The CORINE Land Cover database of The Netherlands

Final report of the CORINE Land Cover project in the Netherlands

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ABSTRACT

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The main objective of the CORINE Land Cover project is the gathering of coherent information on land cover for the European Community and the integration of this information into a Geographical Information System (GIS). The methodology consists of computer-assisted visual interpretation of earth observation satellite images, with the simultaneous consultation of additional data, into the 44 categories of the CORINE Land Cover Nomenclature. The scale of the land cover database is 1 : 100 000. A number of problems were met during the interpretation of the satellite images. To improve the interpretation result some adapted class definitions are proposed. A mixed qualitative/quantitative interpretation accuracy assessment procedure was applied to validate the interpretation result. The interpretation results were digitized using the ARC/INFO Geographical Information System (GIS) software which is compatible with the overall structure of the CORINE database.

Keywords: GIS, land cover, remote sensing, satellite images

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Preface

The CORINE Land Cover database of The Netherlands was produced by order of the Commission of the European Communities, Directorate-General for the Environment, Nuclear Safety and Civil Protection. The funds for production of the database were provided by the Commission of the European Communities and the DLO-Winand Staring Centre. The land cover database forms part of the CORINE (CoORdination of INformation on the Environment) Programme of the European Commission. We want to thank all who participated in this work. R. Dinge performed a considerable part of the interpretation of the satellite images. The digitization of the interpretation results was performed by the Institute of Land and Water management of the University of Leuven and by GIS experts of the CORINE Technical Team in Brussels. Digitization and interpretation errors found during the check of the technical quality of the digitized database were corrected by Ir R. van de Linden. Representatives of the CORINE technical teams performed a semi-quantitative validation of the CORINE Land Cover database of the Netherlands by a field survey. In the framework of the CORINE Programme, funds were provided to organize a regional workshop at the DLO Winand Staring Centre in Wageningen. This workshop was attended by representatives of the CORINE teams of Norway, Denmark, Germany, Ireland (including northern Ireland), Belgium and The Netherlands. Moreover, representatives of the central CORINE team participated to this workshop. All participants enthusiastically discussed the problems concerning the interpretation of a number of land cover types typically for the situation in the north-western part of Europe.

Summary

In order to determine the European Community's environment policy, evaluate the effects of this policy correctly and incorporate the environmental dimension into other Community policies, we must have a proper understanding of the different features of the environment. It was against this background that the CORINE (CoORdination of INformation on the Environment) Programme was started to gather, coordinate and ensure the consistency of information on the state of the environment and natural resources. One of the primary thematic items of this programme is land cover.

The main objective of the CORINE Land Cover project is the gathering of coherent information on land cover for the European Community and the integration of this information into a Geographical Information System (GIS). The methodology consists of computer-assisted visual interpretation of earth observation satellite images, with the simultaneous consultation of additional data, into the categories of the CORINE Land Cover Nomenclature. In order to consider the complete spectrum of land cover an European nomenclature has been developed, the legend of which distinguishes 44 classes, grouped in an open three level nomenclature system. The scale of the land cover database is 1 : 100 000. The surface area of the smallest unit mapped is 25 hectares. For line elements the minimum width is 100 meters. In the Netherlands the CORINE Land Cover project was started with an experiment to convert the raster data, obtained in the framework of the project Land Cover Classification of the Netherlands (LGN), into the CORINE vector database. After evaluation it was decided to produce the complete CORINE database through visual interpretation of the satellite images, supported by exogenous data.

The data set used for the production of the CORINE Land Cover database of The Netherlands consisted of satellite images (mainly Landsat-TM images obtained in August 1986), topographic maps, land use statistics, maps on nature conservation areas and forests and aerial photographs. The satellite images were prepared for visual interpretation through geometric correction, spectral enhancement and the production of photographic hard copies at scale 1 : 100 000. The interpretation work was executed on 29 transparent plastic overlays on the hard copies from the satellite images. In the Netherlands 28 level 3 classes could be distinguished from the total of 44 CORINE Land Cover classes.

A number of problems were met during the interpretation of the satellite images. The interpretation problems are related to identification problems, deliniation problems or to problems with regard to the assignment of specific land units to the Corine land cover nomenclature. Some of the interpretation problems could (partly) be solved by using the available ancillary data. The interpretation result can be improved considerably by making some class definitions more unambiguous and objective. Some adapted definitions are proposed.

A mixed qualitative/quantitative interpretation accuracy assessment procedure was

applied to validate the interpretation result. On the basis of the quality of the satellite images and the ancillary data and the experience gained during the interpretation, a *qualitative* validation can be performed. The spectral resolution of the Landsat TM images and the high quality of the ancillary data used in the interpretation phase implicitly guarantee an accurate identification and delineation of a number of classes, especially at level 1 and 2 and to a less extent at level 3. The identification and delineation accuracy of the classes of which the definition is more or less subjective and/or ambiguous will be dependent on the interpreter and the quality of the ancillary data. That applies also to the classes which are difficult or not discernible on the satellite images. However, in general it can be stated that when the situation of the boundaries between different land cover classes is more or less subjective, it mostly concerns land cover classes within the same level 2 class or at least within the same level 1 class. So, the accuracy increases from level 3 to level 1. Moreover, the CORINE Land Cover database of the Netherlands was produced by only two interpreters in a close cooperation. By that, it can be assumed that the interpretation result is consistent and comparable all over the Netherlands.

Representatives of the CORINE technical teams performed a *semi-quantitative* validation of the CORINE Land Cover database of the Netherlands by a field survey. On the basis of the complexity of the land cover sampling points in three areas were selected. The interpretation accuracy and reliability were determined in these areas by comparing the codes determined in the field with the codes in the CORINE Land Cover database. Totally, 324 points were visited in the field. The average interpretation accuracy amount 87%. These results give a global indication of the quality of the CORINE Land Cover database of The Netherlands and confirm the results of the qualitative validation. In general, it can be concluded that the interpretation has been performed satisfactorily.

The interpretation results were digitized using the ARC/INFO Geographical Information System (GIS) software which is compatible with the overall structure of the CORINE database. ARC/INFO is a vector-based, fully topologically structured GIS.

Because of the applied digitization procedure, initially, the resulting land cover database showed large positional inaccuracies. These positional inaccuracies had to be corrected interactively, which caused a strong delay of the conclusion of the project.

1 Introduction

The existence of good quality information on the state of the environment and natural resources is essential in order to ensure an efficient implementation and orientation of the European Community environment policy and integration of the environment within the other Community policies. It was against this background that the CORINE (Co-ORdinated INformation on the Environment) Programme was started. One of the primary thematic items of this programme is land cover. The main objective of this report is to describe the methodology, the results and the evaluation of the production of the CORINE Land Cover database of the Netherlands by the DLO Winand Staring Centre.

Chapter 2 introduces the CORINE Programme as a whole and describes more profound the CORINE Land Cover project, its purposes and the applied methodology and nomenclature. This chapter is based on publications of the Commission of the European Communities (Commission of the European Communities, 1991; Commissie van de Europese Gemeenschappen, 1991 and European Commission, 1993). Chapter 3 describes the production, evaluation and validation of the CORINE Land Cover database of the Netherlands. Conclusions and recommendations are formulated in Chapter 4. Previous to the producton of the CORINE Land Cover database, an experiment was performed to study the possibilities of converting an existing land cover database, produced by automatic classification of satellite images, to the CORINE Land Cover database. The results of this experiment are described in Annex 2. To discuss the problems concerning the interpretation of a number of land cover types typically for the situation in the north-western part of Europe a reginal workshop was organized at the DLO Winand Staring Centre in Wageningen. The main results of this workshop are described in Annex 5.

2 The CORINE Programme

2.1 Introduction

It is obvious that to be in a position to conserve and improve the environment, one must know what state it is in, and how it is developping. In other words, one must have acces to information on the distribution of the fauna and flora and their habitats, on the sources, extent and location of pollution, on the state of natural resources, as well as on the natural risk threatening the environment and man's activities. This is true at all levels of responsibility: local, regional, national and Community. A difficulty peculiar to the Community level is the considerable variation of environmental data characteristics (availability, definitions, measurement methods etc.) between countries and often even between regions. As a consequence, in the great majority of cases, the data cannot be compared and directly assembled to the state and development of the European environment for the benefit of Community policy.

In response to this need for information, it was decided in to undertake the CORINE Programme (COoRdination of INformation on the Environment). This Programme had three main objectives:

- to compile information on the state of the environment with regard to certain aspects which have priority for all the Member States of the Community;
- to ensure that information is consistent and that data are compatible;
- to coordinate the compilation of data and the organization of information within the Member States or at international level.

From 1985 to 1990, the European Commission has realized the CORINE Programme. The results are essentially of three types, corresponding to the three aims of the Programme:

- An information system on the state of the environment in the European Community has been created (the CORINE system). It is composed of a series of databases describing the Environment in the European Community, as well as of databases with background information (European Commission, 1994). This system is being used in the orientation and application of the Community's environment policy, as well as for other Community policies;
- Nomenclatures and methodologies were developed for carrying out the Programme, which are now used as the reference in the areas concerned at the Community level. This approach has also gained use in some Non-Member States;
- A systematic effort was made to concert activities with all the bodies involved in the production of environmental information especially at international level. Agreements were concluded which made possible to establish common methodologies and optimize data gathering (e.g. with the Counsil of Europe and the OECD). The CORINE programme was also a decisive factor in improving, or even establishing, coordination between Member States in the field of environmental information. As a result of this activity, and indeed of the whole Programme, several groups of international scientists have been working together

towards agreed targets and nowshare a pool of expertise on various themes of environmental information and, perhaps more importantly, have gained mutual understanding.

In 1990, a regulation was adopted which establishes the European Environment Agency (EEA). Until the the choice of the EEA seat in 1994 (Copenhagen), a Task Force had been created within the Commission of the European Community's Directorate General for the Environment, which was in charge of the technical aspects of the preparation of the setting up of the EEA, including maintenance and use of the CORINE Information System.

2.2 The CORINE Land Cover Project

One of the major tasks undertaken in the framework of the CORINE Programme has been the establishment of a land cover database. Data on land cover is necessary for the Environment policy as well as for other policies such as Regional Development. At the same time it provides one of the inputs for the production of more complex information on other themes (e.g. soil erosion risks).

The main objectives of the CORINE Land Cover project are:
- to provide those responsible for and interested in the European policy on the environment with quantitative data on land cover, consistent and comparable across the Community;
- to prepare one land cover database for the twelve EC countries, at an original scale of 1 : 100 000, using the 44 classes of the CORINE nomenclature;
- to extend the work to other European and North African countries.

The CORINE Land Cover project has been completed in Luxemburg, Portugal, Spain, Andorra, the Netherlands and Republic of Ireland and Northern Ireland. Work is in progress in Belgium, Austria, France, Greece, Italy, Germany, Denmark, Tunisia, Czechie, Slovakia, Hungary and Poland. Work is in preparation in Finland, Sweden, Great Britain, Estonia, Bulgaria, Romania and Marocco (situation spring 1994).

2.2.1 Methodology

The analysis made at the definition phase of the project showed, contrarily to the situation met by the other CORINE projects, it was not possible to rely on available data to realize a Community wide inventory on land cover. Existing inventories were either too specific (e.g. agriculture) or covering small areas. As a result it was not possible to simply assemble them in order te create consistent and comparable information useful to the EC policies. In addition, several countries were about to launch similar initiatives. These conditions largely determined the characteristics of the Land Cover Project (i.e. methodology, nomenclature and scale).

It was decided to use earth observation satellite data as the basic information sources. Earth observation satellite data is:
- available on a regular basis;
- inexpensive: 0.5 ECU/km^2 for SPOT multispectral images and 0.14 ECU/km^2 for Landsat Thematic Mapper images;
- available for large areas: 35 000 km^2 for each Landsat scene and 3600 km^2 for each SPOT scene;
- objective: the sensor-transmission-reception system involves no human intervention;
- related to the **earth surface** features;
- available in digital form, which has a number of advantages with regard to data processing.

The methodology consists of computer-assisted photointerpretation of Earth observation satellite images, with the simultaneous consultation of ancillary data, into the categories of the CORINE Land Cover Nomenclature. The photo-interpreters work on transparent plastic overlaid on the 1: 100 000 hard copies of the satellite images. They outline land units and classify them into cover types according to the nomenclature. The surface area of the smallest unit mapped is 25 hectares. For line elements the minimum width is 100 meters. The interpreters are assisted by a computer image processor, which can reveal extra details and resolve ambiguities. Ancillary data (maps, aerial photographs, statistics, local knowledge) are essential to help identify and confirm the contents of certain land units which have been recognised on the images. The results are verified after the interpretation phase (quality control). Finally, the land units are digitised in a topologically structured format, so that the final data can be integrated with the other CORINE data sets.

For a comprehensive description of the methodology one is referred to the Technical Guide of the CORINE Land Cover Project (European Commission, 1993).

2.2.2 Nomenclature

The CORINE Land Cover nomenclature must meet a certain number of requirements:
- it must be possible to map all Community territory; in other words there can be no heading for 'unclassified land';
- the classes must correspond to the needs of future users of the CORINE geographic database;
- classes terminology must be unambiguous.

Moreover, is must be remembered that the scale is 1 : 100 000, the nomenclature applies to relatively large units (25 hectares or more) and the basic information used is earth observation satellite data.

The CORINE Land Cover map is intended to be fundamentally a land cover map. However, the creation of a distinct land cover nomenclature is strongly influenced by land use terminology and is still being developped. Whereas *land use* refers to human activity of certain kind of a given land surface, *land cover* refers to the

vegetational and artificial construction occupying the land surface. There are instances where the cover is completely structured by the land use (e.g. an airport consist of runways, buildings and vegetated areas which form a distinctive unit of cover). In these cases the cover type is described with reference to the land use.

The developed nomenclature distinguishes 44 classes, which are grouped in a 3-level hierarchy (Table 1). The main level categories are: artificial surfaces (cities, etc.), agricultural areas, forests and semi-natural areas, wetlands and water bodies. Annex 1 contains the complete nomenclature with definitions and examples. Each country can add supplementary 4th and 5th hierarchical levels, according to its special conditions and priorities, but the first three levels are identical for all countries.

Table 1 The CORINE Land Cover Nomenclature

LEVEL 1	LEVEL 2	LEVEL 3
1. ARTIFICIAL AREAS	1.1. Urban fabric	1.1.1. Continuous urban fabric 1.1.2. Discontinuous urban fabric
	1.2. Industrial, commercial and transport units	1.2.1. Industrial or commercial units 1.2.2. Road and rail networks and associated land 1.2.3. Port areas 1.2.4. Airports
	1.3. Mine, dump and construction sites	1.3.1. Mineral extraction sites 1.3.2. Dump sites 1.3.3. Construction sites
	1.4. Artificial, non-agricultural vegetated areas	1.4.1. Green urban areas 1.4.2. Sport and leisure facilities
2. AGRICULTURAL AREAS	2.1. Arable land	2.1.1. Non-irrigated arable land 2.1.2. Permanently irrigated land 2.1.3. Rice fields
	2.2. Permanent crops	2.2.1. Vineyards 2.2.2. Fruit trees and berry plantations 2.2.3. Olive groves
	2.3. Pastures	2.3.1. Pastures
	2.4. Heterogenous agricultural areas	2.4.1. Annual crops associated with permanent crops 2.4.2. Complex cultivation patterns 2.4.3. Land principally occupied by agriculture, with significant areas of natural vegetation 2.4.4. Agro-forestry areas
3. FOREST AND SEMI NATURAL AREAS	3.1. Forests	3.1.1. Broad leaved forest 3.1.2. Coniferous forest 3.1.3. Mixed forest
	3.2. Scrub and/or herbaceous vegetation	3.2.1. Natural grasslands 3.2.2. Moors and heathland 3.2.3. Sclerophyllous vegetation 3.2.4. Transitional woodland-scrub
	3.3. Open spaces with little or no vegetation	3.3.1. Beaches, dunes, sands 3.3.2. Bare rocks 3.3.3. Sparsely vegetated areas 3.3.4. Burnt areas 3.3.5. Glaciers and perpetual snow
4. WETLANDS	4.1. Inland wetlands	4.1.1. Inland marches 4.1.2. Peat bogs
	4.2. Maritime wetlands	4.2.1. Salt marches 4.2.2. Salines 4.2.3. Intertidal flats
5. WATER BODIES	5.1. Inland waters	5.1.1. Water courses 5.1.2. Water bodies
	5.2. Marine waters	5.2.1. Coastal lagoons 5.2.2. Estuaries 5.2.3. Sea and ocean

3 Land cover database of the Netherlands

For the production of the CORINE Land Cover database of the Netherlands it could be beneficial to take advantage of the results obtained in the framework of the project 'Land Cover Classification of the Netherlands with Landsat TM Images (LGN)' (Thunnissen et al., 1992 and 1993). Therefore, the CORINE Land Cover project in the Netherlands was started with an experiment to study the possibilities of converting the LGN digital raster database to the polygonal CORINE Land Cover database. The methodology and results of this experiment are described in Annex 2. The possibilities to use automatic classification techniques for the production of the CORINE Land Cover database proved to be restricted. This is mainly caused because the results of automatic classification methods are based only on the radiometric characteristics of individual pixels, while most CORINE Land Cover classes are by nature heterogeneous. By that information on texture and context plays an important role for the delineation and identification of most of the CORINE classes. Moreover, some CORINE classes are determined by the land **use** and consist of different land cover classes (e.g. airports). After evaluation of the results of the experiment it was decided to produce the complete CORINE database by visual interpretation of the satellite images, supported by ancillary data.

