensuing thematic mapping because of their high information content and their geometric accuracy. Area calculations can be carried out without further corrections on these documents.

Each orthophotomap (80 x 100 cm) covers exactly one quarter of a NGI 1/10000 map. It is identified with a serial number based upon the NGI framework. Enclosed colour print represents a detail of orthophotomap 16/2-1 imaging " Zoerselbos ".

4. Photo interpretation techniques

4.1. Equipment

The visual interpretation instruments fulfil one or more purposes : observation of the photographs, measurement of certain parameters or transfer of interpreted information from the photographs onto some kind of base map.

Essential in the process of aerial photo interpretation is the stereoscopic perception. It is a consequence of the human capability of binocular sight : while observing an object each of the two eyes records a distinct image, because both eyes are in a slightly different receiving position. The human brain then synthesises both images in a way that depth consciousness is added to the sight stimulus.

When aerial photographs of one flight line are made to overlap partly, the effect is identical in the sense that two images of a same area are recorded from a different angle. Using a stereoscope, it is possible to examine the common area of a pair of overlapping photographs, called stereopair, in stereovision. The overlap zone is further called effective zone.

A mirror stereoscope is made up of two mirrors set at an angle of 45°. As the distance between the mirrors exceeds by far the eyebase length, a wide field may be observed stereoscopically.

Zoom stereoscopes, on the other hand, allow for continuous variation of the magnifying factor within given limits. They are very useful for an in-depth examination of details as local stress-symptoms.

Photo interpretation of the Flemish forest is done with the Wild Aviopret APT-1 zoom stereoscope. This high quality instrument enables more information extraction from a stereopair than was previously possible with standard mirror stereoscopes. The magnifying range of the optical zoom varies from 3x to 15x.

Forest cartography requires also instruments to synthesize information, including the transfer of data from aerial photographies onto a base map. The Bausch & Lomb Stereo Zoom Transferscope allows simultaneous observation of a stereopair and a base map for a wide variety of photo and map scales. Moreover, the trans-

Colour infrared orthophotomap (16/2-1) of "Zoersel bos"
Scale 1:16.000

Date aerial photography: 22-07-83

ferscope is capable of optically rotating the image through 360° which facilitates the superposition of the photos on the map. In addition an anamorphic lens system allows the stretching of an image in one direction, resulting in a minor compensation of the geometric distortions in the photos.

4.2. Photo interpretation

Systematic examination of aerial photographies of an area reveals the physical nature of the forest stands through a qualitative and quantitative appraisal of different image parameters. Commonly interpreted parameters are the tonality or colour, the texture or granularity, the structure or texture-distribution in the image, the shape of the objects and their shadow, the relief, the site etc.

Interpretation and terrain verification allow to relate these photoparameters to the terrain situation. A photo interpretation key has to be established, whereby codes are connected to physical phenomena and combinations of different codes point to particular crown covers. Interpretation keys however are only valid for the images of the photo flight they are based on.

The photo interpretation key allows the delineation of homogeneous areas, corresponding to specific code combinations. Different code combinations may be related to : species composition, development phase or management class, age class, stand height, stand structure and structure of the crown cover. Finally shadow shapes and crown density are analyzed. A detailed visual interpretation may also lead to detection of stress symptoms, such as foliage decolorations, partial defoliation or dead trees.

4.3. Field verification

To relate the photo interpretation to the vegetation classes, ground thruth checking is required. The ortophotomap is an ideal document for this purpose as it offers optimal orientation possibilities.

A field survey of an entire forest area (Hallerbos) was carried out in order to obtain a valid and trustworthy photo interpretation key. Once a key has been established field verification can be reduced to less than 20 % of the forest area. Specially equiped and trained survey crews carried out the field work.

Boundary delineations proved to be very accurate. All forest units were sequentially numbered in the field and all characteristics were fully documented. Photographs of the main vegetation types were taken for further reference and training purposes.

5. Interpretation units

Photo interpretation classes sometimes proved to be too detailed for management purposes. Small groups of Robinia pseudoacacia trees for example were easily identified, but are of minor importance in an overal management concept.

In cooperation with the forest administration, photo interpretation units were combined to meaningfull entities and a standard interpretation legend was developed based on the Hallerbos test-area. In this way the original base map was transformed to a set of thematic overlays. Each of this transparent maps fits perfectly on the orthophotomap and depicts one of the following items.

(I) Species composition.
(II) Forest development.
  a. Age class.
  b. Percentage cover.
  c. Silvicultural system.
(III) Ownership.
(IV) Health status.

