Historic land use dynamics in and around Natura2000 sites as indicators for impact on biodiversity

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Phase I of the BIOPRESS project for the Netherlands

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ABSTRACT

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BIOPRESS is a EC-FP5 research project to support GMES 'Global Monitoring for Environment and Security'. It aims to provide the EU-user community with quantitative information on how changes in land cover and land use have affected the environment and biodiversity in Europe. This report is dealing with the results of the first phase of the BIOPRESS project for the Netherlands. The report concentrates on the selection, acquisition, processing and interpretation of recent and historical aerial photographs, and the production of land use change statistics for the Netherlands. Land cover and land cover change statistics were derived for five windows (30km by 30km) for 1950 and 1990 (scale 1:100.000) and nine transects (2km by 15km) for 1950, 1990 and 2000 (scale 1:20.000). Subsequently, the historic land cover dynamics have been analysed within the Natura2000 sites as well as outside these areas, including descriptions of land cover changes and their related pressures (intensification, abandonment, afforestation and urbanisation) influencing biodiversity.

Keywords: Natura2000 sites, Historic land use changes, aerial photo interpretations, land cover, biodiversity

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Preface

The BIOPRESS project is currently funded by the framework of the dedicated call under EC-FP5 for research to support GMES 'Global Monitoring for Environment and Security'. It is the only GMES project under the priority theme "Land cover change in Europe". The BIOPRESS consortium consists of seven international partners and aims to provide the EU-user community with quantitative information on how changes in land cover and land use have affected the environment and biodiversity in Europe. The main stakeholder is the European Environment Agency, through its European Topic Centres on Nature and Biodiversity (ETC-NPB) and the Terrestrial Environment (ETC-TE). Other potential users are DG Environment, DG Regional Policy, the GMES project LADAMER, National conservation agencies and regional and local authorities responsible for Natura-2000 sites.

The BIOPRESS project consists of two interrelated phases. Phase-I focuses on the production of consistent and coherent sets of historical (1950 – 1990 – 2000) land cover change information in and around of selected Natura-2000 sites located from the Boreal to the Mediterranean, and from the Atlantic to the Continental zones of Europe. Phase-II brings together methodologies in remote sensing and spatial analysis to associate the land cover changes to main pressures on biodiversity (urbanisation, abandonment, afforestation, and urbanisation).

This report describes the work and the results obtained in the first phase of the BIOPRESS project. In particular, this report describes the work carried out and implemented by ALTERRA. It contains the processing and interpretation of historic and recent aerial photographs for the production of detailed land cover statistics, in and around, Natura2000 sites in the Netherlands. The results of Phase-I in the Netherlands corroborate to the European Commission goal of using the situation in the fifties as a baseline and understanding how the surrounding land and the Natura2000 sites themselves have evolved since that date and to see what the effect is of these land cover changes on the habitat quality.

This report is of interest to everyone concerned with the land cover dynamics and habitat quality in Dutch Natura2000 sites. However, the report is also of interest to everyone interested in the BIOPRESS project. This report can also be used as an example of a Europe wide planning implementation.

Acknowledgements

The BIOPRESS project has been commissioned and financed by EU within the 5th Framework Programme. Additional fundings were obtained from the Ministry of Agriculture, Nature and Food Quality (LNV) through DWK programme GIS & Remote Sensing 431 (now BO Geo-Information) and from internal fundings of Alterra.

During the selection of the Dutch windows and transects in relation to the Dutch Natura2000 sites, Marion Pelk (Ministry of LNV), Joop Schaminée and John Janssen (Alterra) were of great help. Hereby we would like to thank them.

Furthermore, we would like to thank all BIOPRESS partners for their useful contributions during the interpretation, analysis and reporting phase of this report. Special thanks to the overall coordinator France Gerard and GISAT for the 1950 land cover interpretation of the aerial photo mosaics for the five Dutch windows.

Special thanks to Monica Wachowicz and Bob Bunce for their useful contributions and suggestions in the editing phase of this report

Summary

BIOPRESS has been designed to develop a standardised product that relates historical land cover changes (1950 – 2000) to pressures on biodiversity. The focus was given to land cover changes that have occurred in the vicinity of areas protected for their high biodiversity. The product was aimed at the EU-user community concerned with the impact of land cover changes on the environment and biodiversity. The developed activities of the project were geared to the activities of the European Environment Agency (EEA) and European Topic Centres (ETC's) as well as the activities for further development of the Community Information Systems for nature, biodiversity and forests.

This report describes the Phase-I of the BIOPRESS project that focuses on the production of consistent and coherent sets of historical (1950 – 1990 – 2000) land cover change information in and around of selected Natura-2000 sites in the Netherlands. First, a sample of sites were selected consisting of five windows of 30km by 30 km and nine transects of 2km by 15km. These Dutch windows were selected by P. Devillers and some Dutch experts. They cover all major Dutch landscape types. Furthermore, the selection of windows was based on the location of clusters of Natura2000 sites and to cover as much habitat types as possible. The selection of the transects was based on three criteria: 1) the location of the windows, 2) the location of Natura2000 sites within the windows and, 3) the land use patterns within the CORINE land cover database. The habitat types that received highest priority were forests, natural and semi-natural grasslands and inland wetlands. They are positioned in such a way that they run from a Natura2000 site to an urban area and its surroundings.

In this report, the sampling sites are described in terms of their location, CORINE land cover, Natura2000 sites and habitat types that were present at the selected windows. The location of transects within the windows cover different land cover types such as urban, agricultural, forest and semi-natural and wetland areas.

Second, Black and White (B&W) aerial photographs of 1950 (+/- 5 years), 1990 and 2000 (at least ten years time span between 1990 – 2000) were georeferenced and mosaics were produced. The CORINE land cover nomenclature was used to visually interpret these B&W aerial photographs. The CORINE nomenclature (Level 3) and the scale 1:100.000 were used for obtaining the land cover change statistics of the 5 windows, each covering an area of 900 km^2, for 1950 and 1990. The same nomenclature but using the scale 1:20.000 was used for computing the land cover change statistics of the 9 transects, each covering an area of 30 km^2, for 1950, 1990, and 2000. However, a small adaptation was made during the photo interpretation of transects that dealt with the introduction of ambiguous classes of farmed land (621) and forest (631). The use of these ambiguous classes was restricted to cases where different agricultural and/or forest land cover classes were not possible to be separated by means of aerial photo characteristics.

The visual interpretation was based on differences in tone, shape, size and texture of land cover objects. The mapping criteria for the windows were defined using the CORINE norms: 1) mapping scale, 1:100.000, 2) minimum size of objects, 25ha and 3) minimum width, 100m. The criteria used in the interpretation process of the transects consisted of: 1) mapping scale 1:20.000, 2) minimum size of objects, 0.5 ha and 3) minimum width of linear elements, 20m, 4) land cover changes must be larger than 0.5 ha size and 20m width.

Third, the backdating procedure was used to quantify the land cover changes. In the case of the window sample sites, the existing CORINE1990 land cover layer was overlapped with the 1950 B&W aerial photograph mosaics of the windows. Changes were then digitised and labelled. For the transect interpretation, the B&W aerial photographs of 2000 were interpreted with the help of the Dutch digital topographical map (Top10-vector). Afterwards, this land cover layer was overlapped with the B&W aerial photographs of 1990 and only the land cover changes were digitised. The same step was repeated using the B&W aerial photographs of 1950. The final result consists of a data layer with polygons containing a label describing their land cover for the three different time steps. In summary, the interpretation of land cover changes for 1950 and 1990 is a backdating land cover interpretation of the 2000 year.

The results of this first phase of the BIOPRESS projects show that the Netherlands has undergone major land cover changes. The five Dutch windows have land cover dynamics ranging from almost 3% up to more than 20% during the period 1950 - 1990. Most changes have occurred within the agricultural system (internal changes, i.e. from pasture to arable land and vice versa). Other important land cover changes were observed from agricultural areas (211, 222, 231, and 242 CORINE classes) into artificial areas (112 and 121 CORINE classes). These changes have had major impacts on the landscape and its biodiversity. Furthermore they are virtually irreversible. Therefore, it is possible to ascertain that the urbanisation process is one of the most important factors which have changed the landscape of the Netherlands in the last fifty years. Also the area of land covered by semi-natural vegetation has declined dramatically. For example, the window "Drenthe" explicitly shows the decline of moors and heathland (322) in the last fifty years. This land cover change is also supported by the other statistic sources such as Historic Land cover database of the Netherlands (HGN) and (Central Bureau of Statistics (CBS).

The results at a more detailed level using the transect sample sites reveal that the land cover area that has changed within the last 50 years (1950-2000) is much larger. The measured land cover changes encompass a range of 24 - 63% of the total transect area. Moreover, the type of land cover change is different among the transects. For example, some transects (Bemelerberg, Kampina, Drentse Aa, Dwingelerveld and Overijsselse Vecht) are characterised by changes within the agricultural system having high proportions of internal and less relevant changes in terms of their impact on biodiversity. A large part of these internal changes were produced by the introduction of the ambiguous class farmed land (621). The land cover changes

relevant due to their impact on biodiversity are between 12 and 41%. The most important change is the conversion of agricultural land (211, 231) into artificial land (112, 211). The only exception was observed in the transect 9 "Terschelling" where the most important land cover change has occurred from beaches and dunes (331) into salt marshes (421).

The comparison between windows and transects have also revealed the difference between the number and type of land cover changes. The different levels of detail of windows (1:100.000) and transects (1:20.000) have played a major role in the results obtained from the photo interpretation of land cover changes. Moreover, more expert knowledge was used during the photo interpretation of the transects. The differences can also be explained by the introduction of ambiguous classes during the transect interpretation. For example, changes occurred from arable land to farmed land were registered as land cover changes. Finally, the location and orientation of the transects within the windows have contributed to the difference of land cover changes found in the windows. Most of the transects were oriented from a Nautura2000 site towards an urban centre, following a land cover gradient.

Finally, the results of the transect interpretation point out that the major land cover changes took place outside the Natura2000 sites. A 74% of all land cover changes took place in the areas outside the Natura2000 sites which means a 26% of land cover changed inside the Natura2000 sites. The major changes observed inside the Natura2000 sites were internal changes (without the ambiguous classes), changes into forest and semi-natural areas and into wetlands. In contrast, the major changes observed outside the Natura2000 sites were changes between agricultural classes and farmed land (ambiguous class 621), changes into artificial areas and internal changes.

1 Introduction

1.1 Objective

The objective of this report is to describe the research work carried out within the first phase of the BIOPRESS project and examine the final results obtained for the Netherlands. The reports focuses on the selection of the sample sites, the acquisition, processing and interpretation of the recent and historical Dutch aerial photographs, and the production of land cover change statistics. The sample sites consisted of five windows of 30km by 30km where land cover changes have been measured from 1990 to 1950 at 1:100.000 scale, and nine detailed transects 15km by 2km running through selected Natura2000 sites in the Netherlands where land cover changes were measured from 2000 to 1990 and 1950 at 1:20.000 scale.