3.1 Satellite images

3.1.1 Selection of the satellite images

The satellite data constitute the fundamental data source for the project since they are the interpretation base for the production of the CORINE Land Cover map. Landsat MSS images are not suitable for application in the Netherlands because of the poor spatial resolution. The spatial resolution of data from second generation sensors (Landsat TM and SPOT) is sufficient for the recognition of individual agricultural fields in the Netherlands. However, taking spectral resolution into consideration, one may conclude that TM has a clear advantage over SPOT, since this latter satellite lacks bands in the middle-infrared part of the spectrum (Table 2). Several studies showed that the TM middle-infrared bands in particular have significantly enhanced the possibility to discriminate different land cover types.

Table 2 Overview of the wave length bands and the spatial resolution of the Thematic Mapper sensor aboard the Landsat satellite

Band	Wave length (µm)	Resolution (m)	Description
1	0,45- 0,52	30	visible blue
2	0,52- 0,60	30	visible green
3	0,63- 0,69	30	visible red
4	0,75- 0,90	30	near infra red
5	1,55- 1,75	30	middle infra red
6	10,40-12,50	120	thermal infra red
7	2,08- 2,35	30	middle infra red

For the situation in the Netherlands the optimum acquisition period is the summer period, especially the months July and August. However, the distinction between pastures and some arable crops can be troublesome in this period. Therefore, for some areas additional images from the spring would be beneficial. However, the costs of data acquisition, processing time and image interpretation can be prohibitive for the application of multi temporal images. Besides, in practice the selection of the images for the Netherlands is much dependent on the availability of cloud free images.

Landsat-TM images obtained in August 1986 were used for the production of the CORINE Land Cover database of the greater part of the country. For those areas not suitably covered by the images from August 1986, images obtained in June and September 1986, July 1987 and June 1988 were applied (Annex 4). For a narrow strip in the most south western part of the Netherlands a TM-image from august 1984 was used. These images were also used for the project 'Land Cover Classification of the Netherlands with Landsat TM Images' (Thunnissen et al., 1992 and 1993). By that, there were no image acquisition costs in the CORINE Land Cover project.

3.1.2 Processing of the satellite images and production of the hard copies

The reason for computer processing digital satellite data is to perform geometric corrections, resampling and contrast enhancement in order to obtain optimal images for visual interpretation.

The purpose of the *geometric corrections* is to correct the various distortions which may occur (change in satellite altitude and orbit, movement of the earth below the satellite, panoramic effect, etc.) and to transform the data in order to obtain an image which is matched to the projection system used for the standard topographic map of the Netherlands (stereografic projection). This transformation was achieved by aligning a set of Ground Control Points (GCP) marked on the map (1:50 000 topographic map of the Netherlands) with the corresponding points in the image data. The points must be fixed (road intersections, end of runways, etc.) and easily identified on a display of satellite data. Each control point is characterized by its image

coordinates (i.e. the row and column coordinates in the raw image data) and his map coordinates. These points must be sufficient in number and distributed evenly over the whole image. These data were used to calculate a first-order polynomal transfer function between the grid coordinates of the raw image and the map coordinates. The dimension of the pixels in the corrected image were changed to 25m by 25m to achieve a close match with topographical maps.

As a result of the geometric correction the dimension and/or positions of the pixels in the corrected image were changed in relation to the original pixels. The values of the new pixels were determined by applying the nearest neighbour *resampling* algorithm. This resampling method chooses the pixel in the raw image closest to the pixel to be resampled. The value of the pixel in the raw image is then transferred to the pixel in the corrected image. Applying this method, the original pixel values are retained.

The geometric correction and resampling of the Landsat-TM images were already performed in the framework of the project 'Land Cover Classification of the Netherlands with Landsat TM Images'.

Three optimal bands were required to be selected for production of photographic hard copies The best spectral band combination for land cover mapping is: TM4 (near infrared), TM5 (middle infrared) and TM3 (red) of Landsat TM data. These bands were depicted as red, green and blue respectively. To produce qood quality images for visual interpretation the dymamic ranges of the pixel values of the selected TM bands were adjusted by applying a linear contrast enhancement technique. The contrast was iteratively optimized for each individual band to maximize the discrimination between the different land cover classes. An optimal contrast enhancement is of consequence for the interpretation phase. It will save time and increase the quality of the interpretation result.

An Optronics colour laser film-writer was used to produce small-scale (1 : 500 000) transparancies of the processed satellite data. To obtain a colour composite, bands 4, 5 and 3 were exposed successively by the red, green and blue rays (additive colouring). Scenes of 3800 by 4800 pixels can be represented on one slide. The scene on the slide was divided in several subscenes (0.5 by 0.6 m at the scale 1 : 100 000) which were printed on colour photographic paper (Cibachrome procedure) on scale 1 : 100 000.

3.2 Collection and application of ancillary data

The term 'ancillary' data refers to any documentary, cartographic or photographic information concerning land cover which does not come directly from the satellite data. Such data essentially comprise topographic maps (3.2.1), thematic maps relating to land cover (3.2.2), statistical information (3.2.3) and aerial photographs (3.2.4). Ancillary data are indispensable for the delineation and/or the identification of a number of land cover classes.

3.2.1 Topographic maps

In the Netherlands topographic maps on different scales are available: 10 000, 25 000, 50 000, 100 000 and 250 000. For the CORINE Land Cover project topographic maps on scales of 1 : 100 000 and 1 : 50 000 were used at various stages of the production of the CORINE Land Cover database. For the production of the topographic maps at the scale 1 : 50 000 the stereographic projection according to the ellipsoid of Bessel is applied and the geographical coordinates refer to the *National Triangulation System.* The topographic map at the scale 1 : 100 000 has been derived from the topographic map at the scale 1 : 50 000 by *direct reduction* and the geographical coordinates of the sheets refer to the *European Triangulation System. So the topographic maps at the scales 1 : 50 000 and 1 : 100 000 refer to different coordinate systems.* Both topographic maps were used for several purposes:

- Determination of the map coordinates of the Ground Control Points for the geometric correction of the satellite images (scale 1 : 50 000);
- They constitute the reference document for controlling the geometry of the digitization of the interpretation sheets (scale 1 : 100 000);
- They are a very important source of ancillary information on land cover, for instance:
  . they support the delineation of the boundaries between the agricultural classes (especially 2.4.2 and 2.4.3.);
  . they can be used incidentally for the interpretation of small areas of which satellite imagery is missing or covered by clouds;
  . they support the delineation and/or identification of classes which are difficult to be recognized unambiguously on the the satellite images, for instance urban fabric situated in wooded areas or small airports with runways of grass.

3.2.2 Thematic maps relating to land cover

In behalf of the nature- and landscape conservation policy in the Netherlands it was necessary to obtain a global view on the character, extent and distribution of natural conservation areas, forests and natural values in the agricultural landscape. Previous maps and other data needed updating and more detail. Therefore, new maps were produced by the Dutch Forestry Service (SBB, Inspectie Natuurbehoud, 1984). These maps contain 9 different natural land cover classes which are relevant for the CORINE Land Cover database (Table 3). The maps were published at the scale 1 : 250 000 but the information was gathered at the scale 1 : 100 000. On the basis of these maps all the relevant natural areas (CORINE Land Cover class 3) and wetlands (CORINE Land Cover class 4) could be identified. Besides, these maps give global information on the situation of the relevant natural areas and wetlands.

Table 3 Relevant items on the map: Nature conservation areas and forests in The Netherlands

No.	Class description
1.	**Dunes and drift sands**
2.	**Dunes with forest**
3.	**Heathland**
4.	**Inland marches and small lakes (< ca. 100 hectares)**
5.	**Lakes (> ca. 100 hectares)**
6.	**Natural grasslands**
7.	**Brackish or saline marches**
8.	**Peat bogs**
9.	**Forests**

3.2.3 Land use statistics

The Central Bureau of Statistics (CBS) in the Netherlands produces a land use database containing 31 land use classes (Annex 3). For every grid of 500 x 500 m^2 the acreage of the present land use classes are stored. The original database has been transformed into a format to be analysed with ARC/INFO. From the database of 1986, 15 land use classes relevant to the CORINE Land Cover project were selected (Table 4). The selected land use classes concern mainly classes within the sphere of influence of built-up areas. Further airports, dumping sites, mineral extraction sites, greenhouses, wet natural areas and areas used for recreation were selected. For practical reasons for every grid of 500 x 500 m^2 only the classes larger then 10 hectares were selected and stored. The land use database proved to be very helpful in the identification of a large number of land units. Recently, the CBS land use database has come available as a polygonal ARC-INFO coverage. So, in future these land use statistics cannot only be used for the identification but also for the delineation of a large number of land cover classes. Besides, it will be possible to include some classes directly into the CORINE database, avoiding a part of the time consuming digitisation.

Table 4 Items CBS land use statistics used for the Corine Land Cover project of the Netherlands

No.	Class description
1.	**Sports grounds (incl. car parks)**
2.	**Airfields and airports**
3.	**Allotments**
4.	**Dumping sites**
5.	**Car wreck sites**
6.	**Mining areas**
7.	**Parks and public gardens**
8.	**Holiday recreation**
9.	**Recreational objects and areas**
10.	**Industrial and harbour areas (incl. car parks, offices and other auxiliary buildings).**
11.	**Commercial areas (e.g. auction buildings, storage yards for trade)**
12.	**Building sites for industrial and harbour areas**
13.	**Building sites for other purposes**
14.	**Glasshouses**
15.	**Wet natural areas (wet heaths, moors)**

3.2.4 Aerial photographs and field work

For some classes which could not be identified sufficiently accurate with the above mentioned information sources, aerial photographs were interpreted. A nation wide aerial photograph archive is present at the Dutch Topographical Service in Emmen. Aerial photographs proved especially useful in interpreting some areas with construction sites (1.3.3).

Because of the abundance and the high quality of the ancillary data no field work was necessary during the interpretation phase. For a rough validation of the Corine Land Cover database of the Netherlands some reference data were collected in the field after the production of the database (see 3.4.3).

3.3 The visual interpretation of the photographic hard copies

3.3.1. Nomenclature and interpretation criteria

In order to obtain a comparable land cover map from all the 12 Member States the CORINE Land Cover nomenclature was introduced (see paragraph 2.2.2.) and interpretation criteria were defined. The CORINE Land Cover nomenclature was developed, in order to consider the complete spectrum of land cover. To assure a similar interpretation of the nomenclature classes, definitions are given for the different land cover classes (Annex 1). In general, the interpretation of the photographic hard copies was performed level by level, beginning at level 1 down to level 3.

Interpreters worked according to the following interpretation criteria:

- Considering the objectives of the project and the working scale, the minimum size of areal features is 25 ha (5 x 5 mm or a circle of radius 2.8 mm on the map) and the minimum width of linear features to be mapped is 100 m;
- All areas of more than 25 ha that can be identified as a separate land cover class on the satellite image must be delimited and identified, either using the image or with the help of exogenous data, at level 3 of the nomenclature, considering the following criteria:
  . only one level 3 code is assigned to each land cover unit of more than 25 hectares;
  . no areas may be left unmapped or assigned to a 'don't know' class;
  . assigning a code is no problem when the land cover of the unit is homogeneous (e.g. dense woodland, continuous urban fabric, etc.). Where the land cover of the unit is heterogeneous, its classification will depend on:
    . either the predominant type of land cover as a percentage of the total area of the unit; e.g. a pasture area may contain patches of arable land and stands of trees but will be classified as 'Pastures' (2.3.1);
    . or the land cover which, altough not predominant in terms of land area, determines the structure of the unit in terms of land use or its ecological function; e.g. the level 3 classes 'Discontinuous urban fabric' (1.1.2), 'Airports' (1.2.4), 'Land principally occupied by agriculture, with significant areas of natural vegetation' (2.4.3), etc.

3.3.2. The interpretation transparencies

The land cover units were delineated on the transparancies overlaid on the 1:100 000 hard copies of the satellite images. The transparencies correspond with the subscenes of circa 0.5 by 0.6 m on the photographic hard copies (see 3.1.2). Some transparencies cover two or more hard copies depending on the occurrence of clouds (Annex 4). The total area of the Netherlands is covered by 29 tranparencies (Figure 1).

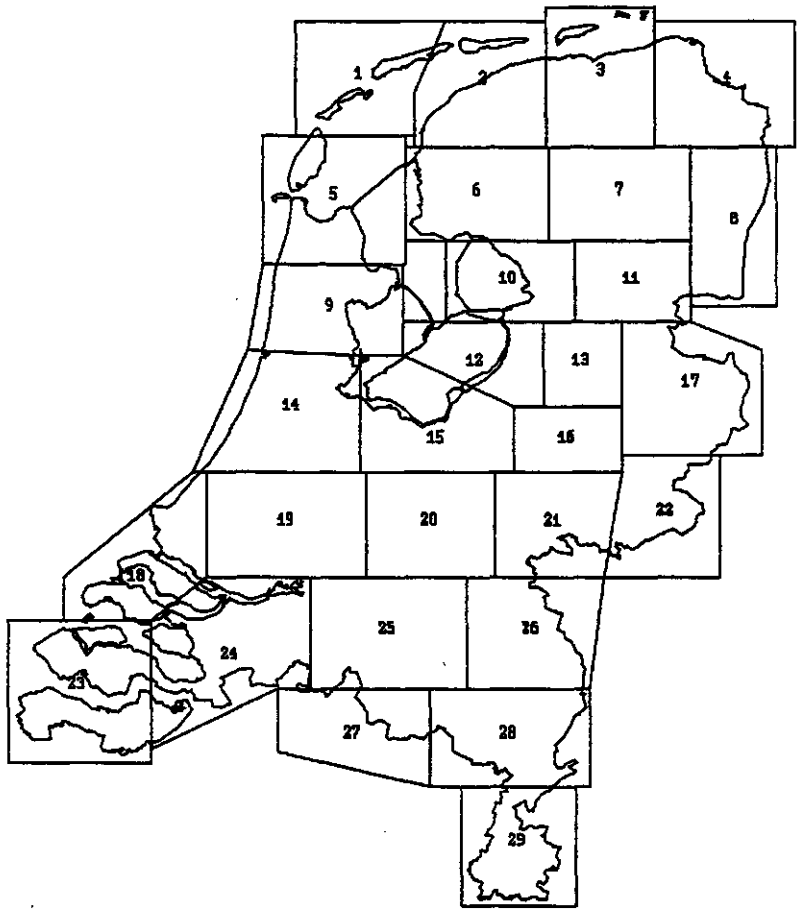

Fig. 1 Situation of the 29 transparencies used for the CORINE Land Cover Project of The Netherlands

3.3.3. Evaluation of the interpretation result

Only 28 of the total of 44 CORINE Land Cover classes at level 3 are relevant for the Netherlands (Table 5).