5.1. Species composition

The interpretation of the species composition was based upon the legend represented in Table 2.

Table 2 : Species composition legend

Code		Description	Map symbol
00		Bare terrain	TB
1*		Deciduous forest (<20% conifers)	
	11	Beech	B
	12	Oak/American red oak	E
	13	Poplar	Po
	14	Others or mixtures	LH
2*		Mixed deciduous forest (20-50% conifers)	
	21	Beech	B
	22	Oak/American red oak	E
	23	Poplar	Po
	24	Others or mixtures	LH
3*		Mixed coniferous forest (20-50% broadleaved)	
	31	Larch	L
	32	Scots pine	Ps
	33	Black pine (Corsican/Austrian)	Pn
	34	Norway spruce	Ep
	35	Douglas fir	Do
	36	Others or mixtures	NH
4*		Coniferous forest (< 20% broadleaved)	
	41	Larch	L.
	42	Scots pine	Ps
	43	Black pine (Corsican/Austrian)	Pn
	44	Norway spruce	Ep
	45	Douglas fir	Do
	46	Others or mixtures	NH
50		Open area	NB
60		Heather	He
70		Lakes and ponds	Wa

Bare terrain (00) covers recently harvested areas, as well as fire-devastated blocks or simply bare soils.

Deciduous forests with less than 20% conifers (1*) have been subdivided according to the economically important species. The mixed deciduous forest (2*) is intermixed with 20 to 50% of conifers. Class 21 and 22 indicate that beech and oak are the dominant species.

The mixed coniferous forests (3*) are also subdivided with reference to the dominant species. Coniferous stands (4*) mention the most important softwood species.

Classes 50,60 and 70 include areas of a forest complex having no timber production function.

5.2. Forest development

This map features both age class, crown cover percentage and silvicultural system as illustrated in table 3.

The development stage (young, medium, old, uneven aged) can be assessed from texture interpretation of the forest crown cover, rough texture corresponding to old stands.

Three crown cover-classes are that ample that visual interpretation has proved to be extremely accurate, even more accurate than assessment in the field.

The silvicultural system is often difficult to interpret, especially for many private forests where any management system fails. A separate class " to be determined " has been foreseen for these cases.

The class " not applicable " corresponds to non-forest areas(lakes, bare terrain ...).

Table 3 : Forest development legend

Item	Code		Description	Map symbol
Development stage/ age class	00		Not applicable	
	1*		Deciduous forest	
		11	Young	
		12	Medium	
		13	Old	
		14	Uneven aged.	
	2*		Coniferous forest	
		21	Young (0-20 year)	
		22	Medium (20-60 year)	
		23	Old (> 60 year)	
		24	Uneven aged	
Crown cover	0		Not applicable	0
	1		0 - 1/3	1
	2		1/3-2/3	2
	3		> 2/3	3
Silvicultural system	0		Not applicable	NT
	1		To be determined	TB
	2		High forest	HH
	3		Coppice with standards	MH
	4		Coppice	HA

5.3. Ownership

Ownership information is an entirely administrative matter. It plays, however, a major role in global forest statistics and management formulation. Therefore the ownership regime has been included, as illustrated in table 4. This is done using existing documents or after consultation of the forest administration.

Table 4 : Ownership

1* Managed by the forest administration.
- 11 State
- 12 Province
- 13 Municipality
- 14 Public institution

2* Not managed by the forest administration.

5.4. Phytosanitary assessment

The CIR image is a very useful tool for forest health status evaluation and mapping. Stress symptoms as pollution damage, fungal infection, insect attacks ... may be detected. Other phenomena (windfall, fire damage) are easily recognized. Therefore a map covering this subject should be included.

However a 1/30000 image scale and a fixed ten year interval between photoflights are not ideal. Therefore forest administration decided to monitor forest condition by more optimally planned CIR aerial photography over selected areas and at an appropriate scale. In the context of the acid rain problem 1/5000 flights are planned for damage assessment of coniferous stands in the Campine. As a consequence a phytosanitary map is no longer included in the project.

6. Area determination

Base document for the map production, including area determination, is a 1/5000 combined orthophotomap /draft-overlay. This draft transparent is the photointerpretation result containing all information necessary for thematic map production.

Stand boundaries are digitized from the base document, for area determination and automatic mapping. Customized software for this problem has been developed on a PDP 11/44 computer-based interactive graphic system (Wild Synercom), including a 100x120 cm graphic tablet, at EUROSENSE BELFOTOP.