Subsequently, the historic land cover changes have been analysed within the Natura2000 sites as well as outside of these protected areas. This report contains the descriptions of the land cover changes for windows and transects. Their related pressures (intensification, abandonment, afforestation, and urbanisation) which had an impact on the biodiversity of Natura2000 sites in the Netherlands in the last fifty-years will be investigated in the second phase of the BIOPRESS project

1.2 Background

The European environment is changing rapidly caused by a combination of socio-economic and political developments. To protect the environment and to ensure sustainable use of natural resources a wide variety of national and international legal mechanisms (e.g. Amsterdam Treaty 1997, Habitats Directive, EU Common Agricultural Policy and Kyoto Protocol) have been established which in their turn have spurred on a wide range of environmental monitoring activities. Today Europe urgently needs to consolidate these monitoring efforts. The GMES initiative aims at achieving this 'European Capacity for Global Monitoring for the Environment and Security' by 2008.

The BIOPRESS project made possible to realise this ambitious goal by computing land cover changes in the vicinity of protected areas that are statistically representative of anthropogenic pressures on biodiversity in the different bio-geographical regions of Europe. Therefore, the BIOPRESS project has delivered information that is currently not available from any other information source to support relevant EU Directorates and Agencies in developing appropriate policies, assessing their effectiveness and adapting them to future circumstances.

The focus of the project is to develop a standardised product that will be extendable to Europe. The proposed product will link measures of historical (1950 – 2000) land cover change to pressures on biodiversity and is aimed at the EU-user community

concerned with the impact of land cover/use changes on the environment and biodiversity. The proposed activities of the project are geared to the activities of the European Environment Agency (EEA) and European Topic Centres (ETC's) and support the further development of Community Information Systems for nature, biodiversity and forests.

The BIOPRESS project consists of two closely linked but consecutive phases. Phase-I is the production phase in the first 18 months that has concentrated on the production of the land cover change statistics (workpackages WP2000, WP3000 and WP7000). Phase-II covers the second half on the three year project and will concentrate on applying methodologies to associate the land cover change statistics to pressures on biodiversity (see Figure 1). The activities of the first and second phases of the BIOPRESS project can be described as following:

Phase-I (months 1-18):
The characterisation of land cover change in and around of a representative stratified sample of Natura2000 sites:

- For a sample of 100 windows containing Natura2000 sites and their surrounding landscape, land cover change matrices were produced by back dating CORINE1990 land cover layer with aerial photographs of the 1950's. By the end of 2003, an area of approximately 100,000km^2 was covered and distributed across the main biotope types in European countries (Europe 15+) for which CORINE1990 level 3 is available. The estimated total number of sites and area covered was based on an assumed cost of 2.5 EUR/km^2 that includes data search, acquisition and interpretation. The output was depended on the availability and cost of aerial photographs of the 1950'ies.
- For a sample of approximately 60 transects, land cover change matrices were produced based on a more detailed interpretation and analysis of aerial photographs acquired in 1950, 1990 and 2000. The sample was a subset of the sites used for backdating CORINE1990 and was selected to represent biotopes types specified by the user community. The final number of sites and total area covered was selected on the basis of the availability of aerial photographs and the size of selected sites.
- The land cover change matrices from both exercises were extrapolated using CORINE1990 land cover layer.

Phase –II (months 19-36):
Overview of activities in phase II which are still taking place.

- To set up a GIS framework that will not only support the extrapolation of the change matrices but also facilitate the integration of pan-European spatial data sets building upon existing European led initiatives and concepts (e.g. EEA TERRIS database).
- To develop a pan-European land cover change (1990-2000 and beyond) monitoring concept based on the integration of CORINE Land Cover, Earth Observation and field data and focusing on the area in and around the Natura 2000 sites.

- To develop a spatially referenced product showing the main pressures on biodiversity (e.g. intensification, abandonment, afforestation, urbanisation) from the integration of data on land cover change (1950-1990/2000) and other biological, environmental and socio-economic data. A state-of-the-art semi-quantitative pressure state-model called MIRABEL will convert the quantified pressures into assessments of impacts on biodiversity. The characteristics of the pressures product will be defined by the EU-user community and the pressure – state model operating on the product. This part of the project intends to add value to the land cover change product and will involve research which will look into specific problems related to data integration, land cover change detection, pressure-state models and error propagation, with the aim of improving the tools used for monitoring the environment at pan-European level.

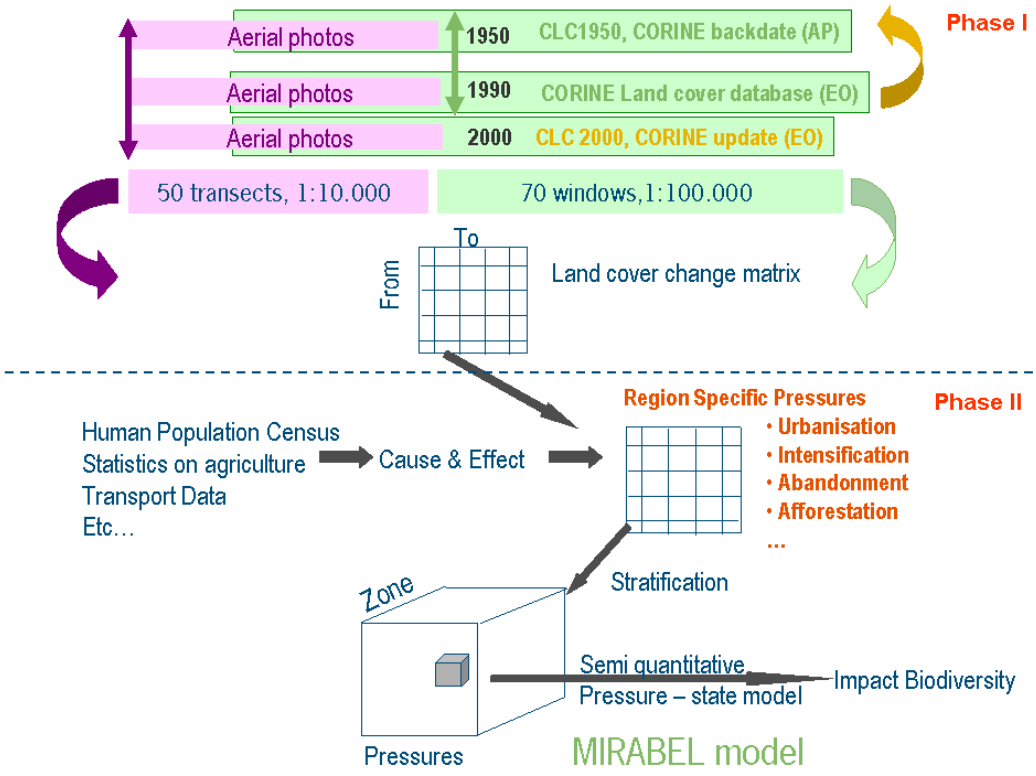


Figure 1. Schematic representation of the BIOPRESS work flow and research components. Phase 1 is shown in the upper part above the dotted line and, phase 2 is demonstrated below the dotted line

This project is implemented by means of eight work packages with the following objectives:

Work Package 1000 "Coordination of data search and data access"
The specific objectives of WP1000 is (i) to identify existing European datasets related to land cover, land use and the four pressures (intensification, abandonment, afforestation, urbanisation) acting on the environment, (ii) to streamline and coordinate access to these datasets and databases and (iii) stream line and coordinate access to the aerial photos acquired for WP7000, WP2000 and WP3000.

Work Package 2000 "Methodological development for photo-to-photo interpretation for characterising land cover change between 1950, 1990 and 2000"
The overall aim of WP2000 is to develop a quality assured method for the production of land cover change matrices from the interpretation of aerial photographs.

- WP2100: The development of interpreters rules for photo to photo interpretation based on the CORINE1990 level 3 classification. Finalising the preliminary interpreters rules developed by the EEA for backdating CORINE1990.
- WP2200: The development of an optimal stratification strategy for (i) sampling Natura2000 sites and (ii) extrapolating the change matrices to Europe.
- WP2300: The selection of representative Natura2000 sites across Europe producing a list of sites for input to WP7000 and WP2400. Acquisition and preprocessing of aerial photographs (1950, 1990 and 2000) required for Nature2000 sites relevant to WP2400, WP2500 and WP3000.
- WP2400: The interpretation of the aerial photographs and production of land cover change matrices for an initial small set of Natura2000 sites (approximately 20) and their surrounding landscape. A thorough assessment of the results and review of interpreters manual.

Work Package 3000 "Production of land cover change products"
The specific objectives of WP3000 are:

- WP3100: The interpretation of the aerial photographs and production of land cover change matrices for the Natura2000 sites (approximately 40) and their surrounding landscape followed by a thorough assessment of the results.
- WP3200: Extrapolating the land cover change matrices produced under WP2300 and WP3100 to a European product. Extrapolating the land cover change matrices produced under WP7000.
- WP3300: To organise and summarise review by external experts of interpretation and land cover change results from WP3100 and WP7000.

Work Package 7000 "Backdating CORINE 1990 using 1950'ies aerial photos"
The overall aim of WP7000 is to produce land cover change matrices for a large sample of natura2000 sites by backdating CORINE 1990 using aerial photographs of the 1950's. The specific objectives are:

- WP7100: To locate, acquire and pre-process the 1950's aerial photos required to backdate CORINE 1990.
- WP7200: Backdating of CORINE1990 using 1950's photographs on the basis of the interpretation rules provided by EEA and finalised in WP2100.
- WP7300: To develop and carry out a quality assessment of the CORINE1990 backdating results.

Work Package 8000 "Review workplan for Phase-II (i.e. WP4000)"
The workplan for phase-II (WP4000) is reviewed based on the experiences from Phase-I. A detailed assessment of the potential of high- and medium-resolution satellites adequate for the purpose of assessing land cover change in and outside Natura2000 sites including a cost-benefit analysis will be carried out.

Work Package 4000. Linking land cover change to pressures on biodiversity.
The overall aim of WP4000 is to develop a quantitative and spatially referenced product showing the main pressures on biodiversity (intensification, abandonment, afforestation, urbanisation). The work has five distinct objectives:

- WP4100: The development of a GIS framework and a method for spatial stratification that support and facilitate the data integration.
- WP4200: The development of improved pan-European land cover change (1990-2000 and beyond) products from Earth observation.
- WP4300: The development of a method for integrating socio-economic data with measures of land cover change to quantify pressures (intensification, abandonment, afforestation and urbanisation) on biodiversity.
- WP4400: The development of a method for linking the quantitative and spatially referenced data describing intensification, abandonment, afforestation and urbanisation to changes in biodiversity by means of a semi-quantitative pressure-state model.
- WP4500: The development of methods which acquire measures of error and assess the propagation of error through the entire sequence of data manipulation (task 4200: land cover change, task 4300: data integration and task 4400: linking to biodiversity).

Work Package 5000. Assessing problems.
The specific objective of WP5000 is to collect feedback from partners regarding problems (technical, scientific, all aspects of data accessibility, data quality, organisational, legal and institutional hurdles) encountered at each stage of the development and production process (WP2000 and WP3000). Bi-monthly meetings with the assessment team will ensure continuous dialogue between BIOPRESS and the assessment team.

The interconnections between the different workpackages is presented in Figure 2. For a detailed description of the workpackages and deliverables we refer to the "Description of work".