Table 5 Overview of the CORINE level 3 classes occurring in the Netherlands

LEVEL 3 class no.	Description
1.1.1	**Continuous urban fabric**
1.1.2	**Discontinuous urban fabric**
1.2.1	**Industrial or commercial units**
1.2.2	**Road and rail networks and associated land**
1.2.3	**Port areas**
1.2.4	**Airports**
1.3.1	**Mineral extraction sites**
1.3.2	**Dump sites**
1.3.3	**Construction sites**
1.4.1	**Green urban areas**
1.4.2	**Sport and leisure facilities**
2.1.1	**Non irrigated arable land**
2.2.2	**Fruit trees and berry plantations**
2.3.1	**Pastures**
2.4.2	**Complex cultivation patterns**
2.4.3	**Land principally occupied by agriculture, with significant areas of natural vegetation**
3.1.1	**Broad leaved forest**
3.1.2	**Coniferous forest**
3.1.3	**Mixed forest**
3.2.1	**Natural grasslands**
3.3.1	**Beaches, dunes, sands**
4.1.1	**Inland marches**
4.2.1	**Salt marches**
4.2.3	**Intertidal flats**
5.1.1	**Water courses**
5.1.2	**Water bodies**
5.2.2	**Estuaries**
5.2.3	**Sea and ocean**

A number of problems were met during the interpretation of the satellite images. The interpretation problems are related to identification problems, deliniation problems or to problems with regard to the assignment of specific land units to the Corine land cover nomenclature. Some of the interpretation problems could (partly) be solved by using the available ancillary data. The following interpretation problems are relevant for the situation in the Netherlands (the used ancillary information is mentioned between brackets):

Artificial areas:

- Sometimes, the distinction between 'Continuous urban fabric' (1.1.1) and 'Discontinuous urban fabric' (1.1.2) could be troublesome on the available hard copies. Both classes are defined in a qualitative way. By that the deliniation of these areas is very much dependent on the interpreter. (topographic maps and

additional, interactive contrast enhancement);
- Built-up areas situated in a wooded area, which have to be classified as 'Discontinuous urban fabric' (1.1.2), were sometimes difficult to distinguish from forest (3.1). Moreover, the transition between built-up areas situated in a wooded area and forests is a gradual one. (topographic maps and additional, interactive contrast enhancement);
- Sometimes it was difficult to distinguish between 'Continuous urban fabric' (1.1.1) and 'Industrial or commercial units' (1.1.2), especially when the industrial area is situated within urban area. (topographic maps and CBS land use statistics);
- Airports (1.2.4) consisting only of grassland could be confused with 'Pastures' (2.3.1). (CBS land use statistics);
- Sometimes areas with forest or agricultural land occur within the outer boudaries of airports. Are these areas to be considered as 'associated land' as mentioned in the CORINE nomenclature definition (Annex 1).
- Mineral extraction sites (1.3.1), especially gravel pits under water, could not be distinguished from 'Water bodies' (5.1.2) (topographic maps and CBS land use statistics).

Agricultural areas:
- For problems with regard to the distinction between 'Pastures' (2.3.1) and 'Natural grasslands' (3.2.1) see below;
- In some areas in the Netherlands orchards (2.2.2) are a very important land cover class. However, individual complexes are hardly ever larger than 25 ha. Sometimes subareas can be found where orchards dominate the surface in terms of percentage (i.e. more than 50 % of the area consists of orchards). However, the deliniation of these areas is often troublesome and dependent on the interpreter. Mostly, orchards are included in class 2.4.2 (Complex cultivation patterns) (topographic maps);
- The land cover classes 'Complex cultivation patterns' (2.4.2) and 'Land principally occupied by agriculture, with significant areas of natural vegetation' (2.4.3) are defined in a qualitative way. By that the deliniation of these areas is very much dependent on the interpreter. The interpretation problem concerns mainly the situation of the boundary between classes 2.4.2 and 2.4.3 with other agricultural classes within the level 1 class 'Agricultural areas' (topographic maps);
- In the Netherlands there are some large allotment complexes. They are interpreted as 'Complex cultivation patterns' (2.4.2), but maybe they could, according to their main use, better be classified as 'Sport and leisure facilities' (1.4.2).

Forest and semi natural areas:
- Broad-leaved forest (3.1.1) situated in inland marches was difficult to distinghuish from the CORINE class 'inland marches' (4.1.1) on the available hard copies (topographic map and map with nature conservation areas);
- Wet, low wooded land situated in 'inland marches' is interpreted as 'Broad leaved forest' (3.1.1), but contextual information and the class definition, indicates that it could sometimes also be 'Transitional woodland-scrub' (3.2.4);
- Locally, distinction between different forest types was troublesome on the available hard copies, depending on the tree species and the density of the forest. This is however a minor problem (topographic maps);

- The CORINE Land Cover classes 'Broad-leaved forest' (3.1.1), 'Coniferous forest' (3.1.2) and 'Mixed forest' (3.1.3) are defined in a qualitative way. By that the deliniation of these class is very much dependent on the interpreter. The interpretation problem concerns mainly the situation of the boundaries between the different forest classes (topographic maps);
- In the beginning of this century large areas in the Netherlands consisted of low productivity grasslands which were rich in herbs and not manured. The management of these grasslands consisted of mowing or grazing. Nowadays most of these 'natural' grasslands are intensively used for agricultural purposes. Only a few of the original low productivity grasslands are not or only extensively used for agricultural purposes, because they are situated in areas of uneven ground or in areas with unfavourable hydrological conditions for agricultural use. In general these low productivity grasslands can spectrally not be distinghuished from intensively used grasslands, which show a large spectral heterogeneity because of mowing, grazing and other management activities. However, the acreage of the remained low productivity grasslands is often less than 25 hectare and a large number of these grasslands are situated in nature reserves.

  Nowadays, in the Netherlands more and more attention is paid to nature restoration. In the framework of this policy low and also high productivity grasslands, which are situated in areas with potential, high natural values (f.i. seepage areas within brook valleys and forelands) are managed with the purpose to restore the original natural values, i.e. they will only be mown or grazed by animals and no manure will be applied anymore. So, in future the area of 'natural' grassland will increase considerably. That development will give rise to two problems with regard to the CORINE Land Cover database:
  - Altough more and more grasslands will be withdrawn from agricultural use the transition to low productivity grasslands will be a gradual one. Have these grasslands to be classified as 'Pastures' (2.3.1) or as 'Natural grassland' (3.2.1) and where will be the cut-off point;
  - The delineation of these 'natural grasslands' will be troublesome, because of the spectral confusion between these grasslands and graslands in agricultural use, which show a large spectral heterogeneity because of mowing, grazing and other management activities. So, ancillary data must be available for a correct identification and delineation of these areas.

Wetlands:
- Hardly any intertidal flats (4.2.3) are incuded in the CORINE Land Cover database of the Netherlands, because they could not be distinghuished on the availabl satellite images. According to the definition intertidal flats must be located at 0 meter or sea level contour (Annex 1). What is meant with 'sea level contour? Intertidal flats can only be delineation on the basis of ancillary data;
- Estuaries (5.2.2) are defined as the mouth of a river where it broadens into the sea and within which the tide ebbs and flows. The seaward edge of an estuary is arbitralily taken as a line between two prominent headlands unless some other feature suggest otherwise (e.g. presence of dam, bridge or sluice). The landward limit is arbitrarily taken as a point of broadening (even though in terms of salinity the estuary may extend further inland) unless available ancillary data suggest

otherwise (e.g. presence of sluice or weir).

An other problem is formed by the 'Oosterschelde' which is still subject to ebb-tide and flood-tide, but into which no river flows anymore. The Oosterschelde is classified as an estuary.

To diminish subjectivity in interpretation results and to ensure consistency and comparability in interpretation it would be helpful to make some definitions more unambiguous and objective, taking into account the discernability on the satellite images. Some adapted definitions were proposed at the regional CORINE Land Cover meeting, held at 28th and 29th September 1992 in Wageningen the Netherlands. The main results of this meeting which are relevant for the Dutch situation, are included in Annex 5.

3.4 Digitization and quality check of the digitized geographical database and validation of the interpretation result

3.4.1 Digitization

In fact, there is no original 1 : 100 000 topographic map series available in The Netherlands (3.2.1). The available topographic map sheets at 1 : 100 000 scale have been derived from the topographic maps at 1 : 50 000 scale by direct reduction and the geographical coordinates of the 1 : 100 000 sheets refer to the European Triangulation System. So the topographic maps at scales 1 : 50 000 and 1 : 100 000 refer to different coordinate systems. The individual 1 : 100 000 topographic map sheets are rather large. To keep the interpretation transparencies manageable, several hard copies of the satellite images were produced to cover each complete map sheet. The transparencies correspond with the subscenes of circa 0.5 by 0.6 m on the photographic hard copies (see 3.1.2). For each tranparency reference points must be chosen to convert data from the coordinate reference plane of the digitizing table to the map coordinates. Because of the deviating coordinate system of the 1:100 000 maps reference points with known map coordinates could not be carried over directly on to the interpretation transparencies. Therefore, the procedure for the identification of the reference points, as specified in the CORINE Technical Guide (European Commission, 1993) was adapted. For every transparency reference points should be selected from the hard copies of the satellite images at scale 1 : 100 000 and transferred exactly to the transparent overlay and to the 1 : 50 000 topographic maps (stereographic projection according to the ellipsoid of Bessel, 1842). The corresponding coordinates should be digitized from the 1 : 50 000 topographic maps and refer to the national rectangular coordinate system of the Netherlands. The reference points on the transparencies must be recorded each time the corresponding transparency is laid on the digitizing tablet.

However, the adapted digitization procedure was not applied by the University of Leuven which carried out the digitization of the CORINE Land Cover interpretation of the Netherlands. On the contrary, the maps at scale 1 : 100 000 were used as a

base on which the individual transparencies were superimposed and as such digitized, using only the corners of the 1 : 100 000 map as reference points. By doing so a large number of transparencies contained no reference points at all. Eventually the 8 maps, each of which consists of several digitized overlays were joined together forming one logical unit. The resulting database showed large positional inaccuracies which were corrected interactively (i.e. by linearily moving the different digitized transparencies) by GIS experts of the CORINE Technical Team. The final database shows still som minor positional inaccuracies. Because of the geometrical problems the execution of the project was strongly delayed.

The interpretation results were digitized using the ARC/INFO Geographical Information System (GIS) software which is compatible with the overall structure of the CORINE database. ARC/INFO is a vector-based, fully topologically structured GIS.

3.4.2 Quality check of the digitized geographical database

Quality check of the geographical database consisted of:
- checking the geometrical quality of the digitized database (3.4.1);
- checking that a single code has been assigned to each unit (closed polygones);
- checking that adjacent units do not contain the same code;
- checking that the correct codes were assigned during digitization;
- checking that the areas have been completely marked off;
- checking the size (25 ha) of the smallest units;
- checking that adjacent maps link up.

Errors found during the quality check of the digitized database were corrected. The main part of the correction process consisted of the assignment of polygons smaller than 25 ha. Totally circa 1000 polygons smaller than 25 ha were found. Since more than 50% of these polygons were larger than 20 ha, it was decided to correct only polygons smaller than 20 ha. As a rule the concerning polygons were assigned to the neighbour polygon which is thematically closest related according to the following procedure:
- When polygons smaller than 20 ha border on a polygon with the same level 3 code (Table 1) they were merged (step 1). *In general, polygons with the same land cover code will not be contiguous. However, some times polygons smaller than 20 ha were accidentally introduced by addition of extra arcs by the interpreter. These extra arcs are necessary to split up very large polygons which can not be processed by ARC-INFO.*
- Step 2 consisted of the assignment of polygons smaller than 20 ha to a neighbour polygon with the same level 2 code. For example joining polygons with codes 141 ('Green urban areas') and 142 ('Sport and leisure facilities'). The common level 2 code is 14 ('Artificial, non-agricultural vegetated areas').
- Step 3 consisted of the assignment of polygons smaller than 20 ha to a neighbour polygon with the same level 1 code. For example joining polygons with codes 133 ('Construction sites') and 111 ('Continuous urban fabric'). The common level 1 code is 1 ('Artificial areas').

- If polygons smaller than 20 ha were not merged in the preceding steps, the direct surroundings were searched for thematic related polygons at the three levels of the nomenclature (as described in steps 1 to 3). The searched polygons should be situated within a distance smaller than about half of the length of the polygon smaller than 20 ha. When a thematically related polygon was found both polygons were interactively merged supported by the satellite images and topographic maps.

- Finally, if still no suited polygon was found for merging a polygon smaller than 20 ha the interpreter performed the merging with a neighbour polygon interactively supported by the satellite images and topographic maps. Mostly, the polygons smaller than 20 ha were assigned two the polygons with the largest common boundary. However 'land classes' could never be merged with 'water classes' and non-artificial surfaces were never merged with artificial surfaces.

Figure 2 shows the final classification result of the CORINE Land Cover database of the Netherlands. Because of the legibility of the map only the level 2 classes are shown.

3.4.3 Validation of the interpretation result

Because cost and time required for a random sampling of the entire country were prohibitive, a mixed qualitative/quantitative interpretation accuracy assessment procedure was applied. On the basis of the quality of the satellite images and the ancillary data and the experience gained during the interpretation, a *qualitative* validation can be performed. The spectral resolution of the Landsat TM images and the high quality of the ancillary data used in the interpretation phase implicitly guarantee an accurate identification and delineation of a number of classes, especially at level 1 and 2 and to a less extent at level 3. The identification and delineation accuracy of the classes of which the definition is more or less subjective and/or ambiguous (see 3.3.3) will be dependent on the interpreter and the quality of the ancillary data. That applies also to the classes which are difficult or not discernible on the satellite images. That affects of course the quality of the interpretation results. It is however difficult to assess quantitatively the effect hereof. However, in general it can be stated that when the situation of the boundaries between different land cover classes is more or less subjective, it mostly concerns land cover classes within the same level 2 class or at least within the same level 1 class. So, the accuracy increases from level 3 to level 1. Moreover, the CORINE Land Cover database of the Netherlands was produced by only two interpreters in a close cooperation. By that, it can be assumed that the interpretation result is consistent and comparable all over the Netherlands.