This vector database contains all graphic information : delineation of interpretation units, municipality boundaries and forest district limits. Alphanumeric datafiles (coordinates, species, ownership ...) can be combined with the graphical data.

On line visualisation on the graphic display of the Synercom permits the operator to control and correct the resulting map during the digitalisation process.

Planimetric map accuracy is 2 by 2 mm resulting, for a 1/5000 scale, in a field accuracy of 1 are.

7. Forest data base

Each orthophotomap has a number corresponding to the topographic 1/10000 NGI map grid. This grid number constitutes the fundament of the databank structure. Also report generation is based on that framework.

A code for the different forest entities enables an evaluation of the forest cover fragmentation, including geographical situation and surface. Forest entities are described as unit areas with no gap larger than 100 meters within the units.

Every interpretation unit (IU) is coded by the Lambert coordinates of an at random point in the unit. This coordinate based identification, related to the upperleft corner of the orthophotomap,results in an unequivocal IU numbering. The data report concept is based on that number.

All interpretation results (species, development)and administrative data (ownership) for every IU, including its surface, are stored in the data base.

The data bank concept allows for updating and extension (stand volumes) of the information. The possibility to generate numerical or cartographic output, both global or thematic, is of special interest for the user.

8. Presentation of the results

The information is presented in cartographic (overlays) as well as in numerical form (computer output). Methodology and output are outlined in figure 1.

8.1. Cartographic output

The cartographic presentation is based on the CIR orthophotomap (80 x 100 cm) at a 1/5000 scale. Information is made available on transparent overlays (stable polyester film). A topographic overlay complementsthe thematic forest maps.

As such, the analogue output consists of 4 thematic overlays :

(I) species composition map
(II) forest development map
(III) ownership map
(IV) topographic map.

While the first two overlays contain interpretation data such as species composition (I), development stage/age class, crown cover and silvicultural system (II) respectively, the ownership map (III) also indicates the legal status of the forest specifying if management is carried out by the forest administration or not. Delineation of forest districts or subdistricts and municipalities is essential for the statistical report.

Map design is completely software based. An appropriate selection of drawing symbols symbolises the hierarchical level of boundaries : interpretation unit-, forest complex-, municipality -, forest district-, province- and state-limits. Careful choice of line pattern symbols provides the computermaps with the indispensible cartographic relief resulting in a strikingvisual discrimination between important classes (e.g. deciduous/coniferous). Within class differences are indicated, both on the map and in the data listing by an alphanumeric symbol. Fig.2 depicts a detail out of a species composition map.