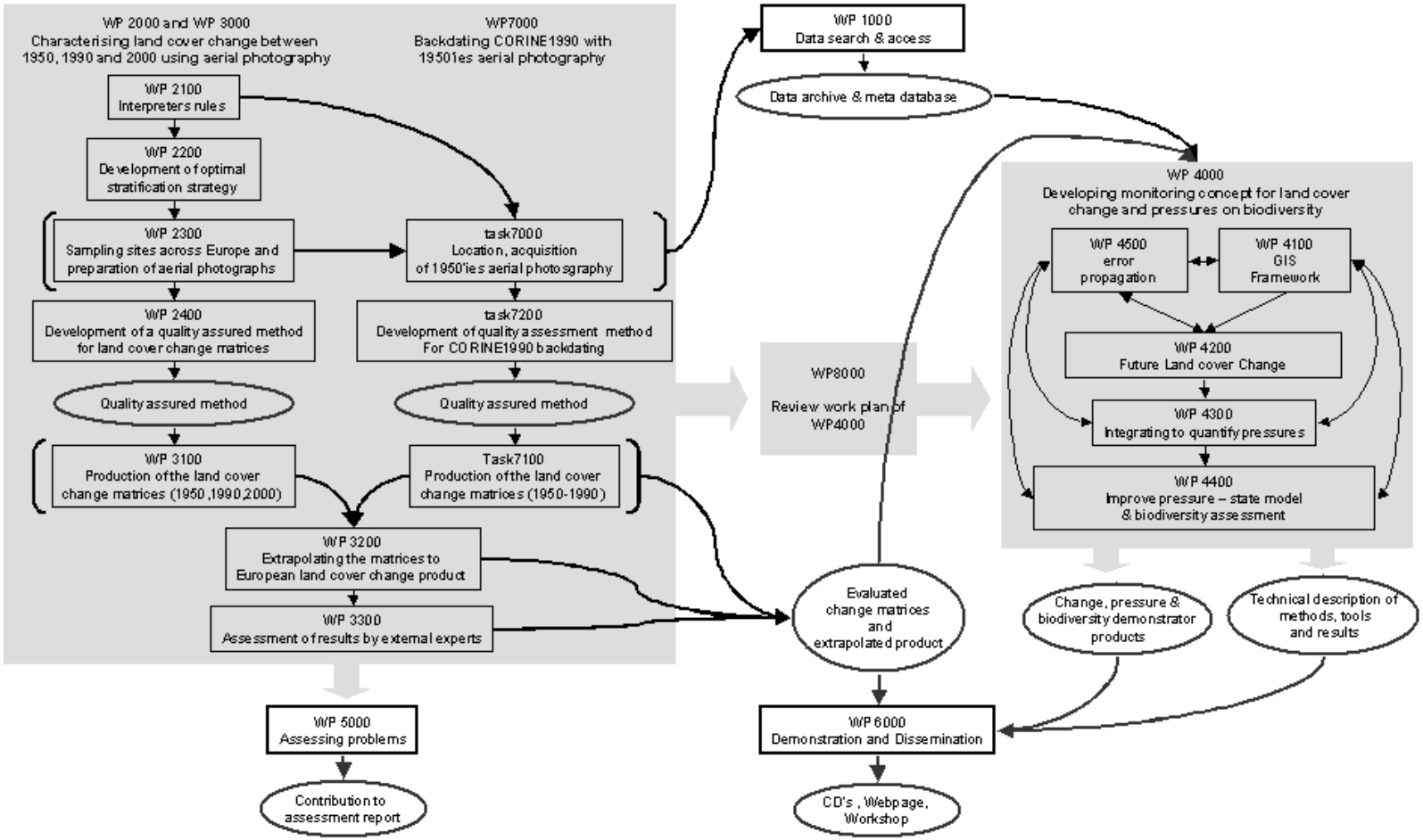


Figure 2. Graphical presentation of project's components.

1.3 Report outline

Chapter 2 describes the Dutch sample sites. The selection of the Dutch windows and transects is described in sections 2.1 and 2.2. A short description of all Dutch windows and transects is provided in section 2.3 and 2.4 by means of their location, the Natura2000 sites and habitat types present in the sample sites and the main land cover changes.

Chapter 3 introduces the processing and interpretation of the aerial photographs. Acquisition, preprocessing and georeferencing of aerial photographs are described in section 3.1. The land cover interpretation methodology is explained in section 3.2. – 3.4.. The window sample sites are interpreted according to the CORINE methodology whereas the transects are interpreted at a higher level of detail. The backdating approach (section 3.4.), the CORINE legend (section 3.3.), and interpretation criteria used for the interpretation of B&W aerial photographs (section 3.2.) are also described.

Chapter 4 presents a general introduction on land cover changes in the Netherlands (section 4.1.), the land cover changes for windows (section 4.2.) and transects (section 4.3.). The analysis of land cover dynamics in the transects is also discussed in section 4.3. Differences in dynamics for areas inside and outside the Natura2000 sites and the rate of land cover changes are discussed. In section 4.4 the land cover changes are compared between the windows and transects. The last section discusses the relation of the identified land cover changes with the anthropogenic pressures selected in the BIOPRESS project.

2 Selection of sample sites in the Netherlands

Sampling methods are classified as either probability or nonprobability. In probability samples, each member of the population has a known non-zero probability of being selected. Probability methods include random sampling, systematic sampling, and stratified sampling. The advantage of probability sampling is that sampling error can be calculated. Sampling error is the degree to which a sample might differ from the population. When inferring to the population, results are reported plus or minus the sampling error (Pyle, 1999).

In nonprobability sampling, members are selected from the population in some nonrandom manner. These include convenience sampling, judgment sampling, quota sampling, and snowball sampling. In this case, the degree to which the sample differs from the population remains unknown. This chapter describes the nonprobability sampling for the selection of sample sites in the Netherlands using the quota sampling approach.

2.1 Selection of windows

It is the vital importance to clearly define the sample (target) population. However, there are no strict rules to follow, and the researchers must rely on logic and judgment. Within the BIOPRESS project a quota sampling approach has been applied to select 100 windows over Europe. This approach is the nonprobability equivalent of stratified sampling. Like stratified sampling, the researcher first identifies the stratums and their proportions as they are represented in the population. Then judgement is used to select the required number of subjects from each stratum. This differs from stratified sampling where the stratums are filled by random sampling.

The first stratum identification was carried out by in March 2003 by P. Devillers (from the Royal Belgian Institute of Natural Sciences) who proposed a preliminary selection of 228 windows over Europe based on the geopolitical regions in Europe, the Natura2000 database (EU and access countries) and expert knowledge on request by the EU (see Figure 3). Each window was defined to have a size of 30km by 30km. From the list of 228 windows a subsample of 100 windows was selected in consultation with the individual BIOPRESS partners. Of this subsample 75% was implemented within the project using the CORINE backdating methodology on basis of historic aerial photographs of the ‘50s. Due to availability of aerial photographs and budget constraints the project had to reduce the number of windows to be interpreted.

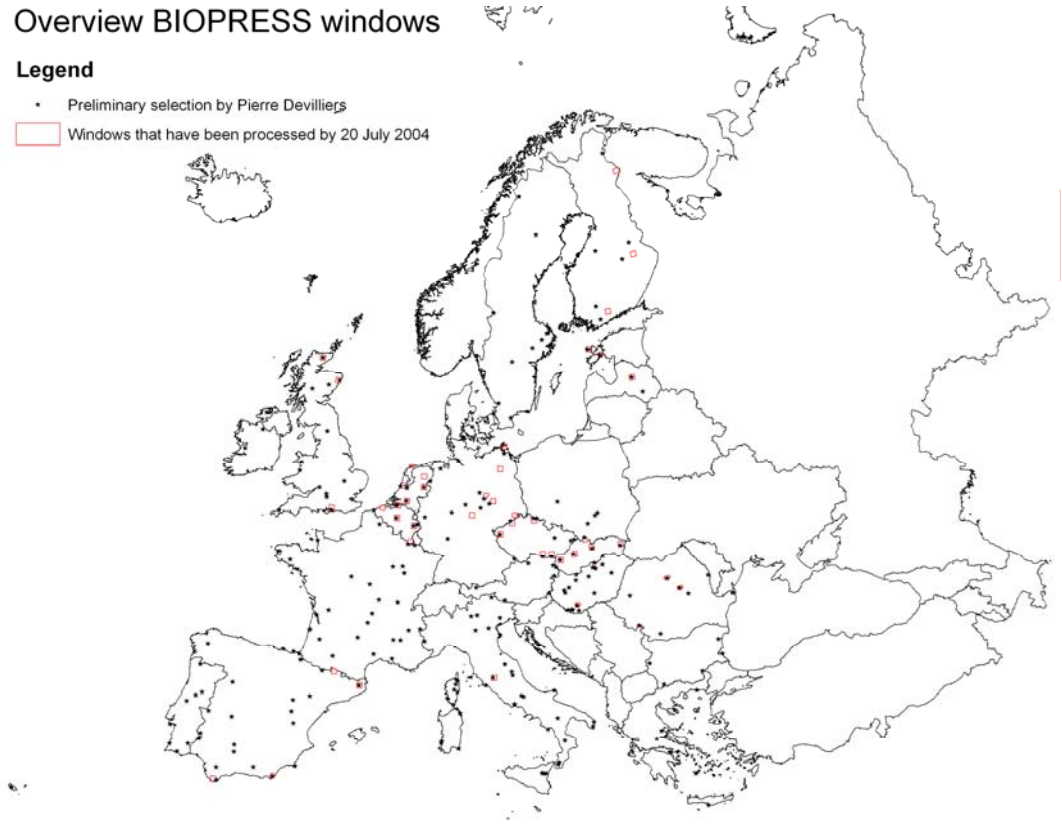


Figure 3. Overview of the sampled windows over Europe and the part that has been implemented by July 2004

Seven windows located in the Netherlands were proposed after the evaluation of the list provided by P. Devillers and after consultation of Marion Pelk of the Ministry of Agriculture, Nature and and Food Quality (Ministry LNV) and the vegetation experts Joop Schaminée and John Janssen from Alterra. Of these seven sampling windows two windows have been ruled out for the photo interpretation. The Window NL209A in the Province Zeeland was discarded since it was located almost on the same location with equal characteristics as the Belgium window BE209. In a later stage of the project, the window Z in the Province of Limburg was excluded due to budget constraints. In the end, five windows have been selected for the Netherlands with a total area of about 4500 km^2 (see Figure 4).