Representatives of the CORINE technical teams performed a *semi-quantitative* validation of the CORINE Land Cover database of the Netherlands by a field survey. A comprehensive report of the results of this validation is included in Annex 6. On the basis of the complexity of the land cover three areas were selected, situated in the central and southern part of the Netherlands. With the help of the hard copies of the satellite images and the topographic maps at scale 1:100 000 several routes were defined through each of the three selected areas. The validation was performed

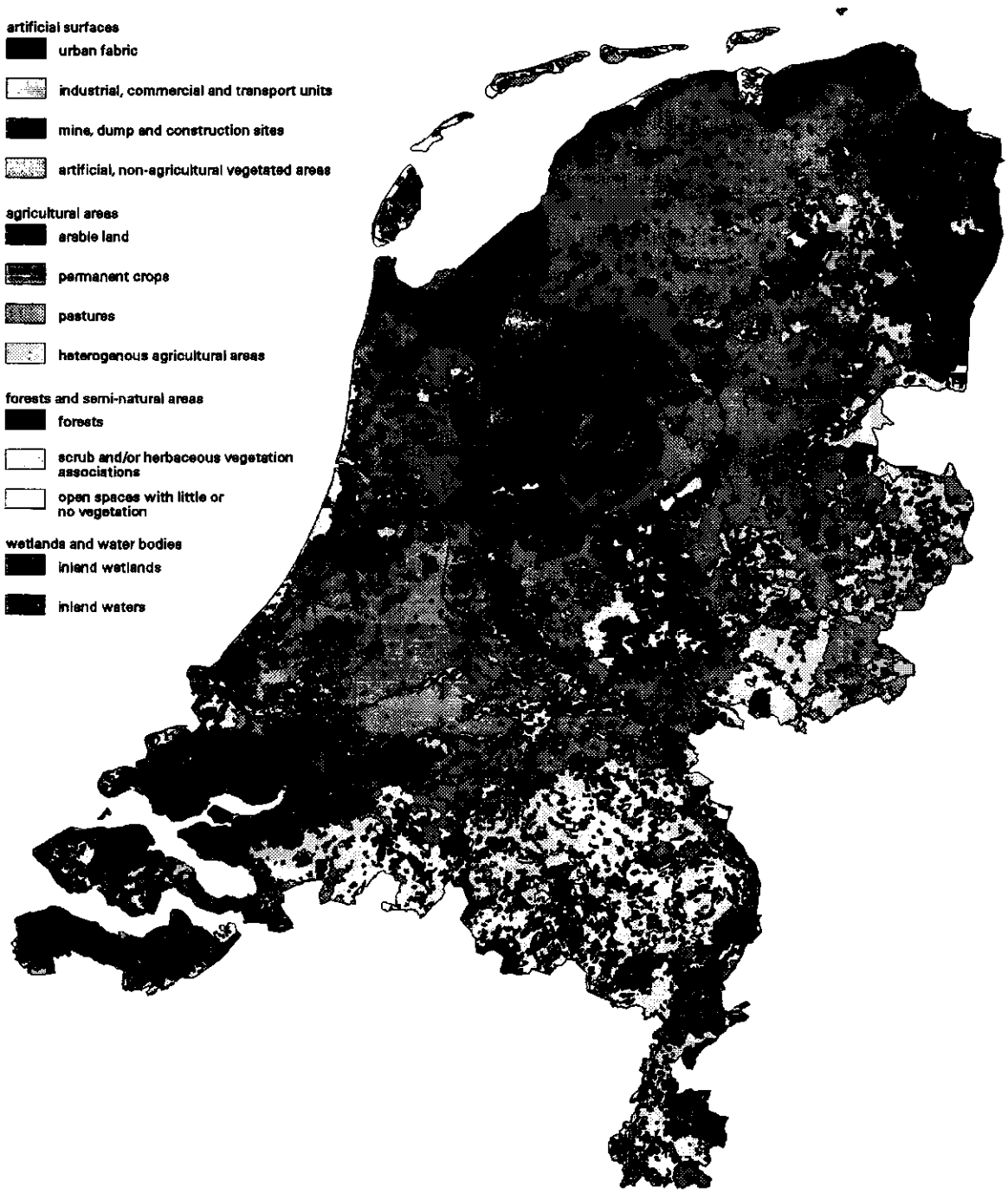

Figure 2. CORINE Land Cover map of the Netherlands showing level 2 classes.

by determining every kilometer the land cover on both sides of the selected roads. The land cover type and the corresponding code of the CORINE nomenclature were determined from one point of view taking into account the scale of the CORINE Land Cover database and the minimum area to be mapped (25 ha). The accuracy of the situation of the boundaries between different land cover units was only determined for the boundaries that cross the selected roads. The interpretation accuracy and reliability were determined by comparing the codes determined in the field with the codes in the CORINE Land Cover database. The results are summarized in the confusion matrix in Table 6. Totally, 324 points were visited in the field. The overall interpretation accuracy amounts 87%. However, these results have to be considered carefully, because the field validation was performed quickly, does not cover all the different landscapes in The Netherlands and comprises for a number of land cover classes no or only a restricted number of field observations. Nevertheless, the confusion matrix in Table 6 gives a global indication of the quality of the CORINE Land Cover database of The Netherlands and confirms the results of the qualitative validation. In general, it can be concluded that the interpretation has been performed satisfactorily.

Table 6 Confusion matrix of the CORINE Land Cover database of The Netherlands drawn up on the basis of a restricted field survey performed by representatives of the CORINE technical team. See Table 1 for the explanation of the land cover codes

Land cover class determined in the field	number of sample points in the CORINE Land Cover database of the Netherlands classified as:																					
	111	112	121	122	123	131	133	141	142	211	231	242	243	311	312	313	322	411	511	512	?	Total
111	42									4											1	48
112		2																				2
121	1		4																			5
122				2																		2
123					1																	1
131									1													1
133	1						2			1												4
141								1														1
142									9													9
211										20		5										25
231										1	82	4										87
242										2	12	58										72
243													4									4
311										2				11								13
312															16	1	1					18
313																17						17
322																	12					12
411											2							2				4
511																			5			5
512																				9		9
Total	44	2	4	2	1		2	1	10	30	96	67	4	11	16	18	13	2	5	9	1	

4 Conclusions and recommendations

The possibilities to use automatic classification techniques for the production of the CORINE Land Cover database are restricted. This is mainly caused because the results of automatic classification methods are based only on the radiometric characteristics of individual pixels, while most CORINE Land Cover classes are by nature heterogeneous. By that information on texture and context plays an important role for the delineation and identification of most of the CORINE classes. Moreover, some CORINE classes are determined by the land **use** and consist of different land cover classes (e.g. airports).
The best combination of three TM bands for land cover mapping is: TM4 (near infrared), TM5 (middle infrared) and TM3 (red). An optimal contrast enhancement of the hard copies to be used for visual interpretation is of consequence. It will save time and increase the quality of the interpretation result.

In general it can be stated that high quality exogeneous data (topographic maps, land use statistics, aerial photographs) and experienced interpreters are necessary to get an good interpretation result. For some classes which were difficult to be recognized unambiguously on the satellite images the delineation and/or identification was strongly supported by ancillary data. In fact the same updated ancillary data will have to be available during the updating of the database. Problems will arise when ancillary data are not updated any more or are updated with a very low frequency.

A number of the CORINE Land Cover classes is defined in a qualitative way. Moreover, some classes are difficult or not discernible on the satellite images. By that the identification and delineation is not totally objective. That means that the interpretation results can differ between different interpreters. The subjectivity of some interpretation results can have large consequences for the updating of the land cover database, because it is very difficult to determine after updating of the database if the changes in land cover are real changes or if the changes are due to interpretation differences. To diminish subjectivity in interpretation results it is important that the photo interpreters are competent and experienced and have knowledge of the region to be mapped. If the interpretation of the satellite images is performed by different (teams of) interpreters, coordination of the work and mutual communication to ensure consistency and comparability in interpretation is of vital importance. This also applies to different countries. To ensure consistency and comparability in interpretation between different countries it is of consequence to organize regional workshops. Central meetings attended by representatives from all the participating countries are less effective.

To diminish subjectivity in interpretation results and to ensure consistency and comparability in interpretation it would also be helpful to make some definitions more unambiguous and/or objective, taking into account the discernability on the satellite images. Some adapted definitions were proposed at the regional CORINE Land Cover meeting, held at 28th and 29th September 1992 in Wageningen the Netherlands. The main results of this meeting which are relevant for the Dutch situ-

ation, are included in Annex 5. Further it is advised to include interpretation results of different land cover types in the manual. Meanwhile, examples of interpretation result were included in the last version of the technical guide (European Commission, 1994).

Updating of the CORINE Land Cover database will be performed by direct digitisation on screen, enabling optimal contrast enhancement and complementary processing (e.g. vegetation index) of the satellite images and the use of digital ancillary data.

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Annex 1. CORINE Land Cover project, nomenclature definitions

Source: European Commission, Directorate-General Environment, Nuclear Safety and Civil Protection, 1993. *CORINE land cover. Technical guide*. Luxemburg. Office for Official Publications of the European Communities. pp. 28-31

Nomenclature definitions

1. Artificial surfaces

1.1. Urban fabric

1.1.1. Continuous urban fabric

Most of the land is covered by structures. Buildings, roads and artificially surfaced areas cover almost all the ground. Non-linear areas of vegetation and bare soil are exceptional.

1.1.2. Discontinuous urban fabric

Most of the land is covered by structures. Buildings, roads and artificially surfaced areas associated with vegetated areas and bare soil, which occupy discontinuous but significant surfaces.

1.2. Industrial, commercial and transport units

1.2.1. Industrial or commercial units

Artificially surfaced areas (with concrete, asphalt, tarmacadam, or stabilized, e.g. beaten earth) devoid of vegetation, occupy most of the area in question, which also contains buildings and/or vegetated areas.

1.2.2. Road and rail networks and associated land

Motorways, railways, including associated installations (stations, platforms, embankments). Minimum width to include: 100 m.

1.2.3. Port areas

Infrastructure of port areas, including quays, dockyards and marinas.

1.2.4. Airports

Airport installations: runways, buildings and associated land.

1.3. Mine, dump and construction sites

1.3.1. Mineral extraction sites

Areas with open-pit extraction of industrial minerals (sandpits, quarries) or other minerals (opencast mines). Includes flooded gravel pits, except for river-bed extraction.

1.3.2. Dump sites

Landfill or mine dump sites, industrial or public.

1.3.3. Construction sites

Spaces under construction development, soil or bedrock excavations, earthworks.

1.4. Artificial, non-agricultural vegetated areas

1.4.1. Green urban areas

Areas with vegetation within urban fabric. Includes parks and cemeteries with vegetation.

1.4.2. Sport and leisure facilities

Camping grounds, sports grounds, leisure parks, golf courses, racecourses, etc. Includes formal parks not surrounded by urban zones.

2. Agricultural areas

2.1. Arable land

Cultivated areas regularly ploughed and generally under a rotation system.

2.1.1. Non-irrigated arable land

Cereals, legumes, fodder crops, root crops and fallow land. Includes flower and tree (nurseries) cultivation and vegetables, whether open field, under plastic or glass (includes market gardening). Includes aromatic, medicinal and culinary plants. Excludes permanent pastures.

2.1.2. Permanently irrigated land

Crops irrigated permanently and periodically, using a permanent infrastructure (irrigation channels, drainage network). Most of these crops could not be cultivated without an artificial water supply. Does not include sporadically irrigated land.

2.1.3. Rice fields

Land developed for rice cultivation. Flat surfaces with irrigation channels. Surfaces regularly flooded.

2.2. Permanent crops

Crops not under a rotation system which provide repeated harvests and occupy the land for a long period before it is ploughed and replanted: mainly plantations of woody crops. Excludes pastures, grazing lands and forests.

2.2.1. Vineyards

Areas planted with vines.

2.2.2. Fruit trees and berry plantations

Parcels planted with fruit trees or shrubs: single or mixed fruit species, fruit trees associated with permanently grassed surfaces. Includes chestnut and walnut groves.

2.2.3. Olive groves

Areas planted with olive trees, including mixed occurrence of olive trees and vines on the same parcel.

2.3. Pastures

2.3.1. Pastures

Dense, predominantly graminoid grass cover, of floral composition, not under a rotation system. Mainly used for grazing, but the fodder may be harvested mechanically. Includes areas with hedges (bocage).

2.4. Heterogeneous agricultural areas

2.4.1. Annual crops associated with permanent crops

Non-permanent crops (arable lands or pasture) associated with permanent crops on the same parcel.

2.4.2. Complex cultivation patterns

Juxtaposition of small parcels of diverse annual crops, pasture and/or permanent crops.

2.4.3. Land principally occupied by agriculture, with significant areas of natural vegetation

Areas principally occupied by agriculture, interspersed with significant natural areas.

2.4.4. Agro-forestry areas

Annual crops or grazing land under the wooded cover of forestry species.

3. Forests and semi-natural areas

3.1. Forests

3.1.1. Broad-leaved forest

Vegetation formation composed principally of trees, including shrub and bush understories, where broad-leaved species predominate.

3.1.2. Coniferous forest

Vegetation formation composed principally of trees, including shrub and bush understories, where coniferous species predominate.

3.1.3. Mixed forest

Vegetation formation composed principally of trees, including shrub and bush understories, where broad-leaved and coniferous species co-dominate.

3.2. Shrub and/or herbaceous vegetation associations

3.2.1. Natural grassland

Low productivity grassland. Often situated in areas of rough uneven ground. Frequently includes rocky areas, briars, and heathland.

3.2.2. Moors and heathland

Vegetation with low and closed cover, dominated by bushes, shrubs and herbaceous plants (heath, briars, broom, gorse, laburnum, etc.).

3.2.3. Sclerophyllous vegetation

Bushy sclerophyllous vegetation. Includes *maquis* and *garrigue*.
Maquis: a dense vegetation association composed of numerous shrubs associated with siliceous soils in the Mediterranean environment.
Garrigue: discontinuous bushy associations of Mediterranean calcareous plateaus. Generally composed of kermes oak, arbutus, lavender, thyme, cistus, etc. May include a few isolated trees.

3.2.4. Transitional woodland/shrub

Bushy or herbaceous vegetation with scattered trees. Can represent either woodland degradation or forest regeneration/colonization.

3.3. Open spaces with little or no vegetation

3.3.1. Beaches, dunes, and sand plains

Beaches, dunes and expanses of sand or pebbles in coastal or continental locations, including beds of stream channels with torrential regime.

3.3.2. Bare rock

Scree, cliffs, rocks and outcrops.

3.3.3. Sparsely vegetated areas

Includes steppes, tundra and badlands. Scattered high-attitude vegetation.

3.3.4. Burnt areas

Areas affected by recent fires, still mainly black.

3.3.5. Glaciers and perpetual snow

Land covered by glaciers or permanent snowfields.

4. Wetlands

4.1. Inland wetlands

Non-forested areas either partially, seasonally or permanently waterlogged. The water may be stagnant or circulating.

4.1.1. Inland marshes

Low-lying land usually flooded in winter, and more or less saturated by water all year round.

4.1.2. Peatbogs

Peatland consisting mainly of decomposed moss and vegetable matter. May or may not be exploited.

4.2. Coastal wetlands

Non-wooded areas either tidally, seasonally or permanently waterlogged with brackish or saline water.

4.2.1. Salt marshes

Vegetated low-lying areas, above the high-tide line, susceptible to flooding by sea water. Often in the process of filling in, gradually being colonized by halophilic plants.

4.2.2. Salines

Salt-pans, active or in process of abandonment. Sections of salt marsh exploited for the production of salt by evaporation. They are clearly distinguishable from the rest of the marsh by their segmentation and embankment systems.

4.2.3. Intertidal flats

Generally unvegetated expanses of mud, sand or rock lying between high and low water-marks. On contour on maps.

5. Water bodies

5.1. Inland waters

5.1.1. Water courses

Natural or artificial water-courses serving as water drainage channels. Includes canals. Minimum width to include: 100 m.

5.1.2. Water bodies

Natural or artificial stretches of water.

5.2. Marine waters

5.2.1. Coastal lagoons

Unvegetated stretches of salt or brackish waters separated from the sea by a tongue of land or other similar topography. These water bodies can be connected with the sea at limited points, either permanently or for parts of the year only.

5.2.2. Estuaries

The mouth of a river within which the tide ebbs and flows.

5.2.3. Sea and ocean

Zone seaward of the lowest tide limit.

NB : When the various national CORINE land cover projects are carried out the above definitions may be tightened up and supplemented in order to make them more operational.

Annex 2. Methodology and result of the experiment to convert the LGN raster based land cover database into the polygonal CORINE land cover database

For the production of the CORINE Land Cover database of the Netherlands it could be beneficial to take advantage of the results obtained in the framework of the project 'Land Cover Classification of the Netherlands with LANDSAT TM Images (Thunnissen, 1991 and 1993). It has to be noted that both databases differ concerning:

- nomenclature
  The classes in the LGN database are based on an agricultural point of view, while The CORINE classes are defined from a environmental point of view.
- methodology
  The recommended interpretation method for the CORINE project is based on computer assisted photo interpretation. For the LGN project, on the contrary, the classification is performed using an automatic classification procedure. This method is chosen in view of the objective of the project and the rather homogeneous agricultural plots in the Netherlands.
- data storage
  The LGN database is stored in raster format, while the CORINE Land Cover database is stored in vector format.
- scale
  The LGN database consists of grid cells of 25 x 25 m, while in the CORINE Land Cover database the smallest area to be delineated equals 25 ha.