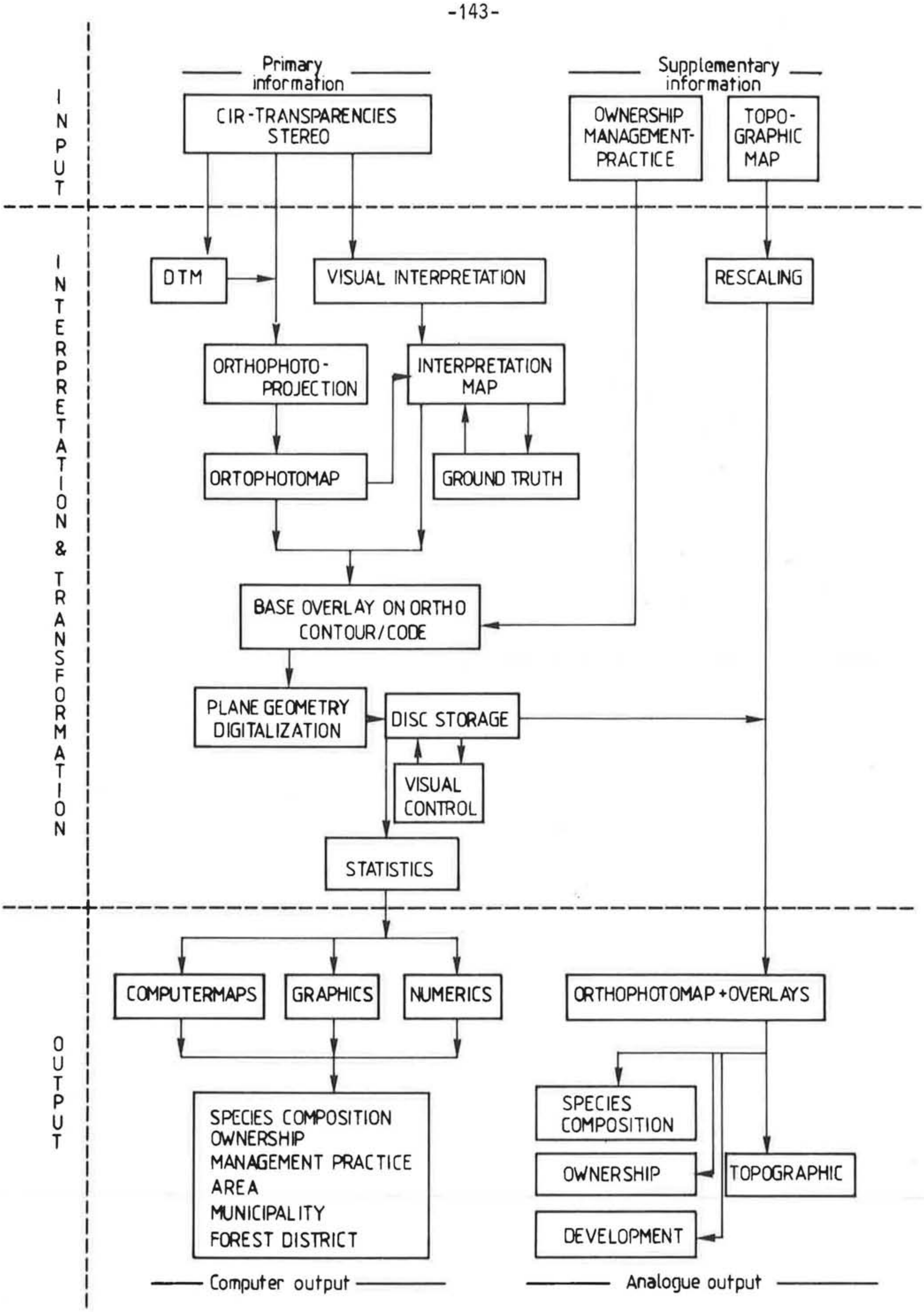

Fig 1: Methodology

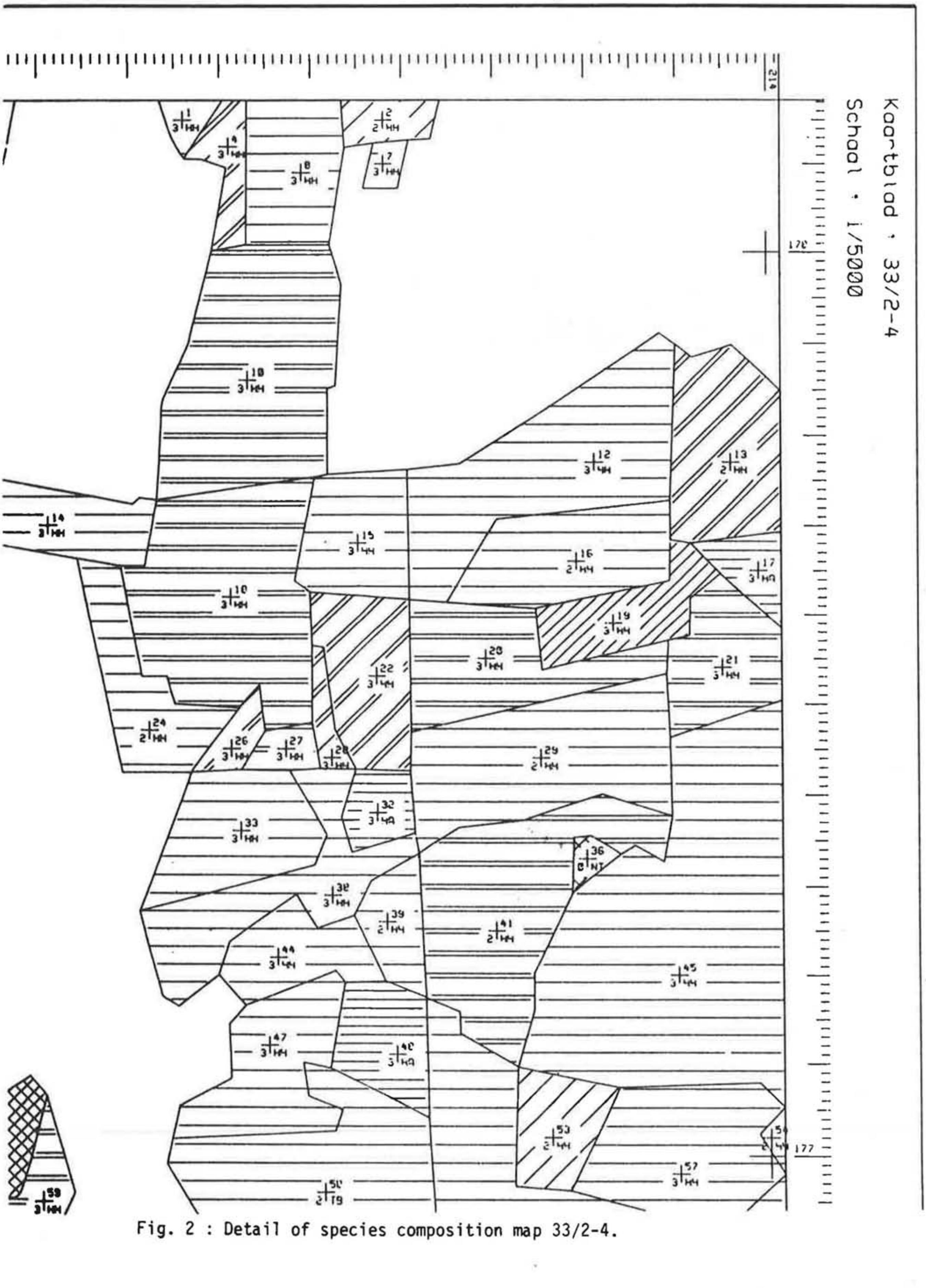

Fig. 2 : Detail of species composition map 33/2-4.

A plus (+) sign on the map indicates the at random point within every IU. The Lambert coordinates of this point are the parameters to treat the data. The IU number, based on this coordinates, is printed on the overlay to enable the link between forest map and data report. As the coordinates are related to the upper left corner of the map, the numbering continues from above left to under right. In this way one can easily locate an IU mentioned in the data report, on the map.

Important for the user is the possibility to generate thematic maps covering one or more preselected items. Figure 3 shows a quick look computermap of the state owned deciduous forest in the Hallerbos pilot study.

Fig.3 : State owned deciduous forest (Hallerbos).

Flexible interactive correction,updating and extension procedures of the maps are important in view of the ten-year forest mapping concept.

All forest maps are produced on an automatic WILD TA 2 drawing table, connected to a PDP 11/44 microcomputer.

The topographic map is a rescaled (1 : 5000) black and white copy of the existing NGI 1/10000 map on stable polyester film.

8.2. Numerical output

A comprehensive software package has been developed for data entry, data processing and report generation. A detailed description of the software falls outside the scope of this paper. Only the main facilities are mentioned.