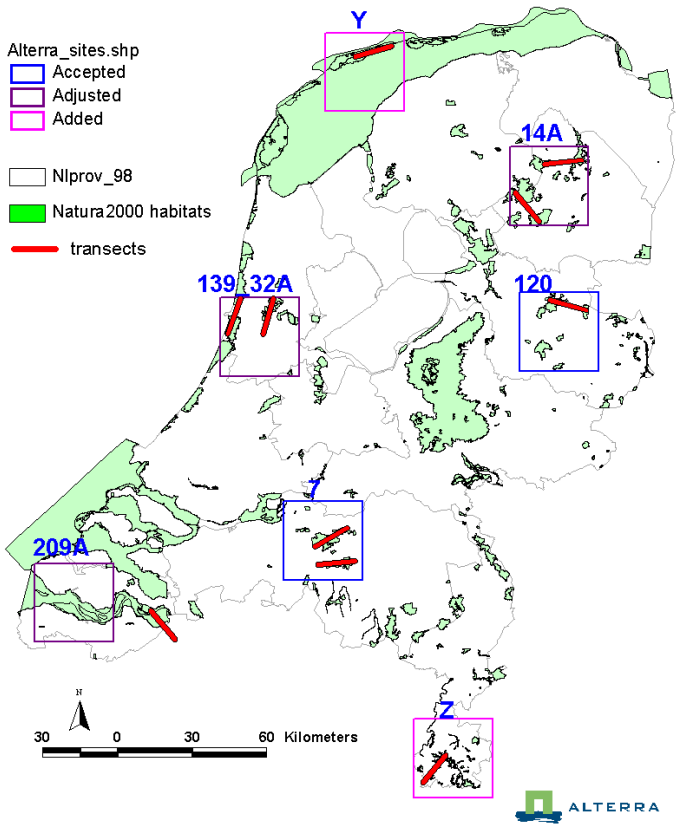


Figure 4. Location of the seven sampled windows in relation to the Natura2000 habitat sites in the Netherlands. Each window has a size of 30 by 30 km and was backdated by GISAT on a scale 1:100.000 using historic aerial photographs of the 50's in conjunction with the CORINE land cover methodology. Within the windows nine transects of 15by 2 km have been selected which were backdated by Alterra on a scale 1:20.000 using time series of aerial photographs concerning the reference years 1950, 1990 and 2000

Table 1 summarises the selected windows for the Netherlands. The five sampled windows were selected in such a way that they would cover all major landscape types in the Netherlands and at the same time, they should cover a maximum of Natura2000 habitat sites. Figure 5 shows the location of the seven windows in relation to the main Dutch landscapes.

Table 1. Final five windows selected for the Netherlands

N°WINDOW	Region	LONG	LAT
NL7	Noord-Brabant	5,1322	51,6494
NL14	Drenthe	6,4644	52,9232
NL_Z (skipped)	Zuid-Limburg	5,8694	50,8616
NL_Y	Terschelling	5,3629	53,3410
NL120	Overijssel	6,5183	52,3756
NL139	Noord-Holland	4,7439	52,3835
NL 209A (skipped)	Westerschelde	3,6867	51,4111

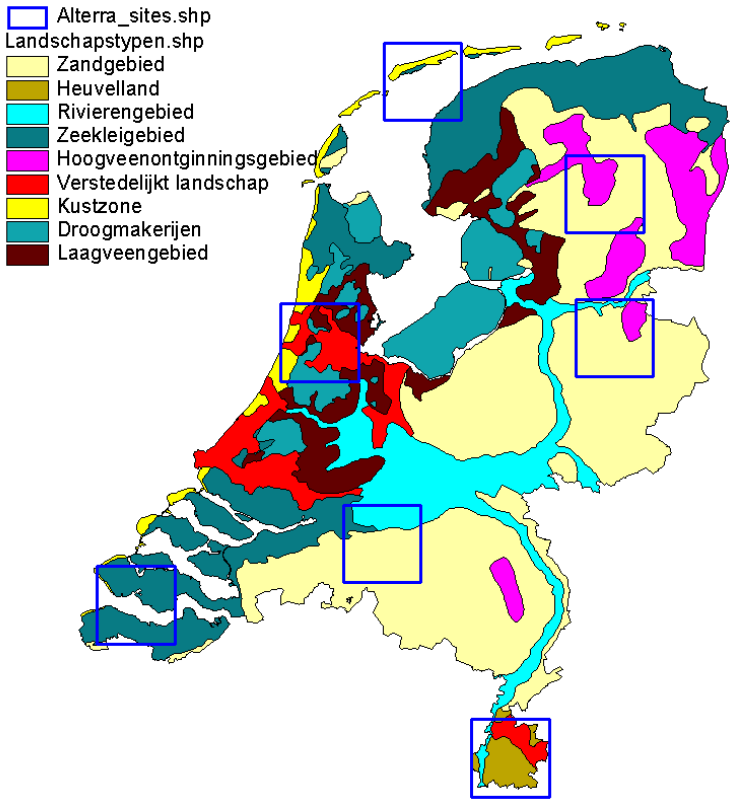


Figure 5. Dutch landscapes (source Nota Landschap) with the location of selected windows

2.2 Selection of transects

The transects were chosen to demonstrate a gradient of pressures for land cover change. For the Netherlands, ten transects have been selected each with a length of 15km and a width of 2km. In most cases, the transects were located within the defined windows as shown in Figure 4. The transects have been located in such a way that they follow a pressure gradient in the local environment. It was assumed that the specific pressures, such as agricultural intensification and urbanisation, are at their lowest in the centre of a Natura2000 site and at their highest in the immediate surrounding of urban areas. The final decision on the exact location of the ten transects has been made on basis of the following criteria: 1) the location of the sampling windows, 2) the location of the Natura2000 sites within the windows and, 3) the land use patterns within the CORINE land cover database. The habitat types that received the highest priority were forests, natural and semi-natural grasslands and inland wetlands. Table 2 shows the Natura2000 habitat sites that were intersected by the selected transects.

From the ten selected transects only the transect 10 "Land van Saeftinge" within the Westerschelde was not implemented, since the transect was located near the window 209A which had already been excluded. As shown in Figure 4, three windows contain each two transects, while three other windows contain each one transect.

Table 2. Summary of the Dutch transects within the specific windows and the Natura2000 sites that they cover

Nr Window	Nr Transect	Natura2000_site	Site_Number	Site nr.
7		**Province Noord-Brabant**		
	1	Loonse en Drunense duinen en de Brand	NL9803030	42
	1	Vlijmens ven, moerputten en bossche broek	NL9801049	66
	4	Kampina en Oisterwijkse bossen en vennen	NL3000401	35
14A		**Province Drenthe**		
	6	Drentse Aa	NL9801009	12
	6	Fochteloerveen en Esmeer	NL9801007	25
	7	Drents-Friese Wold	NL9803011	13
	7	Dwingelerveld	NL3000070	23
139_32A		**Province Noord-Holland**		
	5	Wormer- en Jisperveld en Kalverpolder	NL2003054	132
	5	Polder Westzaan	NL2003040	118
	2	Kennemerduinen en Amsterdamse waterleidingduinen	NL1000012	37
	2	Noordhollands Duinreservaat	NL9801080	50
120		**Province Overijssel**		
	8	Vecht en Beneden-Regge	NL9801017	64
	8	Engbertsdijksvenen	NL1000004	24
Y		**Province Friesland (Terschelling)**		
	9	Duinen Terschelling	NL2003059	18
	9	Waddenzee	NL1000001	69
Z		**Province Limburg (Zuid-Limburg)**		
	3	Savelsbos	NL9801040	59
	3	Bemelerberg en schiepersberg	NL9801076	4
	3	Geuldal	NL9801041	
209A		**Province Zeeland (Westerschelde)**		
	10	Westerschelde "Land van Saeftinge"	NL9803061	73

Although these transects cover a limited proportion of Natura2000 sites in the Netherlands, they intersect Natura2000 sites that cover most of the habitat types in the Netherlands as shown in Table 3.

Table 3. Summary of the habitat types present in the Natura2000 sites that intersect with the Dutch transects.

All Annex I Habitats in the Netherlands	TRANSECTS										
	1	2	3	4	5	6	7	8	9	10	TOT
1130 (13.2) - Estuaries									1	1	2
1310 (15.11) - Salicornia and other annuals colonizing mud and sand									1	1	2
1320 (15.12) - Spartina swards (Spartinion)									1	1	2
1330 (15.13) - Atlantic salt meadows (Glauco-Puccinellietalia)									1	1	2
2110 (16.211) - Embryonic shifting dunes									1	1	2
2120 (16.212) - Shifting dunes along the shoreline with Ammophila arenaria (white dunes)		1							1	1	3
2190 (16.31_->_16.35) - Humid dune slacks		1							1	1	3
6230 (35.1) - Species-rich Nardus grasslands, on siliceous substrates in mountain areas (and submountain areas, in continental Europe)			1			1	1	1			4
91E0 * Alluvial forests with Alnus glutinosa and Fraxinus excelsior (Alno-Padion, Alnion incanae, Salicion albae)	1		1			1		1			4
3260 (24.4) - Floating vegetation of Ranunculus of plain, submountainous rivers			1								1
6110 (34.11) * Rupiculous calcareous or basophilic grasslands of the Alysso-Sedion albi			1								1
6130 Calaminarian grasslands of the Violetalia calaminariae			1								1
6210 (34.31) Semi-natural dry grasslands and scrubland facies on calcerous substrates (Festuco-Brometalia) (*important orchid sites)			1								1
7220 (54.12) *Petrifying springs with tufa formation (Cratoneurion)			1								1
7230 Alkaline fens			1			1					2
9110 (41.11) - Acidophilous (Luzulo-Fagetum) beech forests			1								1
9160 (41.24) - Sub-Atlantic (Stellario-Carpinetum) oak-hornbeam forests			1			1					2
1110 (11.25) - Sandbanks which are slightly covered by sea water all the time									1		1
1140 (14) Mudflats and sanflats not covered by seawater at low tide									1		1
2130 * Fixed coastal dunes with herbaceous vegetation ('grey dunes')		1							1		2
2140 (16.23) - Decalcified fixed dunes with Empetrum nigrum									1		1
2160 (16.25) - Dunes with Hyppophae rhamnoides		1							1		2
2170 (16.26) - Dunes with Salix arenaria		1							1		2
2180 (16.29) - Wooded dunes of the Atlantic coast		1							1		2
4010 (31.11) - Northern Atlantic wet heaths with Erica tetralix				1	1	1	1	1			5
6430 (37.7_&_37.8) - Eutrophic tall herbs					1			1			2
2320 (64.1_x_31.227) - Dry sandy heaths with Calluna and Empetrum nigrum							1	1			2
4030 (31.2) - Dry heaths (all subtypes)				1		1	1	1			4
5130 (31.88) - Juniperus communis formations on calcareous heaths or grasslands							1	1			2
7120 (51.2) - Degraded raised bogs (still capable of natural regeneration)						1		1			2
7150 (54.6) - Depressions on peat substrates (Rhynchosporion)							1	1			2
7140 (54.5) - Transition mires and quaking bogs					1						1
1160 (-) - Large shallow inlets and bays											0
2150 * Atlantic decalcified fixed dunes (Calluno-Ulicetea)		1									1
2310 (64.1_x_31.223) - Dry sandy heaths with Calluna and Genista	1					1	1				3
2330 (64.1_x_35.2) - Open grassland with Corynephorus and Agrostis of continental dunes	1					1	1				3
3110 (22.11_x_22.31) - Oligotrophic waters containing very few minerals of Atlantic sandy plains with amphibious vegetation				1			1				2
3130 (22.12_x_(22.31_&_22.32)) - Oligotrophic waters in medio-European and perialpine area with amphibious vegetation				1		1	1				3
3140 (22.12_x_22.44) - Hard oligo-mesotrophic waters with benthic vegetation of chara formations	1										1
3150 (22.13) - Natural eutrophic lakes with Magnopotamion or											0

Hydrocharition-type vegetation											
3160 (22.14) - Dystrophic lakes				1			1				2
3270 (24.52) - Pionner annual vegetation on muds (Chenopodietum rubri) of submountainous rivers											0
6120 (34.12) - Xeric sand calcareous grasslands (Koelerion glaucae)											0
6410 (37.31) - Molinia meadows on chalk and clay (Eu-Molinion)	1					1					2
6431 (37.7) - Humid tall herb fringes of watercourses and woodlands											0
6432 (37.8) - Subalpine and alpine tall herb communities											0
6510 (38.2) - Lowland hay meadows (Alopecurus pratensis, Sanguisorba officinalis)	1										1
7110 (51.1) - Active raised bogs											0
7210 * Calcareous fens with Cladium mariscus and species of the Caricion davallianae				1							1
9120 Atlantic acidophilous beech forests with Ilex and sometimes also Taxus in the shrublayer (Quercion robori-petraeae or Ilici-Fagenion)											0
9130 (41.13) - Neutrophilous (Asperulo-Fagetum) beech forests											0
9180 (41.4) - Tilio-Acerion ravine forests											0
9190 (41.51) - Old acidophilous oak woods with Quercus robur on sandy plains						1	1				2
91F0 (44.4) - Mixed oak-elm-ash forests of great rivers											0
91D0 * Bog woodland											0
Totals	6	7	10	6	3	12	12	9	14	7	

2.3 Short description of windows and transects

2.3.1 Windows

The five Dutch windows represent the major landscape types in the Netherlands, as was shown in Figure 5. All thirty CORINE land cover types that occur in the Netherlands are present within the five windows (see Hazeu, 2003). However, the exclusion of window 209A "Westerschelde" and window Z "Zuid-Limburg" has resulted in the exclusion of specific landscapes such as the estuary of the river Schelde in the Province of Zeeland and the only hilly region of the Netherlands in the Province of Limburg.