Because of the differences in databases an experiment was performed to convert the LGN raster database into the CORINE vector database.

Methodology

The following methodology was proposed for the production of the CORINE Land Cover database, using the LGN database as a starting point:

- the land cover classes in the LGN database were grouped according to the CORINE nomenclature;
- the raster based LGN database was automatically transformed into a vector based CORINE Land Cover database. The following procedure was applied:
  . repeated application (3 times) of a 3 x 3 pixel majority filter to decrease the large number of scattered individual pixels and to speed up the raster to vector conversion;
  . raster to vector conversion. To perform this conversion the image was subdivided into sub areas of 500 x 500 pixels because of ARC/INFO software limitations with regards to the maximum number of arcs per polygon and the maximum number of polygons per coverage;
  . elimination of all polygons within the LGN class 'built-up area' smaller than 25 ha in order to remove to a large extent the linear elements as roads and railways. These were assigned to the neighbouring polygon with the largest

mutual boundary;

. elimination of all polygons smaller than 1 ha to facilitate the manipulation of the polygons and to enable the merging of the individual coverages into larger coverages. This operation was of little influence to the final product;
. assignment of polygons smaller than 25 ha to neighbouring polygons. The final result was influenced by the order in which the different classes were assigned, e.g. starting with the assignment of polygons with arable land provided slightly other results than starting with assigning polygons with pastures. No general advice can be given. The optimal order has to be found by trial and error.

  Polygons smaller than 25 ha were first assigned to neighbouring polygons with a corresponding land cover (i.e. a land cover class within the same level 1 class of the CORINE nomenclature). If no neighbouring polygon within the same level 1 class was found the concerning polygon was assigned to the neighbouring polygon with the largest mutual boundary;
. smoothing of the polygon boundaries. The origin of the data remained visible in the resulting coverage by the grid structure of the lines. Therefore, a smoothing operation was applied by calculation of splines through the lines.

- hard copies of geometrically corrected and contrast enhanced false colour images (TM bands 3, 4 and 5) at scale 1 : 100 000 were produced;
- the coverage resulting from application of the conversion algorithm was plotted on a transparency to be superimposed on the hard copies of the satellite images;
- the quality of the result of the raster to vector conversion was determined by the comparison of the polygons on the transparency with the land cover classes visible on the satellite image. If necessary, corrections were made on the transparencies. The level 1 and 2 classes, resulting from the raster to vector conversion, were further subdivided into level 3 classes by visual interpretation of the satellite images. Those classes not present in the LGN database were added by visual interpretation. Exogenous information as topographical and thematic maps, statistical inventories, aerial photographs etc. was used to support the image interpretation;
- the corrections and additions made on the transparencies were digitized.

Evaluation

The polygons that resulted from the automatic conversion of the LGN database to the CORINE database were compared with the land cover classes visible on the satellite image. Furthermore, the effort needed for the correction and the completion of the CORINE database was evaluated.

The agreement between both databases was disappointing and a large amount of time was required for correction and completion of the database. The main encountered errors/problems concerned:

- The LGN classification was mainly produced by automatic classification, which is based only on the radiometric characteristics of individual pixels, while most CORINE Land Cover classes are by nature heterogeneous. Moreover, some CORINE classes are determined by the land use and consist of different land cover classes (e.g. airports). In the definition of most of the CORINE classes information on texture and contexture plays an important role. Thereby, only in

some cases polygons in the LGN database agreed completely with CORINE polygons. The poor agreement can be imputed to:

  . the criterion that the minimum acreage of individual areas in the CORINE database amounts 25 ha resulted in the outline of units which would not be outlined in a visual interpretation, where the context was taken into account (e.g. individual arable land plots larger then 25 ha scattered in an area with mainly grassland;
  . houses situated in a forested area were classified as the spectral most comparable class i.e. forest, while it should be labelled in the CORINE classification as discontinuous urban area;
  . main roads, water courses and lines of trees were correctly classified in the LGN project and resulted often in polygons larger than 25 ha. However, most of these linear elements are often to narrow to be included in the CORINE database;
  . the interpretation of complex classes like 'complex cultivation patterns' and 'land principally occupied by agriculture, with significant areas of natural vegetation' was hindered by the large number of individual polygons on the transparency, consisting of small areas classified as forest, pastures, arable land etc.;

- by the large number of processing steps applied on the classified satellite image (filtering, raster to vector conversion, eliminating of polygons smaller than 1 ha, assignment of the polygons smaller than 25 ha to neighbouring classes, polygon smoothing) some polygon boundaries were shifted so that their position deviated from the position they would have had after visual interpretation;
- the extremely large amount of computer processing time required for the raster vector conversion, the correction and the completion of the digital database using a digitizer. It required about as much time as digitization of the complete database.

After evaluation of the results it was decided to produce the complete CORINE database by visual interpretation of the satellite images, supported by exogenous data.

Annex 3. Description of items in the land use statistics of the Central Bureau of Statistics of the Netherlands

No.	Class description
1.	Railways, tramways and metros
2.	Metalled roads (incl. verges)
3.	Unmetalled and half-metalled roads (incl. verges)
4.	Water reservoirs
5.	Other water wider than 6 m. (rivers, canals, lakes, excl. cat 32-33)
6.	Cemeteries
7.	Sports grounds (incl. car parks)
8.	Airfields and airports
9.	Allotments
10.	Dumping sites
11.	Car wreck sites
12.	Mining areas
13.	Parks and public gardens
14.	Holiday recreation
15.	Recreational objects and areas
16.	Social-cultural facilities (hospitals, education, club building, museums etc.).
17.	Other public facilities (utility services, storage yards for public authorities).
18.	Industrial and harbour areas (incl. car parks, offices and other auxiliary buildings).
19.	Commercial areas (e.g. auction buildings, storage yards for trade)
20.	Other trade areas (e.g. shops, offices, banks, hotel and catering)
21.	Residential areas (incl. streets, basic schools, gardens and public greens)
22.	Mixed residential and work areas
23.	Building sites for industrial and harbour areas
24.	Building sites for other purposes
25.	Woodland
26.	Woodland with primarily recreational function
27.	Glasshouses
28.	Other agricultural use
29.	Dry natural areas (dry heaths, dunes and sandy beaches)
30.	Wet natural areas (wet heaths, moors)
31.	Other areas
32.	Waddenzee
33.	North sea
34.	IJssel lake
35.	Oosterschelde and Westerschelde

Annex 4. Overview of the acquisition dates of the satellite images used for the production of the CORINE Land Cover database of the Netherlands. For each trancparency the used satellite images are indicated. The situation of the 29 transparencies is given in figure 1

Transparency no.	Acquisition dates of the satelite images						
	20-08-84	03-08-86	16-06-86	12-08-86	05-07-87	14-07-87	14-06-88
1		x					
2		x					
3		x					
4		x					
5		x					
6		x					
7		x	x			x	
8		x	x			x	
9		x					
10		x					
11		x	x				
12		x					
13		x					
14		x	x				
15		x	x				
16		x					
17				x			
18		x					
19		x					
20		x					
21		x					
22				x			
23	x				x		
24		x			x		
25		x					
26		x					
27		x					
28		x					
29							x

Annex 5. Regional CORINE Land Cover meeting in Wageningen at 28th and 29th september 1992

At 28th and 29th September 1992 The Winand Staring Centre for Integrated Land, Soil and Water Research organised a regional CORINE Land Cover meeting in Wageningen, The Netherlands. This meeting was attended by representatives of the CORINE teams of Norway, Denmark, Germany, Ireland (including northern Ireland), Belgium and The Netherlands. Moreover, representatives of the central CORINE team participated to this meeting.

The main aim of the regional CORINE Land Cover meeting was to discuss interpretation problems concerning the CORINE Land Cover database in the north-western part of Europe. Interpretation problems in the CORINE Land Cover project are related to identification problems, deliniation problems or to problems with regard to the assignment of specific land units to the Corine land cover nomenclature. The following interpretation problems and proposed (provisional) solutions are relevant for the Dutch situation:

Artificial areas

- Sometimes, the distinction between 'Continuous urban fabric' (1.1.1) and 'Discontinuous urban fabric' (1.1.2) is troublesome on the available hard copies. Both classes are defined in a qualitative way (for instance 1.1.2: 'A *predominance* of the land is covered by structures' ..... 'vegetated areas and bare soil must occupy *significant* surfaces'). By that the deliniation of these areas is very much dependent on the interpreter. At the meeting in Wageningen it was proposed to make the definition more quantitative c.q. objective: the cut-off point adopted to differentiate between the above two classes is that class 1.1.2 is assigned when the urban fabric (i.e. impermeable surfaces) occupies less then 80% of the surface area. For most countries in humid regions this cut-off point corresponds with a coverage of 20% of the surface with vegetation. This coverage percentage pertains to real ground surface. For instance in streets bordered with trees the real ground surface under the trees is mostly for the graeter part covered with asphalt or such-like material. So, the percentage of the surface covered with vegetation has to be estimated, taking into account the shape, structure and context visible on the satellite image (e.g. streets bordered with trees can easily be recognized as linear elements);
- The transition between built-up areas situated in a wooded area ('Discontinuous urban fabric'; 1.1.2) and 'Forests' (3.1) is a gradual one. A cut-off point has to be determined which must be related to the density of the built-up area and the use of the area (is the area only used for habitation or also for other purposes, e.g. recreation?). The determination of the cut-off point needs still further discussion. The CORINE technical team will work out a more workable definition;
- Sometimes it is difficult to distinguish between 'Continuous urban fabric' (1.1.1) and 'Industrial or commercial units' (1.1.2), especially when the industrial area is situated within urban area. The availability of high quality ancillary data is essential;

- Industrial units associated with 'Seaports' (1.2.3) are not included included in class 1.2.3;
- 'Airports' (1.2.4) consisting only of grassland could be confused with 'Pastures' (2.3.1). The availability of high quality ancillary data is essential;
- Areas within 'Airports' (1.2.4) are considered to be 'associated land' (as mentioned in the CORINE nomenclature definition) when these areas have a *direct functional use* for the airport. So, forested areas or areas in agricultural use situated within the outer boundary of the airport are seperately classified as 'Forests' or 'Agricultural areas' when they are larger then 25 hectare. An exception is made for a zone of 100 m wide along visible infrastucture. These zones are considered to be associated land and classified as 'Airport';
- The land cover class 'Mineral extraction sites' (1.3.1) includes associated industrial land;
- 'Mineral extraction sites' (1.3.1), especially gravel pits under water cannot be distinguished from 'Water bodies' (5.1.2). Contextual information and ancillary data are necessary for a correct interpretation.

Agricultural areas

- In some areas in the Netherlands orchards (2.2.2) are a very important land cover class. However, individual complexes are hardly ever larger than 25 ha. Sometimes subareas can be found where orchards dominate the surface in terms of percentage (i.e. more than 50 % of the area consists of orchards). However, the deliniation of these areas is often troublesome and dependent on the experience of the interpreter. Mostly, orchards are included in class 2.4.2 ('Complex cultivation patterns'). High quality ancillary data are esential;
- For problems with regard to the distinction between 'Pastures' (2.3.1) and 'Natural grasslands' (3.2.1) see below;
- The land cover classes 'Complex cultivation patterns' (2.4.2) and 'Land principally occupied by agriculture, with significant areas of natural vegetation' (2.4.3) are defined in a qualitative way. By that the deliniation of these areas is very much dependent on the interpreter. At the meeting in Wageningen more quantitative c.q. objective definitions were proposed:
  . Class 2.4.2 consists of a mixture of agricultural classes, each smaller than 25 hectares, but together forming a unit larger than 25 hectares. The criterion adopted to distinguish class 2.4.2 is that class 2.4.2 is assigned when 'pure' agricultural classes occupy less than 75% of the surface area;
  . Class 2.4.3 consists of a mixture of agricultural areas and areas of (semi) natural vegetation, each smaller than 25 hectares, but together forming a unit larger than 25 hectares. The criterion adopted to distinguish class 2.4.3 is that class 2.4.3 is assigned when agricultural areas as well as areas of (semi) natural vegetation occupy more than 25% and less than 75% of the surface area.
- In the Netherlands there are some large allotment complexes. They are interpreted as 'Complex cultivation patterns' (2.4.2), but maybe they could, according to their main use, better be classified as 'Sport and leisure facilities' (1.4.2). It was agreed that 2.4.2 is the correct class for these areas.

Forest and semi natural areas

- Broad-leaved forest (3.1.1) situated in inland marches was difficult to distinghuish from the CORINE class 'inland marches' (4.1.1) on the available hard copies. The availability of high quality ancillary data is essential;
- Wet, low wooded land situated in 'inland marches' is interpreted as 'Broad leaved forest' (3.1.1), but contextual information and the class definition, indicates that it could sometimes also be 'Transitional woodland-scrub' (3.2.4);
- The CORINE Land Cover classes 'Broad-leaved forest' (3.1.1), 'Coniferous forest' (3.1.2) and 'Mixed forest' (3.1.3) are defined in a qualitative way. By that the deliniation of these classes is very much dependent on the interpreter. At the meeting in Wageningen more quantitative c.q. objective definitions were proposed: The criterion adopted to differentiate between the above three classes is that class 3.1.1 and 3.1.2 are assigned when broad-leaved forest and coniferous forest, respectively occupy more than 75% of the forested area. If that is not the case the area is interpreted as mixed forest;
- In the beginning of this century large areas in the Netherlands consisted of low productivity grasslands which were rich in herbs and not manured. The management of these grasslands consisted of mowing or grazing. Nowadays most of these 'natural' grasslands are intensively used for agricultural purposes. Only a few of the original low productivity grasslands are not or only extensively used for agricultural purposes, because they are situated in areas of uneven ground or in areas with unfavourable hydrological conditions for agricultural use. In general, these low productivity grasslands can spectrally not be distinghuished from intensively used grasslands, which show a large spectral heterogeneity because of mowing, grazing and other management activities. However, the acreage of the remained low productivity grasslands is often less than 25 hectare and a large number of these grasslands are situated in nature reserves.

  Nowadays in the Netherlands more and more attention is paid to nature restoration. In the framework of this policy grasslands, which are situated in areas with potential, high natural values (f.i. seepage areas within brook valleys and forelands) are managed with the purpose to restore the original natural values, i.e. they will only be mown or grazed by animals and no manure will be applied anymore. So, in future the area of natural grassland will increase considerably. That development will give rise to two problems with regard to the CORINE land cover database:
  . Altough more and more grasslands will be withdrawn from agricultural use the transition to low productivity grasslands will be a gradual one. Have these grasslands to be classified as 'Pastures' (2.3.1) or as 'Natural grassland' (3.2.1) and where will be the cut-off point;
  . The delineation of these 'natural grasslands' will be troublesome, because of the spectral confusion between these grasslands and graslands in agricultural use, which show a large spectral heterogeneity because of mowing, grazing and other management activities. So, ancillary data must be available for a correct identification and delineation of these areas.

Wetlands

- Low-lying, wet grasslands which are usually flooded in winter and in agricultural use during summer have to be classified as 'Pastures' (2.3.1) and not as 'Inland

marches' (4.1.1);
- Hardly any 'Intertidal flats' (4.2.3) are incuded in the CORINE Land Cover database of the Netherlands, because they could not de distinghuished on the available satellite images. According to the definition intertidal flats must be located above 0 meter (sea level contour). This is no workable definition. It is better to define intertidal flats as unvegetated grounds which fall dry at ebb-tide. Intertidal flats can only be delineation on the basis of ancillary data;
- 'Estuaries' (5.2.2) are defined as 'the mouth of a river where it broadens into the sea and within which the tide ebbs and flows'. In practice, especially in the south-western part of the Netherlands large estuaries occur of which the delineation of the seaward and landward limits presents difficulties. Moreover, in this area the 'Oosterschelde' is situated which is still subject to ebb-tide and flood-tide, but in which no river flows anymore. The defenition of estuaries needs further discussion. The CORINE technical team will work out a more workable definition.