The data base enables the generation of listings and reports for the different classes of the thematic maps. A standard report contains a complete datalisting corresponding to one orthophotomap (species, development, ownership, area ...) and a summary. This summary includes a statistical overview for the five ownership classes, mentioning the surface for each legend unit with a 1 are accuracy.

Figure 4 represents a detail of a statistical output. Other kinds of graphs (figure 5) or reports are possible using adequate sort keys.

Comparable reports for all forests belonging to a municipality or to a forest district can be generated, combining data of different ortphophotomaps. In this way present results become comparable with former forest enumeration data.

FOREST MAPPING OF THE FLEMISH REGION.

MAP: 16/3-1.
LILLE.

PHOTOFLIGHT: 22-07-83.

* PRIVATE FOREST *
* SPECIES COMPOSITION *

00/	BARE TERRAIN	KA		6.12 ha
1*/	DECIDUOUS FOREST (<20% CONIFERS)			83.99 ha
11/	BEECH	BE	2.19 ha	
12/	OAK/AMERICAN RED OAK	EI	3.66 ha	
13/	POPLAR	PO	26.50 ha	
14/	OTHERS OR MIXTURES	LH	51.64 ha	
2*/	MIXED DECIDUOUS FOREST (20-50% CONIFERS)			5.62 ha
21/	BEECH	BE	0.00 ha	
22/	OAK/AMERICAN RED OAK	EI	0.56 ha	
23/	POPLAR	PO	0.00 ha	
24/	OTHERS OR MIXTURES	LH	5.06 ha	
3*/	MIXED CONIFEROUS FOREST (20-50% DECIDUOUS)			12.89 ha
31/	LARCH	LA	1.06 ha	
32/	SCOTS PINE	GD	9.25 ha	
33/	BLACK PINE (CORSICAN/AUSTRIAN)	ZD	0.79 ha	
34/	NORWAY SPRUCE	FS	0.33 ha	
35/	DOUGLAS FIR	DG	0.00 ha	
36/	OTHERS OR MIXTURES	NH	1.46 ha	
4*/	CONIFEROUS FOREST (<20% DECIDUOUS)			155.38 ha
41/	LARCH	LA	3.98 ha	
42/	SCOTS PINE	GD	99.34 ha	
43/	BLACK PINE (CORSICAN/AUSTRIAN)	ZD	40.57 ha	
44/	NORWAY SPRUCE	FS	4.97 ha	
45/	DOUGLAS FIR	DG	0.22 ha	
46/	OTHERS OR MIXTURES	NH	6.30 ha	
50/	OPEN AREA	NB		0.00 ha
60/	HEATHER	HE		0.00 ha
70/	LAKES & PONDS	WA		0.00 ha
	TOTAL AREA PRIVATE FOREST			264.00 ha