As an example, Figure 6 displays the sample window 120 of the Overijssel Province using the CORINE land cover database (CLC90), the Natura2000 sites within the region and the location of the transect 8 within the window. Moreover, a detailed topographic map of transect 8 is displayed with the Natura2000 sites. For all other windows and transects we refer to Appendix 1 for their displays and summary of their characteristics (Natura2000 sites, habitat types, land cover types and changes), while continuing within this section with a general description of the selected sample windows (land cover description based on 1990 data).

Window 120 Overijssel, Track 8

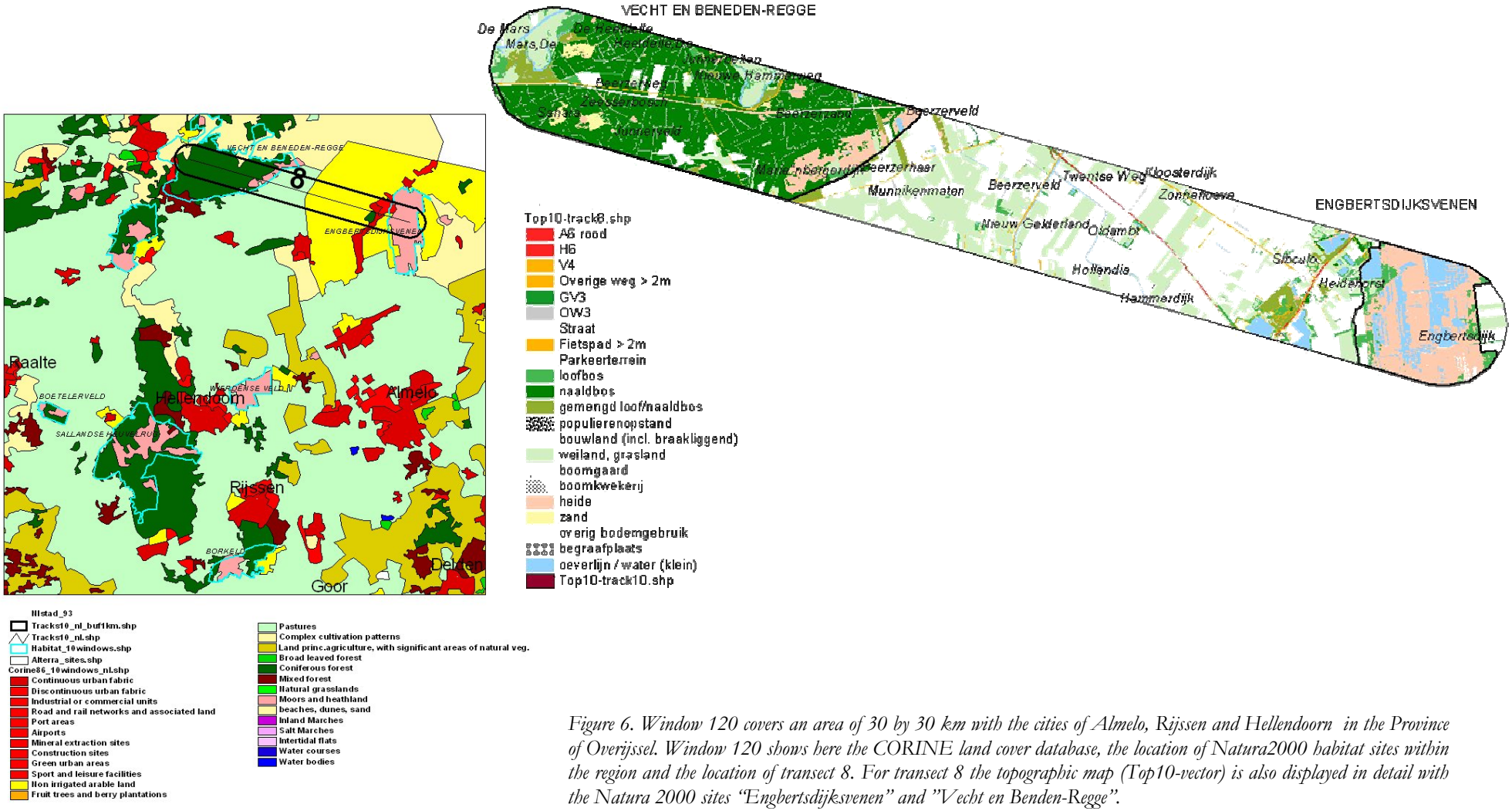


Figure 6. Window 120 covers an area of 30 by 30 km with the cities of Almelo, Rijssen and Hellendoorn in the Province of Overijssel. Window 120 shows here the CORINE land cover database, the location of Natura2000 habitat sites within the region and the location of transect 8. For transect 8 the topographic map (Top10-vector) is also displayed in detail with the Natura 2000 sites "Engbertsdijksvenen" and "Vecht en Benden-Regge".

Window 7 is located in the Province Noord-Brabant, and covers just as the other windows an area of 30km by 30km with large cities such as 's-Hertogenbosch, Tilburg and Waalwijk. The area is characterised by two major landscape types. The first landscape type is a river clay area which is heavily influenced by rivers (flat, clayey soils, high ground water level). The second landscape type is a sandy area which is an almost flat landscape which has sandy soils and peat soils. Main land cover types in window 7 are pastures, complex cultivation patterns, coniferous forest and a high amount of larger and smaller urban areas. The Natura2000 sites present in this window are: Loonse en Drunense Duinen en de Brand, Vlijmens Ven, Moerputten en Bossche Broek, Langstraat bij Capelle Sprang-Cappelle, en Kampina en Oisterwijkse Bossen en Vennen. The Loonse en Drunense Duinen is a national park which is well known for its sandblown dunes which are threatened by the natural process of encroachment and afforestation, see also Photo 1. The Kampina and Oisterwijkse Bossen en Vennen are well known for its beautiful forests and fens. Both areas are intensively used for recreation not only by people from the surrounding but also by many tourists from outside the region.

Photo 1. Panoramic view on the "Loonse en Drunense Duinen" which is well-known for its sand blown dunes with small patches of heather and surrounded by large coniferous woods which are currently threatening to cover the sand blown dunes by the natural process of shrub encroachment and afforestation

Window 120 is located in the Province Overijssel and covers some of the undulated parts of the Netherlands with the ice-pushed ridge "*Sallandse Heuvelrug*" from the former Ice Age. Window 120 contains cities such as Hellendoorn, Almelo, Rijssen en Raalte. Natura2000 sites in this region are the Vecht en Beneden-Regge, Engbertsdijkvenen, Wierdense veld, Boeterlerveld, Borkeld and the Sallandse Heuvelrug. The Natura2000 site Engertsdijkvenen is known for its raised bogs of

which only very small parts are still active and much of the nature management is focussed on the revitalisation of the active raised bogs. The Sallandse Heuvelrug is well known for its recreation and is largely covered by coniferous forests and heather. It is the only part of the Netherlands with some relicts of the Black Grouse (Tetrao tetrix).

Windows 14A is located in the Provinces Drenthe and is intersected in the North-eastern part by the semi-natural river Drentse Aa. Assen is the capital of the Province Drenthe and is located within the window. Other urban areas within the region are much smaller and are villages such as: Rolde, Norg, Veenhuizen, Smilde, Dwingeloo, Beilen en Westerbork. Natura2000 sites within the region are Norgerholt, Drentse Aa, Fochterloerveen en Esmeer, Witterveld, Elperstroom, Drents-Friese Wold, Matingerbos, Mantingerzand and Dwingelderveld. Dwingelderveld was acknowledged as a national park in 1991 and is one of Europe's largest wet moorland area and includes many fens and is surrounded by coniferous forests. Another well-known protected area is the Drentse Aa. Nowhere else in the Netherlands one would find a creek like the Drentse Aa. Together with the stream, the typical Drentse "*esdorp*" landscape has been preserved in the Drentse Aa area: the farming plots around the village square, the fields on the elevated land, the hayfields and the meadows in the valley of the Drentse Aa (Photo 2).

Photo 2. Panoramic view over the Natura2000 site "Drentsche Aa" with the semi-natural creek the Drentsche Aa, taken near the village Loon, which is a typical esdorp

Both window 14 and 120 are characterised by two major landscape types, of which the first one is partly located in a landscape dominated by the reclamation of peat bogs ("*Hoogveenontginnings*" landscape). The other landscape type of importance is an almost flat landscape with sandy soils and low groundwater levels and ("*Zandgebied*" landscape). Dominant CORINE land cover types in both areas are agricultural land (pastures, arable land), forest and small urban areas. Window 14 – Drenthe is also characterised by moors and heathland and some small peat bogs.

Window Y includes the island Terschelling which is surrounded by the Waddensea. The window is located in the Province Friesland, about 25 km from the mainland. So, it is situated in the coastal zone which is dominated by sandy dunes (Coastal zone landscape), heavy clay soils with high groundwater level ("*Zeeklei*" landscape) and the sea. As one can expect, it is the least urbanised window having large protected areas such as the dunes and the well-known Boschplaat (see Photo 3), which is known as a hotspot for many wader birds. The main land cover types are pastures, sea, intertidal flats, salt marshes, natural grasslands, beaches and dunes. It is one of the few remaining natural areas in the Netherlands, where natural processes are still the dominant factor in shaping the landscape. However, the construction of the *stuifdijk* (dike) in the 1930's for the protection against the North Sea, altered many of these natural dynamics. Before the construction of the dike the area was dominantly a sandplate, due to the dike it changed gradually into a complex of primary and secondary dunes and saltmarshes under the influence of the Waddensea (Hazeu et al., 2002). Only a part of the island Terschelling is covered by agricultural land. Tourism is the major source of income for the Island.