Conclusions

In general it can be stated that high quality exogeneous data (topographic maps, land use statistics, aerial photographs) and experienced interpreters are necessary to get a good interpretation result.

A number of the CORINE Land Cover classes is defined in a qualitative way. By that the identification and delineation is not totally objective. That means that the interpretation results can differ between different interpreters. The subjectivity of some interpretation results can have large consequences for the updating of the land cover database, because it is very difficult to determine if changes in land cover are real changes or if the changes are due to interpretation differences. To diminish subjectivity in interpretation results it is important that the photo interpreters are competent and experienced and have knowledge of the region to be mapped. Moreover, the definitions of some CORINE Land Cover classes have to be adapted and to be made more quantititive, c.q. objective. Some adapted definitions were proposed at the CORINE meeting in Wageningen. All the proposed solutions for the encountered interpretation problems are provisional. They need further discussion within in the CORINE technical team and with other countries involved in the CORINE Land Cover project. Nevertheless, from now on the adapted definitions of some of the CORINE Land Cover classes can be used in the interpretation phase.

Annex 6. Validation of the CORINE Land Cover database by field survey

OPÉRATION DE CONTRÔLE

résultats de l'enquête terrain

février 1992

Michel BOSSARD IGN

Yves HEYMANN SITEE

CORINE LAND-COVER PAYS-BAS

CONTROLE TERRAIN.

1°/ OBJECTIF.

Evaluer rapidement la précisiion de l'interprétation Land-Cover Hollande par une enquête terrain.

2°/ PROCEDURE.

Dans un premier temps trois zones géographiques ont été sélectionnées en fonction de la compléxité de leur occupation du sol. Le contrôle de l'interprétation a été mené par sondages kilométriques le long de transects routiers. La précision de l'interprétation est appréciée du seul point de vue de l'affectation d'un code de la nomenclature à une unité (la précision de la délimitation des unités ne concerne que les limites de l'unité le long du transect routier).

3°/ MISE EN OEUVRE.

Pour chacune des trois zones sélectionnées, on a défini plusieurs transects routiers en fonction de l'intérêt de l'occupation du sol des régions traversées. Pour ce faire on s'est appuyé sur l'éxamen des images satellites et des cartes topographiques au 1:100.000°.

Un détail topographique remarquable visible sur la carte et sur l'image satellite a permi pour chaque transect de positionner le **Km zéro.** A partir du Km 0, on a effectué tous les kilomètres deux.observations (une de chaque coté de la route) et le code Land-Cover correspondant indiqué sur un calque superposé à l'image satellite.

4°/ LES RESULTATS.

Les observations terrain ont été comparées à l'interprétation et chaque observation a fait l'objet d'un constat d'accord ou de désaccord. Une fiche synthétique résume par zone géographique le résultat de ces comparaisons.

Globalement pour les les trois zones considérées (324 observations), la confrontation terrain/interprétation conduit à **87% de conformité.** Bien évidemmment ce résultat doit être considéré avec précaution dans la mesure où l'opération de contrôle a été rapide et n'a pu couvrir tous les paysages du territoire de la Holllande.
La matrice de confusion (observations terrain/interprétation), bien que ne couvrant qu'un nombre réduit de poste de la nomenclature,permet néanmoins de mettre en évidence les biais d'interprétation les plus fréquents:

- **postes 242/231/211** : le classement de ces unités, s'il n'est pas guidé par le strict respect des instructions du guide (prise en compte de la surface minimum de 25 ha, analyse de la structure et de la texture de l'image pour la délimitation des unités...) fait place àla subjectivité de l'interprète. La matrice de.confusion montre bien ce phénomène entre le poste 242 et les postes 231 et 211.

- **poste 121** : les divergences semblent résulter de la non prise en compte de zones industrielles incluses dans le tissu urbains (mais ces zones sont ,il est vrai, dificilement identifiables sur les images).

- **poste 133** : les confusions relevées concernent les postes 111 et 211. Les confusions s'expliquent par le caractère dynamique de ce poste, lorsque la signature spectrale n'est pas nette; en l'absence de photos aériennes, différentes affections sont envisageables.

- **poste 311** : le biais d'interprétation provient logiquement de la difficulté à identifier les jeunes plantations (à faible pouvoir couvrant) parmi les terres labourables à nues.

- **poste 411** : les confusions relevées (411/231) résultent sans doute du fait que les dates d'enregistrement des données satellites permettent difficilement, d'isoler les phénomènes d'hydromorphie qui sont nettement plus facile à distinguer avec des données enregistrées en hiver.

5°/ CONCLUSIONS :

Le controle réalisé fait apparaitre **une précision globale (87%) satisfaisante** au regard des normes du projet Land-Cover. L'interprétation ayantété réalisée par un seul interprète on peut, de plus supposer que cette fiabilité est valable pour l'ensemble du territoire hollandais.
Il convient toutefois de ne pas perdre de vue les conditions très rapides dans lesquelles ces résultats ont été obtenus. Sans doute un contrôle plus sévère par sondage aléatoire, aves vérification sur photos aériennes (même rapide) permettrait-il de confirmer définitivement cette première appréciation.

* * *

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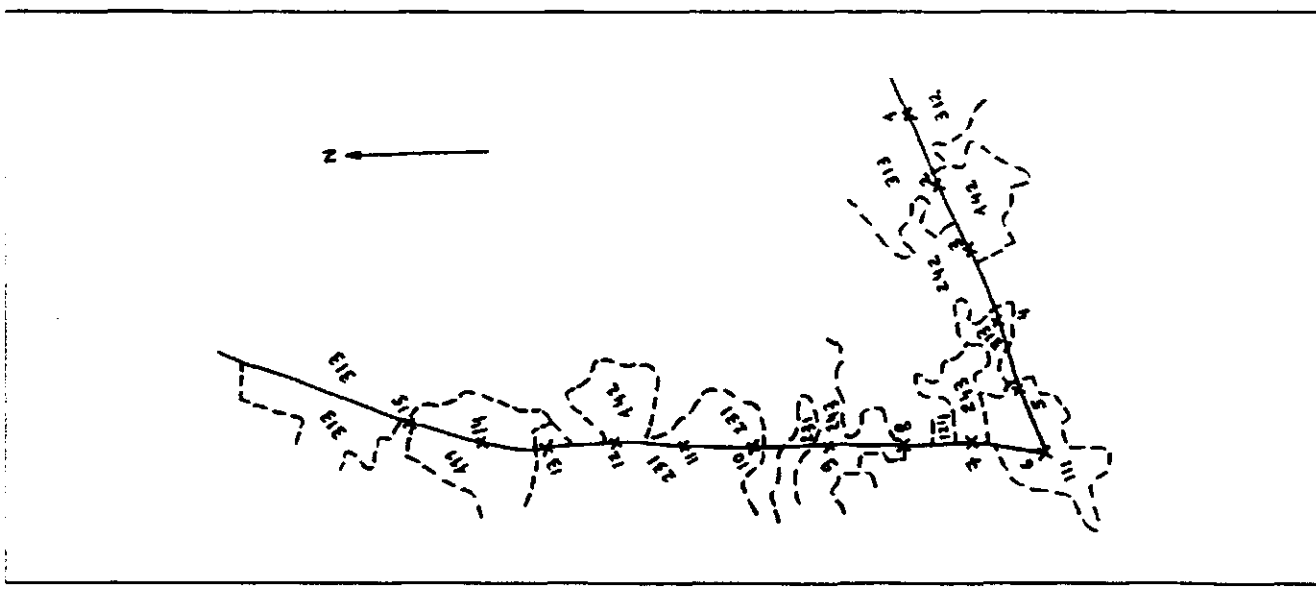
* * *

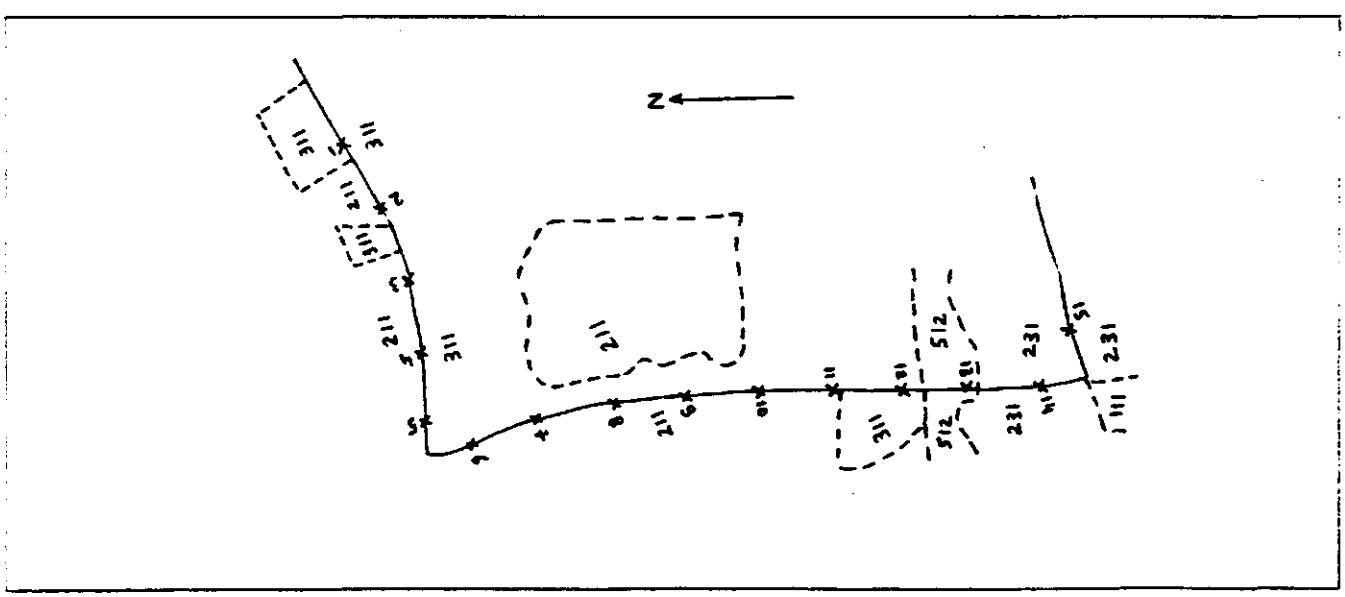
T = contrôle terrain
PI = photointerprétation

HARD COPY n° 15					itinéraire N°1		
km	code droite	accord	divergence	code gauche	accord	divergence	raison de la divergence → ←
1	313	X		312	X		
2	313	X		142	X		
3	242		X	142	X		T=242 PI=231
4	313	X		313	X		
5	111	X		111	X		
6	111	X		111	X		
7	243		X	231	X		T=243 PI=231
8	243	X		243	X		
9	243	X		243	X		
10	231	X		231	X		
11	231	X		231	X		
12	142	X		231	X		
13	231	X		231	X		
14	111	X		11	X		
15	313	X		313	X		
	Bilan	13/15	2/15		15/15		



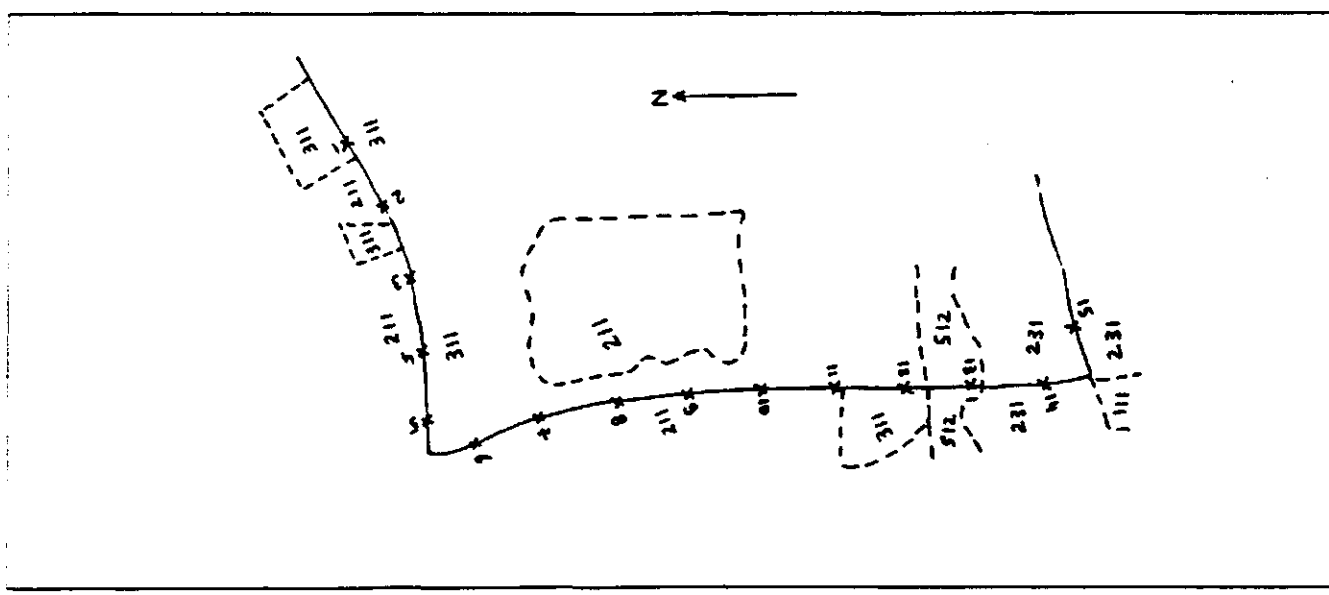
T = contrôle terrain
PI = photointerprétation

HARD COPY n° 15					Itinéraire n°2		
km	code droite	accord	divergence	code gauche	accord	divergence	raison de la divergence → ←
1	311		X	311	X		
2	211	X		311	X		
3	211	X		311	X		
4	211	X		311	X		
5	211	X		311	X		
6	211	X		311	X		
7	211	X		311	X		
8	211	X		311	X		
9	211	X		311	X		
10	211	X		311	X		
11	211	X		231	X		
12	311		X	231	X		T=311 PI=211
13	511	X		511	X		
14	231	X		231	X		
15	231	X		231	X		
Bilan		13/15			15/15		



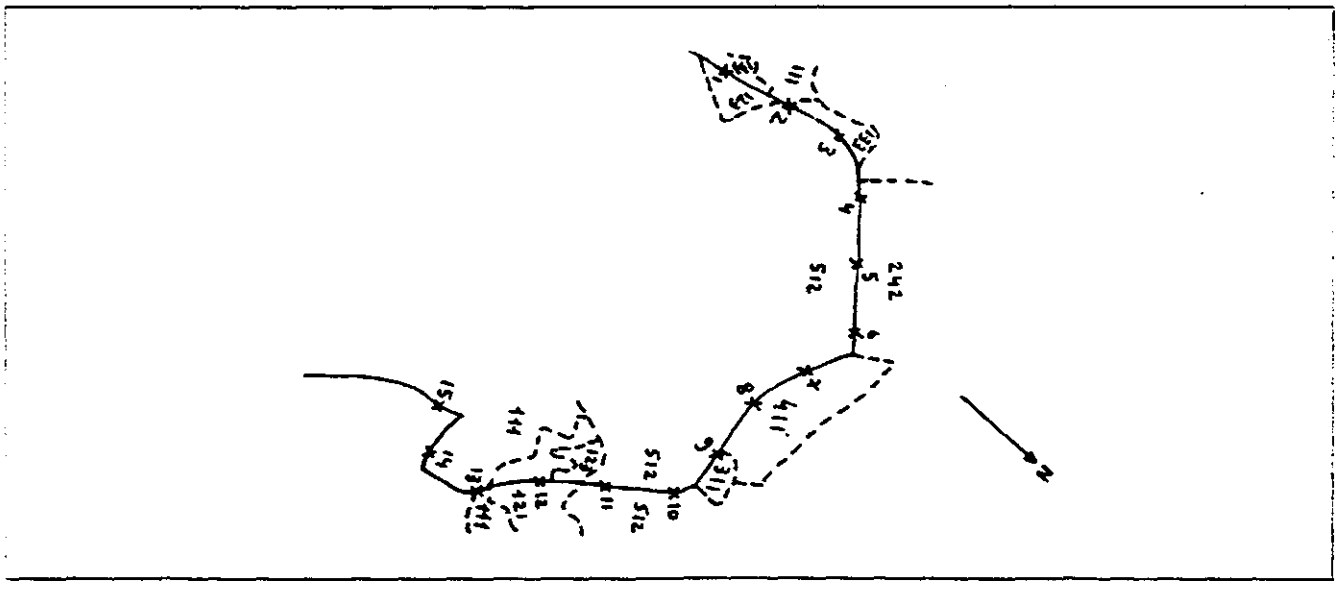
T = contrôle terrain
PI = photointerprétation