Fig.4 : Detail of the statistical ouput : species distribution for the private forests of map 16/3-1.

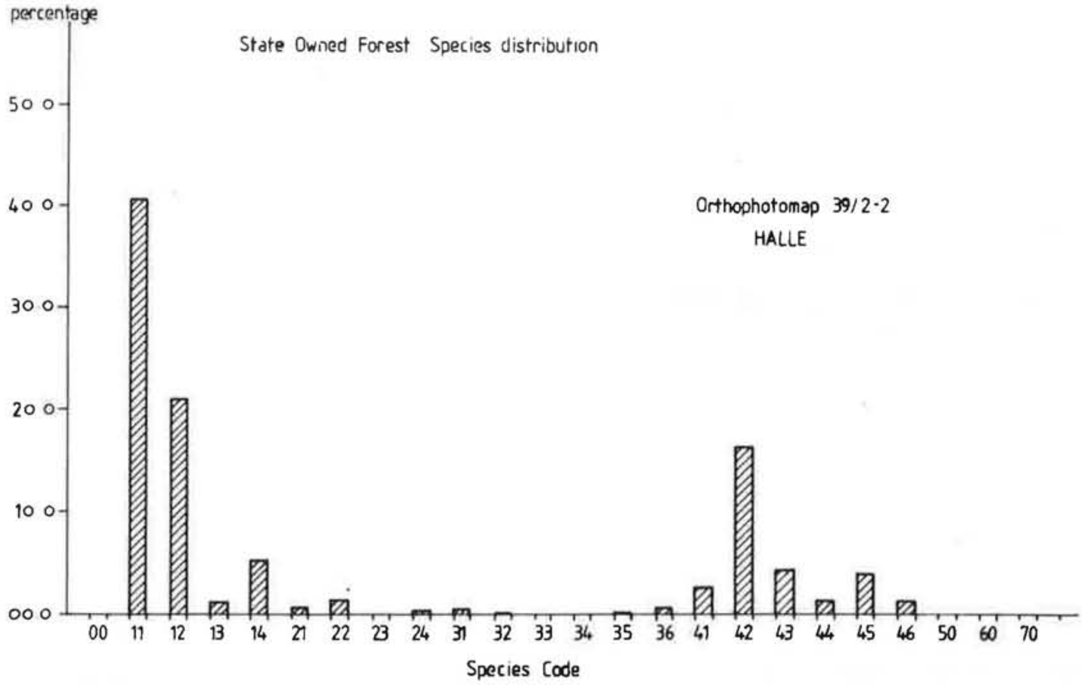

Fig. 5 : Diagram of species distribution. Hallerbos pilot - study (orthophotomap 39/2-2).

9. Conclusions and expected developments

A methodology for a global forest situation assessment in the Flemish region has been developed. Important topics are :

- the concept of a 10-yearly survey by remote sensing techniques
- the use of orthophotomaps to obtain a geometric correct base
- the use of CIR-photography
- the digitalization of interpretation unit boundaries
- the reproduction of information in a flexible format for the forest administration.

The data base is designed for extension, updating and inclusion of new items. Availability of all data, graphical and numerical, in digital form enables the production of thematic computermaps and corresponding reports.

Topographic data are reproduced only in analogue format.

Updating is inherently related to the 10-yearly survey. Because of the now available geometric base, new orthophotomaps will not be of utmost necessity in the future. As a consequence costs will decrease significantly.

The data base structure is designed for further extension. At a later stage, stand volume, basal area and stocking density data may complete the inventory. For most state forests these data already exist but updating will be needed.

Multi Spectral Scanner (MSS) data have also been acquired. Current research at CEVA indicates that airborne MSS and satellite data (TM, HRV) offer capabilities for forest classification.