Window 139 is located in the Province Noord-Holland and as the other windows covers an area of about 900 square kilometres. This window is the most urbanised window with large cities as Amsterdam, Zaanstad, Purmerend, Beverwijk, Velsen, Zandvoort, Amstelveen, Aalsmeer en Lisse. Although the area is heavily populated it has also important Natura2000 sites such as: Kennemerduinen en Amsterdamse Waterleidingduinen, Noordhollands duinreservaat, Wormer- en Jisperveld en Kalverpolder, Polder Westzaan, Ilperveld, Oostzanerveld en Varkensland", and Botshol. Most protected areas are located in the coastal strip and in the lowland peatlands (north of Amsterdam) with their wet grasslands and intersected by countless channels. A large part of this landscape was reclaimed from large inland lakes ("*Droogmakerijen*"). Dominant land cover types in the Window 139 are urbanised areas, pastures, arable land, broad leaved forest and natural grasslands. The Natura2000 sites located in the dunes such as the "Kennemerduinen en Amsterdamse Waterleidingduinen" and Noordhollands duinreservaat especially attract every day thousands of people for recreation. Since the last decade the extraction of water has decreased significantly in the dunes having a very positive impact on the groundwater table and nature conservation.

Photo 3. The "Boschplaat" on the island Terschelling is a hotpot for wader birds and is one of the largest remaining natural areas in the Netherlands consisting of primary and secondary dunes, salt marshes, beaches, sandplates and intertidal flats

Photo 4. The Coastal dune area "De Kennemer Duinen" under the "smoke" of the CORUS steel factories near Ijmuiden and Northsea channel

2.3.2 Transects

In total, nine transects have been selected for the Netherlands having a length of 15 km and a width of 2 km, and they were interpreted in terms of land cover changes using a scale 1:20.000 for the years 2000, 1990 and 1950 respectively. In this section the transects will be described based on the land cover information of the year 2000. For detailed land cover statistics of all transects, please refer to Appendix 9.

Transect 1 "Loonse & Drunense Duinen" is situated in Window 7 in the Province Noord-Brabant and almost reaches the city Den Bosch at the Northwest corner of the transect and crosses the village "Loon op het zand" in the Southwest corner of the transect. Transect 1 is dominated by agricultural land (44.8%). Other typical land cover types for the transect are coniferous forest (22.2%), sand dunes (6.4%) and moors and heathland (4.0%). Fourteen percent of the transect is occupied by artificial land (see Figure 7). The transect crosses two important Natura2000 sites "Loonse en Drunense duinen en de Brand" and "Vlijmens ven, Moerputten en Bossche Broek". The part of the transect within the two Natura2000 sites is slightly larger (58%) than the area outside. The Natura2000 site "Loonse en Drunense duinen en de Brand", which is also a national park, has been selected for the following habitat types: habitat 2330 "Open grassland with Corynephorus and Agrostis plant species of inland dunes", next to habitat type 2310 "Dry sandy heaths with Calluna and Genista". The habitat type 91 E0 "Alluvial forests with Alnus glutinosa and Fraxinus excelsior" refers to "de Brand". It one of the most contrasting transects changing from very dry inland dunes to wet forests in a very short distance. The Natura2000 site "Vlijmens ven, Moerputten en Bossche Broek", an inland marsh, has been selected for the habitat type 3140 "Hard oligo-mesotrophic waters with benthic vegetation of chara formations", next to habitat type 6410 "Molinia meadows on chalk and clay" and habitat type 6510 "Lowland hay meadows".

Transect 4 "Kampina" is also situated in Window 7 (see also Appendix 1) and reaches the city Boxtel in the eastern corner, crosses the city Oisterwijk in the middle of the transect and enters Tilburg on the western corner of the transect. Twenty-five percent of the transect is occupied by artificial land. Next to agricultural land (32.5%), important semi-natural land cover classes are mixed forest (17.8%) and moors and heathlands (9.8%). The forests and heathland are also characterised by many oligotrophic fens. This kind of landscapes attracts many visitors from the surrounding cities but also from outside the region. One third of the transect is within the Natura2000 site "Kampina en Oisterwijkse bossen en vennen". This Natura2000 site has been selected for the following habitat types: 1) 3110, 3130, 3160 which are oligotrophic and dystrophic fens, 2) 4010 and 4030 which are wet and dry heathlands, and 3) the priority habitat type 7210 "Calcareous fens with Cladium mariscus and species of the Caricion davallianae".

Photo 5. Klein Aderven, a oligotrophic fen, located in transect 4 within the Oistwijkse Forests. The area attracts many tourists for recreation purposes as walking and cycling. Thousands of years ago the sand was blown away from the region and what was left was an impenetrable loam layer partly filled with rainwater, causing the origin of fens

Transect 2 "Kennemer Duinen" is located in the Province Noord-Holland (Window 139_32) along the Dutch coast and touches the city Zandvoort at its Southern end, crosses IJmuiden and Beverwijk, and reaches Castricum at the Northern end. Although a large part of the transect is within Natura2000 sites (60%), the area which is not protected is largely dominated by heavy industry, such as the CORUS steal factories, and urbanised areas. The small area of agriculture is dominated by arable land (2.3%). The 1.8 square kilometre of water is part of the North Sea Channel and includes also various ports and other channels, such as the Hoogovenhaven, Vissershaven, Haringhaven, Buitenspuikanaal en Buitentoeleidingskanaal. Transect 2 crosses two Natura2000 sites: "Kennemerduinen en Amsterdamse Waterleidingsduinen" en "Noordhollands Duinreservaat". Both Natura2000 sites are coastal dune areas. The "Kennemerduinen en Amsterdamse Waterleidingsduinen" has been selected for the following dune habitat types: 2130 Fixed coastal dunes with herbaceous vegetation ("grey dunes"), 2150 Atlantic decalcified fixed dunes (Calluno-Ulicetea), 2160 Dunes with Hyppophae rhamnoides, 2180 Wooded dunes of the Atlantic coast , and 2190 Humic dune slacks. Another habitat types that occurs is habitat type 2120 Shifting dunes along shoreline with Ammophila arenaria ("white dunes"). The other Natura2000 site "Noordhollands Duinreservaat" has been partly selected for the same habitat types (2120, 2130, 2160 and 2180), but also for habitat types 2130 Fixed decalcified coastal dunes with Empetrum nigrum, and habitat type 2110 Embryonic shifting dunes.

Photo 6. View on the CORUS steel factories and the NorthSea Channel in transect 2 near the port Ijmuiden and. The factories are located north of the Natura2000 site "Kennemerduinen" and south of the Natura2000 site "Noord-Hollands Duinreservaat"

Transect 5 "Jisperveld" is also situated in Window 139_32 in the Province Noord-Holland but is located much more inland, within the lowland peat area. The southern end enters the industrial part of Amsterdam with its ports such as the Amerikahaven which has an important oil refinery. The transect crosses other cities such as Westzaner-overtoom, Koog a/d Zaan, Zaandijk, Wormerveer and Wormer and ends just above the Natura2000 site "Wormer- en Jisperveld en Kalverpolder". The other Natura2000 site is located in the centre of the transect and is the "Polder Westzaan". Almost one-third of the transect is located within the two Natura2000 sites. The area outside the protected areas is heavily industrialized and urbanised and covers 44% of the transect. And is therefore the most urbanised transect (see also Figure 7). The main agricultural land is pastures (31.5%). The Natura2000 site "Polder Westzaan" has been selected for the following habitat types 6430 Eutrophic tall herbs, 4010 Northern Atlantic wet heaths with Erica tetralix, and habitat type 7140 Transition mires and quaking bogs. The Natura2000 sites "Wormer- en Jisperveld en Kalverpolder" has been selected for the same habitat types.

Photo 7. is taken in the Northern part of transect 5 from the city Wormer on the edge of the lake "De Poel" and 't Zwet, which is located within a lowland peat area. Many people within this region have their own boat for recreation

Transect 3 "Bemelerberg" is located in "mountainous" southern part of the Province Limburg and crosses the city Valkenburg aan de Geul at the northern end of the transect, Cadier en Keer in the middle of the transect and the village Eysden at the border of the river Meuse at the Sourthern end of the transect. The transect is very close to the Provincial capital Maastricht. Twenty-three percent of the transect is covered by artificial land. An important part of the agricultural land (63%) is dominated by orchards (14.9%). The forests are located especially on the top and slopes of the hills and are dominated by broadleaf forest (11%). The transect crosses three Natura2000 sites "Geuldal", "Bemelerberg en Schiepersberg" and "Savelsbos", which cover together only 11% of the transect. The Natura2000 site "Geuldal" has been selected for seven habitat types consisting amongst others of habitat type 3260 "Floating vegetation of Ranunculus of plain and submountainous rivers", habitat type 91E0 "Alluvial forests with Alnus glutinosa and Fraxinus excelsior", forests of the Carpinion betuli and Luzulo Fagum (9160 and 9110), and various types of meadows such as the habitat type 6210 "Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometelia)". The Natura2000 site "Bemelerberg en Schiepersberg" has been selected the following habitat types: 1) 6110 "Rupiculous calcareous or basophilic grasslands of the Alysso-Sedion albi" 2) habitat type 6210 mentioned before and 3) 6230 "Species-rich Nardus grasslands on siliceous substrates in (sub-) mountainous areas". The last Natura2000 site

"Salvelsbos" is also selected for habitat type 6210, next t0 habitat type 9160 "Sub-Atlantic Oak-Hornbeam forests (Stellario-Carpinetum)".

Photo 8. One of the many orchards within the region of the village Gronsveld, transect 3, with at the background the "Trichterberg (Trichter mountain) "

Transect 6 "Drentse Aa" is located in window 14 within the Province Drenthe and crosses the Provincial capital Assen in the centre of the transect. Each end of the transect terminates in a Natura2000 site. The Natura200 site on the western end is "Fochterloërveen en Esmeer". The Natura2000 site on the Eastern end is the National Park "Drentse Aa" which includes also Ballooerveld. Both Natura2000 sites cover a little bit more than one-third of the transect. Outside the provincial capital the transect crosses only some small villages in the countryside such as Kloosterveen en Norgervaart, West of Assen, and the village Loon, East of Assen. Twentysix percent of the transect is urbanised (see also Figure 7), mainly caused by the city Assen. The agricultural land surrounding Assen consists for a large part out of arable land (27%). Other important land cover types are heatlands (8%), peatbogs (7%) and broadleaved forest (5%). Natura2000 site "Fochterloërveen en Esmeer" has been selected for the following habitat types 7120 Degraded raised bogs (regeneration possible), 4010 wet heaths with Erica tetralix, and 4030 dry heaths with Calluna and Genista. The other Natura2000 site "Drentse Aa" is characterised by its semi-natural river Drentse Aa with its famous species-rich meadows. The natura2000 site has been selected for the habitat type 6230 Species-rich Nardus grassland on siliceous substrates. Other characterizing habitat types are: 2310, 2330, 3130, 4010, 6410, 7230, 9160 9190 and 91E0.