HARD COPY n° 15					itinéraire n°2		
km	code droite	accord	divergence	code gauche	accord	divergence	raison de la divergence → ←
1	311		X	311	X		
2	211	X		311	X		
3	211	X		311	X		
4	211	X		311	X		
5	211	X		311	X		
6	211	X		311	X		
7	211	X		311	X		
8	211	X		311	X		
9	211	X		311	X		
10	211	X		311	X		
11	211	X		231	X		
12	311		X	231	X		T=311 PI=211
13	511	X		511	X		
14	231	X		231	X		
15	231	X		231	X		
	Bilan	13/15			15/15		



T = contrôle terrain
PI = photointerprétation

HARD COPY n° 15					itinéraire N°3		
km	code droite	accord	divergence	code gauche	accord	divergence	raison de la divergence → ←
1	123	X		133	X		
2	512	X		111	X		
3	512	X		133		X	T=133 PI=211
4	242		X	242		X	T=242 PI=231
5	242		X	242		X	T=242 PI=231
6	242		X	242		X	T=242 PI=231
7	512	X		411	X		
8	512	X		411	X		
9	512	X		311	X		
10	512	X		512	X		
11	512	X		512	X		
12	121	X		121	X		
13	111	X		111	X		
14	111	X		111	X		
15	111	X		111	X		
	Bilan	12/15	3/15		11/15	4/15	



OPÉRATION DE CONTRÔLE

résultats de l'enquête terrain

FEUILLE 1/100 000 n°3
hard copy n°15
AMSTERDAM

Itinéraire n°	Nb de points	accord	divergence	résultat
1	28	26	2	**92%**
2	30	26	4	**86%**
3	30	24	6	**80%**
Total	**88**	**76**	**12**	**86%**

OPÉRATION DE CONTRÔLE

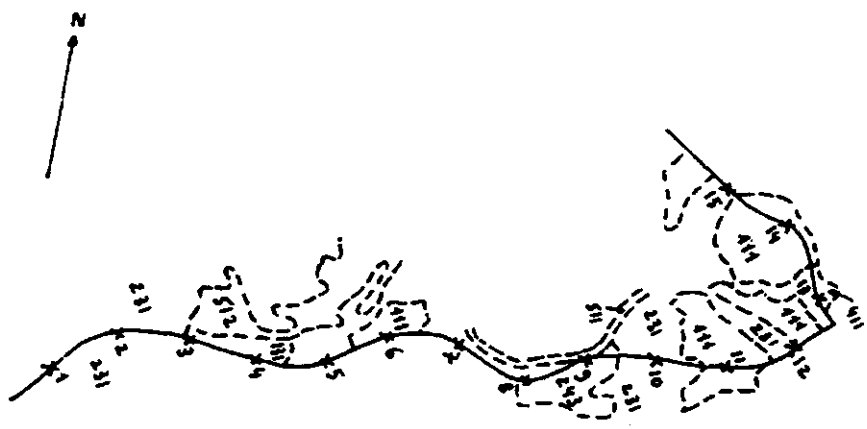
résultats de l'enquête terrain

FEUILLE 1/100 000 n°3
hard copy n°15
AMSTERDAM

Itinéraire n°	Nb de points	accord	divergence	résultat
1	28	26	2	92%
2	30	26	4	86%
3	30	24	6	80%
Total	**88**	**76**	**12**	**86%**

T = contrôle terrain
PI = photointerprétation

HARD COPY n° 21					itinéraire N°1		
km	code droite	accord	divergence	code gauche	accord	divergence	raison de la divergence ⟶ ⟵
1	231	X		231	X		
2	231	X		231	X		
3	231	X		231	X		
4	231	X		131		X	T=131 PI=142
5	231	X		231	X		
6	231	X		111	X		
7	231	X		231	X		
8	142	X		142	X		
9	142	X		511	X		
10	231	X		231	X		
11	111	X		111	X		
12	231	X		231	X		
13	411		X	411		X	T=411 PI=231
14	111	X		111	X		
15	231	X		231	X		
	Bilan	14/15			13/15		droite :93% gauche :86%



T = contrôle terrain
PI = photointerprétation

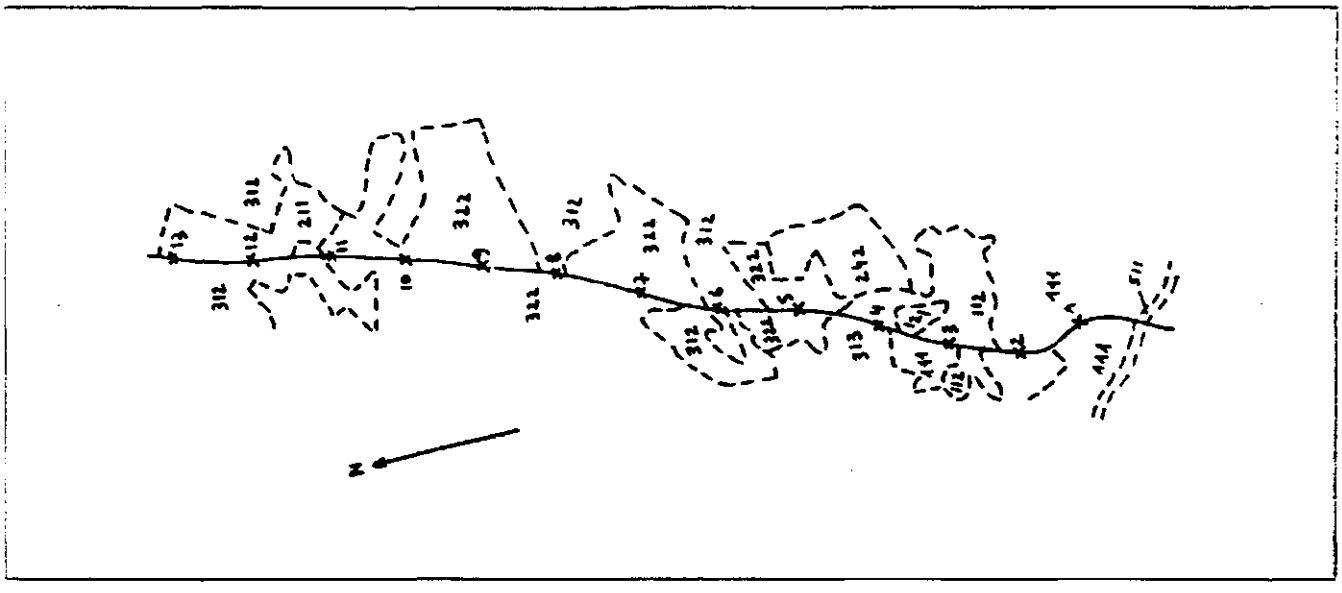
HARD COPY n° 21					itinéraire N°2		
km	code droite	accord	divergence	code gauche	accord	divergence	raison de la divergence ⟶ ⟵
1	231	X		231	X		
2	211	X		231	X		
3	242		X	231	X		T=242 PI=231
4	122	X			X		
5	231	X		231	X		
6	231	X		231	X		
7	242		X	231		X	T=242 PI=231 T=242 PI=211
8	111	X		111	X		
9	511	X		511	X		
10	111	X		242		X	T=242 PI=231
11	231/313	X		231	X		
12	313	X		231	X		
13	231	X		231	X		
14	111	X		231	X		
15	111	X		142	X		
	Bilan						droite :87% gauche :87%

T = contrôle terrain
PI = photointerprétation

HARD COPY n° 21					itinéraire N°2		
km	code droite	accord	divergence	code gauche	accord	divergence	raison de la divergence ⟶ ⟵
1	231	X		231	X		
2	211	X		231	X		
3	242		X	231	X		T=242 PI=231
4	122	X			X		
5	231	X		231	X		
6	231	X		231	X		
7	242		X	231		X	T=242 PI=231 T=242 PI=211
8	111	X		111	X		
9	511	X		511	X		
10	111	X		242		X	T=242 PI=231
11	231/313	X		231	X		
12	313	X		231	X		
13	231	X		231	X		
14	111	X		231	X		
15	111	X		142	X		
	Bilan						droite :87% gauche :87%

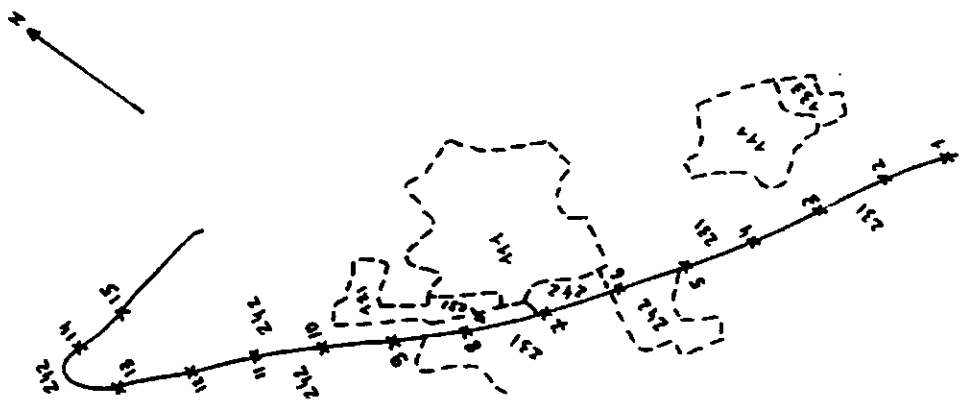
T = contrôle terrain
PI = photointerprétation

HARD COPY n° 21					itinéraire N°3		
km	code droite	accord	divergence	code gauche	accord	divergence	raison de la divergence ⟶ ⟵
1	111	X		111	X		
2	111	X		141	X		
3	112	X		111	X		
4	313	X		313	X		
5	322	X		322	X		
6	312		X	322	X		T=312 PI=322
7	322	X		322	X		
8	312	X		322	X		
9	322	X		322	X		
10	322	X		322	X		
11	322	X		312	X		
12	211	X		322	X		
13	211	X		312	X		
14							
15							
	Bilan	12/13	1/13		13/13		droite :92% gauche :93%



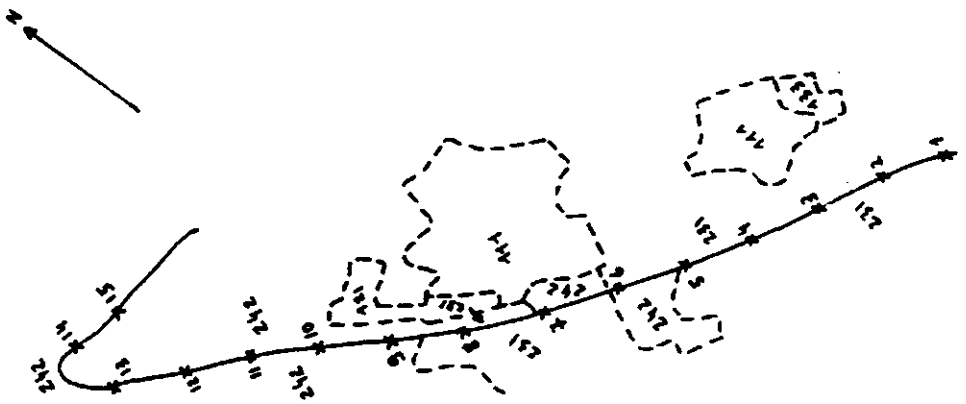
T = contrôle terrain
PI = photointerprétation

HARD COPY n° 21					itinéraire N°4		
km	code droite	accord	divergence	code gauche	accord	divergence	raison de la divergence
1	121	X		121	X		
2	231	X		231	X		
3	231	X		231	X		
4	231	X		231	X		
5	231	X		231	X		
6	231		X	242	X		T=242 PI=231
7	242		X	231		X	T=242 PI=231
8	231	X		231	X		
9	242	X		242	X		
10	242	X		242	X		
11	242	X		242	X		
12	242	X		242	X		
13	242	X		242	X		
14	242	X		242	X		
15	242	X		242	X		
	Bilan	13/15	2/15		14/15	1/15	droite :86% gauche :93%



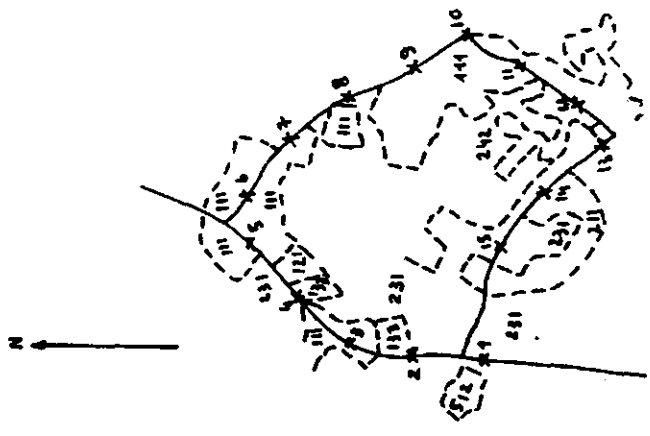
T = contrôle terrain
PI = photointerprétation

HARD COPY n° 21					itinéraire N°4		
km	code droite	accord	divergence	code gauche	accord	divergence	raison de la divergence
1	121	X		121	X		
2	231	X		231	X		
3	231	X		231	X		
4	231	X		231	X		
5	231	X		231	X		
6	231		X	242	X		T=242 PI=231
7	242		X	231		X	T=242 PI=231
8	231	X		231	X		
9	242	X		242	X		
10	242	X		242	X		
11	242	X		242	X		
12	242	X		242	X		
13	242	X		242	X		
14	242	X		242	X		
15	242	X		242	X		
	Bilan	13/15	2/15		14/15	1/15	droite :86% gauche :93%



T = contrôle terrain
PI = photointerprétation

HARD COPY n° 21					itinéraire N°5		
km	code droite	accord	divergence	code gauche	accord	divergence	raison de la divergence → ←
1	321	X		231	X		
2	133/231	X		111	X		
3	111	X		111	X		
4	133		X	142	X		T=133 PI=111
5	111	X		111	X		
6	111	X		111	X		
7	111	X		231	X		
8	111		X	231	X		T=111 PI=?(sans code)
9	111	X		111	X		
10	111	X			X		
11	111		X	111		X	T=111 PI=211
12	111	X		111	X		
13	111		X	111		X	T=111 PI=211
14	242		X	211	X		T=242 PI=211
15	231	X		231	X		
	Bilan	10/15	5/15	13/15	2/15		droite :66% gauche :86%



OPÉRATION DE CONTRÔLE

résultats de l'enquête terrain

FEUILLE 1/100 000 n°6

hard copy n°21

ARNHEM

Itinéraire n°	Nb de points	accord	divergence	résultat
1	30	27	3	90%
2	30	26	4	86%
3	30	27	3	90%
4	26	25	1	96%
5	30	23	7	76%
Total	**146**	**128**	**18**	**87%**