Photo 9. Sedges (caricetum paniculatae) on the edge of the dystrophic lake Esmeer (transect 6). The lake is a Pingo ruin (glacier depression) originating from the former Ice Age and is located in an area of degraded raised peat bogs

Transect 7 "Dwingelerveld" is located in the Southwestern corner of Window 14 within the Province Drenthe and crosses only some small villages such as Diever and Dwingeloo in the center of the transect. Each end of the transect ends in a Natura2000 site. The Natura2000 site on the northern end is the National Park "Drents-Friese Wold". The Natura2000 site on the southern end is the National Park "Dwingelderveld". Almost 60% of the transect is located within protected areas. The area outside the Natura2000 sites is mainly agricultural land, dominated by pastures and arable land which were difficult to distinguish from each other on the historic aerial photographs and were therefore labelled as class 6.2.1 "farmed land". The land cover within the Natura2000 sites is dominated by "moors and heathland" (25%) and forests (9%), mainly coniferous. The Natura2000 site "Drents-Friese Wold" has been selected for the following habitat types: 2320 "Dry sandy heaths with Calluna and Empetrum nigrum", 2330 "Open grasslands with Corynephorus and Agrostis of continental dunes", 3130 "Oligotrophic waters" and 7150 "depressions on peat substrates (Rhynchosporion)". Other relevant habitat types are related to different kinds of heathland (2310, 3120, 4010, 5130, 6230).

Photo 10. Dwingelderveld (transect 7) was acknowledged as a national park in 1991 and is one of Europe's largest wet moorland area and includes many fens and is surrounded by coniferous forests. On the foreground we see some Juniperus (communis) trees

Transect 8 "Overijsselse Vecht" is located within window 120 which is located in the Province Overijssel and crosses only small villages as Sibculo, Beerzerveld, Hollandia and Nieuw Gelderland. The transect is located near the river Overijsselse Vecht and the river is being crossed in the western part of the transect near Junne and De Mars (municipality of Ommen). The western corner of the transect ends in the Natura2000 site "Vecht en Beneden-Regge", which is the river valley of the Overijsselse Vecht. The eastern corner ends in the Natura2000 "Engbertsdijkvenen", which is one of the last remaining raised bog areas. Half of the transect is located within the two Natura2000 sites. The area outside the protected areas is dominated by agriculture, almost equally represented by pastures (16%) and arable land (22%). The land cover within the Natura2000 sites is dominated by Coniferous forests with some small patches of heather and inland sand dunes within the Natura2000 site "Vecht en Beneden-Regge" and is dominated by heather and oligotrophic waterbodies and peat bogs for the "Engbertsdijkvenen". The Natura2000 site "Vecht en Beneden-Regge" has been selected for the following habitat types: 4030 "Dry heaths", 5130 "Juniperus communis formations", 7150 "Depressions on peat substrate", followed by 6430 "Eutrophic tall herbs", 6230 "Species-rich Nardus grasslands" and 4010 "Wet heaths". The Natura2000 site "Engbertsdijkvenen" is characterised by the habitat type 7120 "Degraded raised bogs (still capable of natural regeneration)" and various heather types.

Photo 11. Junne (transect 8) is one of the well conserved villages in the countryside near Ommen and is located very near to the Overijsselse Vecht and the village attracts a lot of tourists

Transect 9 "Terschelling"is located on the island Terschelling within window Y and belongs to the Province Friesland. The transect starts on the eastern end of the island and covers about two-third of the island. So the transect covers a large part of the nature reserve "De Boschplaat", which has the status of National Park since 1988. The villages, such as Formerum, Lies, Hoorn and Oosterend are located more in the western part of the transect. Transect 9 is the transect with the highest percentage (87%) within Natura2000 sites. The two Natura2000 sites are "Duinen Terschelling" and the "WaddenZee". The last site is mainly covering the WaddenSea, but includes also the Boschplaat. The Natura2000 site "Duinen Terschelling" is covering the dunes and beaches of the island. The only part that is not covered by protected areas are the polders with pastures located at the southern part of the main road between Oosterend and West-Terschelling. The Boschplaat (see Photo 3) is known as a hotspot for many wetland birds and is characterised by main land cover types as sea, intertidal flats, salt marshes, beaches and dunes. It is one of the few remaining natural areas in the Netherlands, where natural processes are still the dominant factor in shaping the landscape. However, the construction of the *stuifdijk* (dike) in the 1930's for the protection against the North Sea, altered many of these natural dynamics (see also description of Window Y "Friesland") .

Photo 12. Traditional houses on the island Terschelling (transect 9) near the village Oosterend with at the background the Dunes which are part of the Natura2000 site "Duinen Terschelling"

2.3.3 Land cover distribution within the transects in 2000

This section provides an overview of the distribution of land cover classes among the transects in the year 2000. The Corine level 1 database was used for comparing the land cover statistics of each transect. Figure 7 illustrates the results which portray the transect 5 (Jisperveld) as the most urbanised transect since 44% of its area is being covered by artificial land use.

Looking at urban regions, we find the transects 2 (Kennemer Duinen), 3 (Bemelerberg), 4 (Kampina), 5 and 6 (Drentse Aa) having more than 20% of their area covered by artificial areas. On the other hand, the transects having more than 40% of its area covered by agricultural land include transect 1 (Loonse en Drunense Duinen), transect 3 (Bemelerberg), transect 6 (Drentse Aa) and transect 8 (Overijsselse Vecht). But it is also interesting to point out that transects 3 and 5 are the ones having more than 80% of their area covered by both artificial and agricultural land cover types.

In contrast, the transect 9 (Terschelling) is the least urbanised having only 4% of its area covered by artificial land use. In fact, this transect has over 80% covered by natural land cover types, with wetlands (31.8%) and forest and semi-natural areas (50.9%). Moreover, the transects 2 (Kennemer Duinen), 4 (Kampina), and 7

(Dwingelerveld) show more than 40% of their area being covered by forest and semi-natural areas.

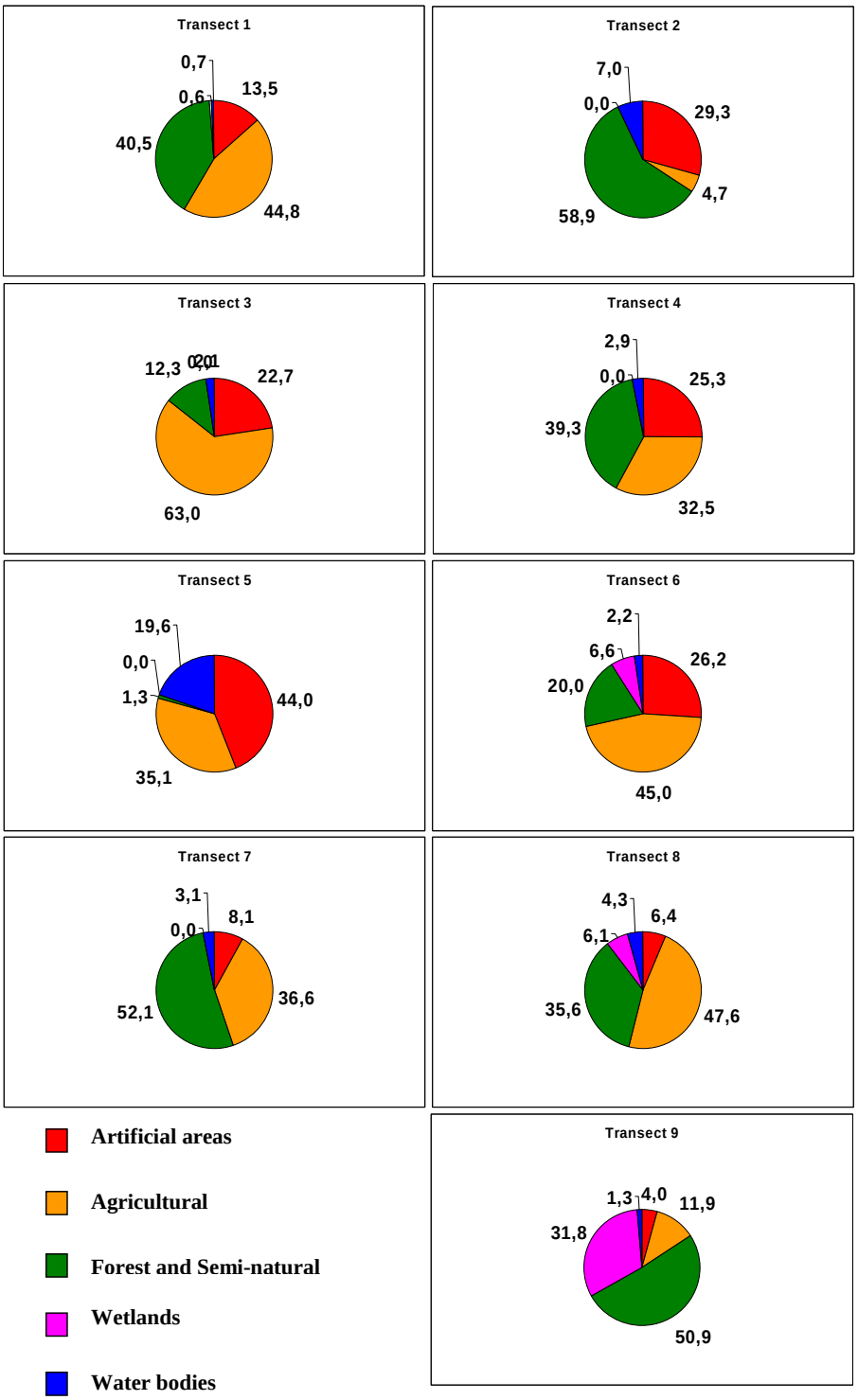


Figure 7. Land cover statistics (%) for 9 Dutch transects (Corine level 1 – year 2000)

Another way of comparing the transects is to compute how much area of the transects is located inside of Natura2000 sites. Figure 8 shows the results obtained for the transects areas located inside of the Natura2000 sites. All transects have a surface area of approximately 33km^2(2km by 15km plus rounded ends). The transect 9 (Terschelling) has 87% of its area inside of Natura 2000 sites. On the contrary, the transect 3 (Bemelerberg) is only 11% inside of Natura2000 sites. Most of the transects have a range between 30% up to 60% of their areas inside of Natura2000 sites.