OPÉRATION DE CONTRÔLE

résultats de l'enquête terrain

FEUILLE 1/100 000 n°6

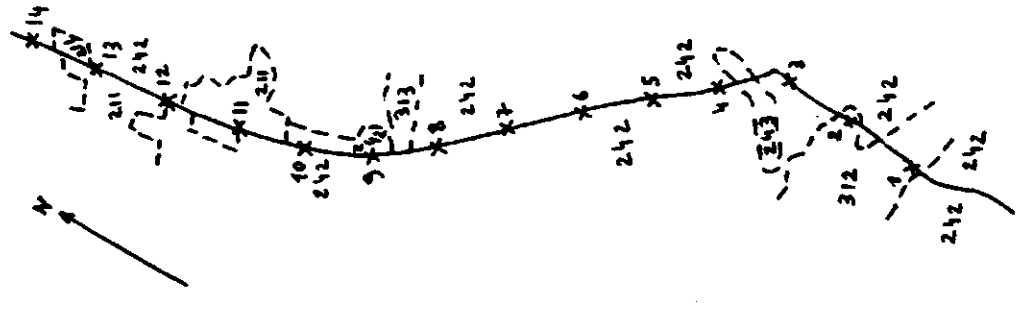
hard copy n°21

ARNHEM

Itinéraire n°	Nb de points	accord	divergence	résultat
1	30	27	3	90%
2	30	26	4	86%
3	30	27	3	90%
4	26	25	1	96%
5	30	23	7	76%
Total	146	128	18	87%

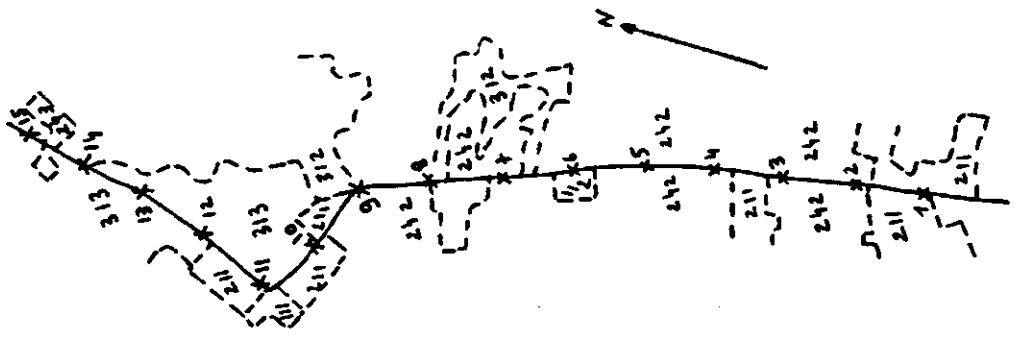
T = contrôle terrain
PI = photointerprétation

HARD COPY n° 26					itinéraire N°1		
km	code droite	accord	divergence	code gauche	accord	divergence	raison de la divergence → ←
1	312	X		312	X		
2	312	X		312	X		
3	242	X		242	X		
4	242	X		242	X		
5	242	X		242	X		
6	242	X		242	X		
7	242	X		242	X		
8	242	X		242	X		
9	242	X		242	X		
10	242	X		242	X		
11			X	211		X	T=211 PI=242
12	242	X		211	X		
13	242	X		211	X		
14	242	X		242	X		
	Bilan	13/14	1/14		13/14	1/14	



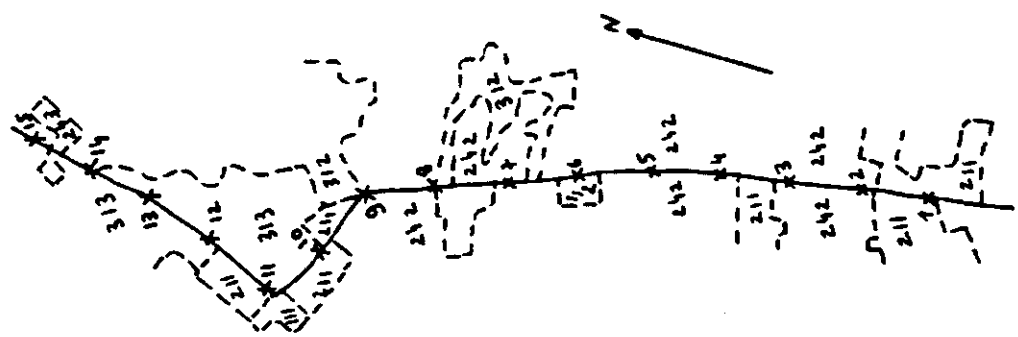
T = contrôle terrain
PI = photointerprétation

HARD COPY n°26					itinéraire N°2		
km	code droite	accord	divergence	code gauche	accord	divergence	raison de la divergence → ←
1	211	X		211	X		
2	242	X		242	X		
3	242	X		242	X		
4	242	X		242	X		
5	242	X		242	X		
6	242	X		111		X	T=112 PI=242
7	242	X		242	X		
8	312		X	231		X	T=312 PI=313 T=231 PI=242
9	312	X		242	X		
10	313	X		211		X	T=211 PI=242
11	313	X		111	X		
12	313	X		313	X		
13	313	X		313	X		
14	312	X		313	X		
15	312	X		312	X		
	Bilan	14/15	1/15		12/15	3/15	



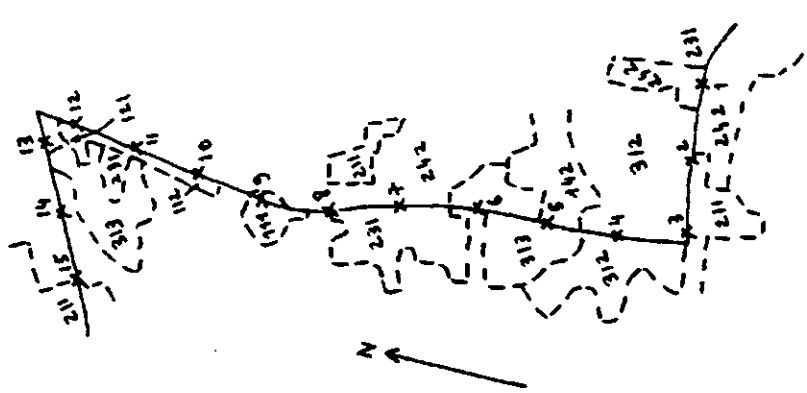
T = contrôle terrain
PI = photointerprétation

HARD COPY n°26					itinéraire N°2		
km	code droite	accord	divergence	code gauche	accord	divergence	raison de la divergence ⟶ ⟵
1	211	X		211	X		
2	242	X		242	X		
3	242	X		242	X		
4	242	X		242	X		
5	242	X		242	X		
6	242	X		111		X	T=112 PI=242
7	242	X		242	X		
8	312		X	231		X	T=312 PI=313 T=231 PI=242
9	312	X		242	X		
10	313	X		211		X	T=211 PI=242
11	313	X		111	X		
12	313	X		313	X		
13	313	X		313	X		
14	312	X		313	X		
15	312	X		312	X		
	Bilan	14/15	1/15		12/15	3/15	



T = contrôle terrain
PI = photointerprétation

HARD COPY n° 26					itinéraire N°3		
km	code droite	accord	divergence	code gauche	accord	divergence	raison de la divergence ⟶ ⟵
1	242		X	242		X	T=242 PI=231 T=242 PI=211
2	312	X		211	X		
3	312	X		211	X		
4	312	X		312	X		
5	142	X		313	X		
6	313	X		313	X		
7	242	X		231		X	T=231 PI=242
8	242	X		242	X		
9	111	X		111	X		
10	112	X		242	X		
11	242	X		121		X	T=121 PI=111
12	242	X		242	X		
13	242	X		242	X		
14	242	X		242	X		
15	211			211		X	T=211 PI=242
	Bilan	13/15	2/15		11/15	4/15	



OPÉRATION DE CONTRÔLE

résultats de l'enquête terrain

FEUILLE 1/100 000 n°6 et 8

Hard copy n°26

ARNHEM –EINDOVEN

Itinéraire n°	Nb de points	accord	divergence	résultat
1	30	28	2	93%
2	30	28	2	93%
3	30	23	7	76%
Total	**90**	**79**	**11**	**87%**

OPÉRATION DE CONTRÔLE

résultats de l'enquête terrain

=EUILLE 1/100 000 n°6 et 8

ıard copy n°26

ARNHEM –EINDOVEN

Itinéraire n°	Nb de points	accord	divergence	résultat
1	30	28	2	93%
2	30	28	2	93%
3	30	23	7	76%
Total	90	79	11	87%

CORINE LAND-COVER HOLLANDE

CONTROLE TERRAIN..

SYNTHESE DES RESULTATS

HARD COPY	NBRE DE POINTS	ACCORD	DESACCORD	RESULTAT
15	90	79	11	**87%**
21	146	128	18	**87%**
26	88	76	12	**86%**
TOTAL	324	283	41	**87%**

CORINE LAND-COVER HOLLANDE

CONTROLE TERRAIN..

SYNTHESE DES RESULTATS
(par poste)

POSTE	NBRE UNITES (P.I)	NBRE UNITES (terrain)	% ACCORD	% < 85%
111	42	48	87.5	
112	2	2	100	
121	4	5	80	XXXX
122	2	2	100	
123	1	1	100	
131	1	1	100	
133	2	4	50	XXXX
141	1	1	100	
142	9	9	100	
211	20	25	80	XXXX
231	82	87	94	
242	58	72	80	XXXX
243	4	4	100	
311	11	13	84	XXXX
312	16	18	88	
313	17	17	100	
322	12	12	100	
411	2	4	50	XXXX
511	5	5	100	
512	9	9	100	

P.I = Photointerprétation.

CORINE LAND-COVER HOLLANDE

CONTROLE TERRAIN..

SYNTHESE DES RESULTATS
(par poste)

POSTE	NBRE UNITES (P.I)	NBRE UNITES (terrain)	% ACCORD	% < 85%
111	42	48	87.5	
112	2	2	100	
121	4	5	80	xxxx
122	2	2	100	
123	1	1	100	
131	1	1	100	
133	2	4	50	xxxx
141	1	1	100	
142	9	9	100	
211	20	25	80	xxxx
231	82	87	94	
242	58	72	80	xxxx
243	4	4	100	
311	11	13	84	xxxx
312	16	18	88	
313	17	17	100	
322	12	12	100	
411	2	4	50	xxxx
511	5	5	100	
512	9	9	100	

P.I = Photointerprétation.

SYNTHESE DES RESULTATS
(matrice de confusion)

T \ P-I	111	112	121	122	123	131	133	141	142	211	231	242	243	311	312	313	322	411	511	512	?	Total
111	42									4											1	48
112		2																				2
121	1		4																			5
122				2																		2
123					1																	1
131									1													1
133	1						2			1												4
141								1														1
142									9													9
211										20		5										25
231										1	82	4										87
242										2	12	58										72
243													4									4
311										2				11								13
312															16	1	1					18
313																17						17
322																	12					12
411											2							2				4
511																			5			5
512																				9		9

Table 1. The CORINE Land Cover Nomenclature

LEVEL 1	LEVEL 2	LEVEL 3
1. ARTIFICIAL AREAS	1.1. Urban fabric	1.1.1. Continuous urban fabric
		1.1.2. Discontinuous urban fabric
	1.2. Industrial, commercial and transport units	1.2.1. Industrial or commercial units
		1.2.2. Road and rail networks and associated land
		1.2.3. Port areas
		1.2.4. Airports
	1.3. Mine, dump and construction sites	1.3.1. Mineral extraction sites
		1.3.2. Dump sites
		1.3.3. Construction sites
	1.4. Artificial, non-agricultural vegetated areas	1.4.1. Green urban areas
		1.4.2. Sport and leisure facilities
2. AGRICULTURAL AREAS	2.1. Arable land	2.1.1. Non-irrigated arable land
		2.1.2. Permanently irrigated land
		2.1.3. Rice fields
	2.2. Permanent crops	2.2.1. Vineyards
		2.2.2. Fruit trees and berry plantations
		2.2.3. Olive groves
	2.3. Pastures	2.3.1. Pastures
	2.4. Heterogenous agricultural areas	2.4.1. Annual crops associated with permanent crops
		2.4.2. Complex cultivation patterns
		2.4.3. Land principally occupied by agriculture, with significant areas of natural vegetation
		2.4.4. Agro-forestry areas
3. FOREST AND SEMI NATURAL AREAS	3.1. Forests	3.1.1. Broad leaved forest
		3.1.2. Coniferous forest
		3.1.3. Mixed forest
	3.2. Scrub and/or herbaceous vegetation	3.2.1. Natural grasslands
		3.2.2. Moors and heathland
		3.2.3. Sclerophyllous vegetation
		3.2.4. Transitional woodland-scrub
	3.3. Open spaces with little or no vegetation	3.3.1. Beaches, dunes, sands
		3.3.2. Bare rocks
		3.3.3. Sparsely vegetated areas
		3.3.4. Burnt areas
		3.3.5. Glaciers and perpetual snow
4. WETLANDS	4.1. Inland wetlands	4.1.1. Inland marches
		4.1.2. Peat bogs
	4.2. Maritime wetlands	4.2.1. Salt marches
		4.2.2. Salines
		4.2.3. Intertidal flats
5. WATER BODIES	5.1. Inland waters	5.1.1. Water courses
		5.1.2. Water bodies
	5.2. Marine waters	5.2.1. Coastal lagoons
		5.2.2. Estuaries
		5.2.3. Sea and ocean

Table 1. The CORINE Land Cover Nomenclature

LEVEL 1	LEVEL 2	LEVEL 3
1. ARTIFICIAL AREAS	1.1. Urban fabric	1.1.1. Continuous urban fabric
		1.1.2. Discontinuous urban fabric
	1.2. Industrial, commercial and transport units	1.2.1. Industrial or commercial units
		1.2.2. Road and rail networks and associated land
		1.2.3. Port areas
		1.2.4. Airports
	1.3. Mine, dump and construction sites	1.3.1. Mineral extraction sites
		1.3.2. Dump sites
		1.3.3. Construction sites
	1.4. Artificial, non-agricultural vegetated areas	1.4.1. Green urban areas
		1.4.2. Sport and leisure facilities
2. AGRICULTURAL AREAS	2.1. Arable land	2.1.1. Non-irrigated arable land
		2.1.2. Permanently irrigated land
		2.1.3. Rice fields
	2.2. Permanent crops	2.2.1. Vineyards
		2.2.2. Fruit trees and berry plantations
		2.2.3. Olive groves
	2.3. Pastures	2.3.1. Pastures
	2.4. Heterogenous agricultural areas	2.4.1. Annual crops associated with permanent crops
		2.4.2. Complex cultivation patterns
		2.4.3. Land principally occupied by agriculture, with significant areas of natural vegetation
		2.4.4. Agro-forestry areas
3. FOREST AND SEMI NATURAL AREAS	3.1. Forests	3.1.1. Broad leaved forest
		3.1.2. Coniferous forest
		3.1.3. Mixed forest
	3.2. Scrub and/or herbaceous vegetation	3.2.1. Natural grasslands
		3.2.2. Moors and heathland
		3.2.3. Sclerophyllous vegetation
		3.2.4. Transitional woodland-scrub
	3.3. Open spaces with little or no vegetation	3.3.1. Beaches, dunes, sands
		3.3.2. Bare rocks
		3.3.3. Sparsely vegetated areas
		3.3.4. Burnt areas
		3.3.5. Glaciers and perpetual snow
4. WETLANDS	4.1. Inland wetlands	4.1.1. Inland marches
		4.1.2. Peat bogs
	4.2. Maritime wetlands	4.2.1. Salt marches
		4.2.2. Salines
		4.2.3. Intertidal flats
5. WATER BODIES	5.1. Inland waters	5.1.1. Water courses
		5.1.2. Water bodies
	5.2. Marine waters	5.2.1. Coastal lagoons
		5.2.2. Estuaries
		5.2.3. Sea and ocean