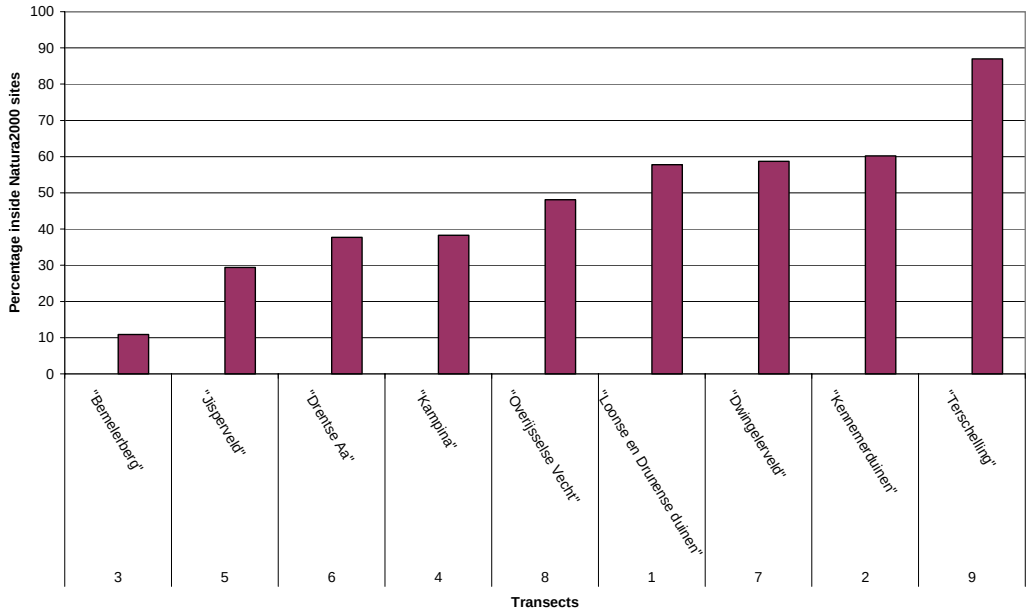


Figure 8. Area of transects inside Natura2000 sites

3 The aerial photo interpretation of land cover changes

Aerial photo interpretation consists of examining images for the purpose of identifying objects and judging their significance. We usually distinguish photo interpretation from photogrammetry, since the former is concerned with taking measurements from photos and using them to make maps, rather than requiring trained operators using expensive equipments. The main procedures of aerial photo interpretation are pre-processing (acquisition and georeferencing), element recognition, class allocation (labelling), and backdating (Avery & Berlin, 1992). This chapter describes these procedures which have been undertaken for the aerial photo interpretation of the selected sampled windows and transects in the Netherlands.

3.1 Pre-processing the aerial photographs

3.1.1 Acquisition

Black and white (B&W) aerial photographs (AP's) were ordered at the Topographic Office in the Netherlands (TDN). For the Dutch windows more than 650 hard copies of AP's of the early 50's were ordered together with topographical maps (1:25.000) from the same time period. For the five windows all materials were sent to GISAT located in the Czech Republic. GISAT is the BIOPRESS partner who was responsible for WP7000 "the CORINE backdating 1990-1950". Their work included scanning of AP's and topographical maps, georeferencing and producing the AP mosaics for all windows.

For the Dutch transects, the pre-processing was carried out by Alterra. More than 430 hard copies of B&W AP's of the reference years 1950, 1990 and 2000 were ordered at the Topographic Office in the Netherlands (TDN). The acquired aerial photographs were at scale of 1:18.000 for 1990 and 2000, and at a scale of 1:20.000 for the reference year 1950. For each transect B&W AP's were acquired in such a way that for the entire transect a stereographic view could be generated if necessary to facilitate the on-screen AP interpretation. For the on-screen AP interpretation about 140 of 430 hard copies of B&W AP's were scanned and georeferenced. Mosaics of aerial photographs were produced for the three time steps (1950, 1990 and 2000) for all transects, see Figure 10 as an example.

Unfortunately, for some transects B&W AP's were not exactly available for the years 1950, 1990 and 2000. In this case, the selection criteria was based on a minimum time span of ten years between AP's for the 1990 and 2000 time span, and a time span of +/- five years for the reference 1950. In Appendix 3 a list is given with the number of aerial photographs used per transect and the date of acquisition. Only the transects 2 and 5 did not comply with the above mentioned criteria since B&W AP's from 1958 were used instead of 1950. Flight recording of most aerial photographs

from the TDN took place in early spring when the trees did not have too many leaves yet and all infrastructure was clearly visible.

3.1.2 Georeferencing

The B&W AP's of the Dutch transects were scanned at 600 dpi as tiff-files. Band 1 of the tiff-files were imported and georeferenced in ERDAS Imagine, resulting in a 40 MB file. For the georeferencing of the AP's we used the Dutch digital elevation model AHN and digital topographical maps of the Netherlands at scale 1:10.000 (Top10-vector). The AHN has a resolution of one measurement point per 4m by 4m ($16m^2$) in centimetres height. The AP's were georeferenced to the Dutch national reference system, the Bessel Stereographic projection ("Rijksdriehoekstelsel"), using a minimum of ten well distributed ground control points (GCP's), with a RMSE of 2–5 m. For resampling the Nearest Neighbourhood (NN) resampling method was used. In ERDAS Imagine 8.7 we used the "Camera" option as the geometric correction method, which offers the possibility of creating a custom geometric correction model for a specific camera. See Appendix 2 for a detailed description of the geometric correction method (numerical restitution) used.

The overall procedure for geometric correction started with aerial photographs from the reference year 2000. These AP's were georeferenced using the above mentioned method and the digital topographic maps of the Netherlands 1:10.000 (Top10-vector). Subsequently, the AP's of 1990 were geometrically referenced to the georeferenced AP's of 2000. The AP's of the reference year 1950 were geometrically referenced to the georeferenced AP's of 1990. This procedure guaranteed a maximum fit between the AP's of respectively the reference years 2000, 1990 and 1950. Finally, the mosaics of AP's were produced and clipped with the transect boundaries before the on-screen interpretations started.

3.2 Element recognition

The recognition of land cover elements was accomplished by computer-aided visual interpretation of black & white aerial photographs (B&W AP's). The seven principles used for the aerial photo interpretation were shape, shadow, pattern, association, texture, tone/colour, and size (Lillesand & Kiefer, 2000). The patterns observed on the B&W AP's by the interpreters and their associations to land cover changes played an important role to assign the right land cover type to the element.

To be sure that all interpreters were using the same rules and guidelines a special photo-to-photo interpretation manual was produced for the transects of BIOPRESS project by Jan Feranec, Tomas Cebecauer and Jan Otahel of the Institute of Geography in Bratislava, Slovak Republic (Feranec et al., 2004). The objective of the "*Photo-to-Photo Interpretation Manual*" was to show interpretation possibilities of aerial B&W photographs in identification of land cover classes at a scale 1:20.000, as well as the linear and point features and land cover changes for the years 1950, 1990 and

2000. This manual was a continuation of the "*Manual of Computer Aided Visual Interpretation of Aerial B&W Photographs"*, the aim of which was to demonstrate interpretation of aerial B&W photographs for the interpretation of the windows at a scale of 1:100.000 in the BIOPRESS project using the CORINE land cover identification methodology (Feranec et al., 2003).

The following criteria were used in the element recognition process of the transects interpretation (Figure 9):

- areas of land cover objects were identified by means of aerial B&W aerial photographs displayed at a 1:20.000 scale. When necessary the interpreter could zoom in on the aerial photographs to improve the capacity to identify the object. However, all delineations should be done at a scale of 1:20.000;
- the minimum size of the objects (polygons) is 0.5 ha (at a scale of 1:20.000 this corresponds to 3.5mm by 3.5 mm);
- the minimum width of a linear element is 20 m (this is 1 mm at scale of
- 1:20.000).

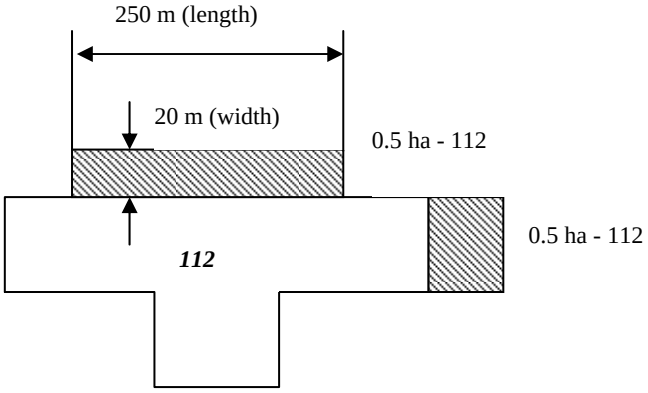


Figure 9. Criteria for the detection of the smallest LC polygon and LC change at scale 1:20.000. The most important are the minimum mapping unit (MMU) of 0.5 ha (at scale 1:20.000 it is 3.5mm by 3.5 mm) and a minimum width of 20m (at scale 1:20.000 it is 1mm)

The final result of all computer-aided visual interpretations is a set of polygons completely covering the area of interest at a scale of 1:20.000 for the transects (1950, 1990 and 2000) and at a scale of 1:100.000 for the windows (1950 and 2000).

3.3 Class allocation

In the process of class allocation (labelling) the use of ancillary data, such as historic topographical maps (scale 1:25.0000), was used to improve the photo interpretation results. The interpreted polygons were assigned to land cover classes that correspond to one of the 44 categories of the CORINE land cover nomenclature (see Table 4). In Appendix 4 definitions are given for each CORINE land cover class. Before any interpretation could be done, the interpreters had to be fully aware of the CORINE nomenclature since it was used in the BIOPRESS project.

Table 4. CLC Nomenclature (Heymann et al. 1994)

1. Artificial surfaces

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
1.1.2. 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 constructions 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. Heterogeneous 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 forests
3.1.2. Coniferous forests
3.1.3. Mixed forests

3.2. Scrub and/or herbaceous vegetation associations

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 marshes
4.1.2. Peat bogs

4.2. Maritime wetlands

4.2.1. Salt marshes
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 oceans

The following criteria were used in the class allocation process of the transects interpretation:

- every land cover class is separated by closed borders and marked by a 3 digit code as quoted in Table 4 and Table 5;
- land cover changes are only valid if they exceed these minimum mappable units (changes in area ≥ 0.5 ha and changes in position of linear features ≥ 20

m). See also Figure 9. Only when these criteria were met, the interpreter embedded the land cover change by adding a new label or delineating a new polygon(s).

3.3.1 Resolving ambiguity in class allocation

At the beginning of the class allocation process it was decided to add two ambiguous classes to the CORINE land cover nomenclature since some land cover classes (e.g. arable land and pastures) were in some cases too difficult to distinguish on basis of the AP characteristics.

The CORINE nomenclature level-3 constitutes the basis for the BIOPRESS AP interpretations, despite its obvious limitations such as the intermingling of land use and land cover classes. When interpreting historical aerial photographs, circumstances frequently arise when it is difficult to assign land cover objects unambiguously and with a high interpretation accuracy to one single CORINE class. In the case that the interpreter was completely uncertain about the allocation to a specific land cover class, the uncertainty was made explicitly by labelling the polygon as a new "class 6" at CORINE level 1. Table 5 gives the newly defined ambiguous land cover classes.

Table 5. Newly defined ambiguous land cover classes

Class		Confused with		Suggested solution	
2.1.1	non-irrigated arable land	2.3.1	pasture	6.2.1	farmed land
3.1.1	broadleaved forest	3.1.2	coniferous forest	6.3.1	forest

3.4 Backdating

The backdating procedure was concerned with tracking and accessing the history of important land cover changes between two successive points in time.

In the BIOPRESS project, the backdating of the windows started with the CORINE Land Cover database of the nineties (CORINE1990). The CORINE1990 data layer was overlapped with the B&W AP's mosaic of the 1950's at the scale 1:100.000. Land cover changes were than identified, digitised, and labelled. Topographical maps of the fifties at scale 1:25.0000 were used as a reference material.

In case of the transect interpretations, the B&W AP's of the year 2000 were interpreted with the help of the Top10-vector (Dutch digital topographical map at scale 1:10.000). After that, this land cover interpretation for 2000 layer was overlayed with the B&W's of the 1990's and only the changes were identified, delineated and interpreted. As a result, only new lines were interpreted using a new attribute code for the specific reference year. This step was repeated for the interpretation of the B&W AP's of the 1950's. A detailed representation of land cover on B&W AP's is displayed in Figure 11.

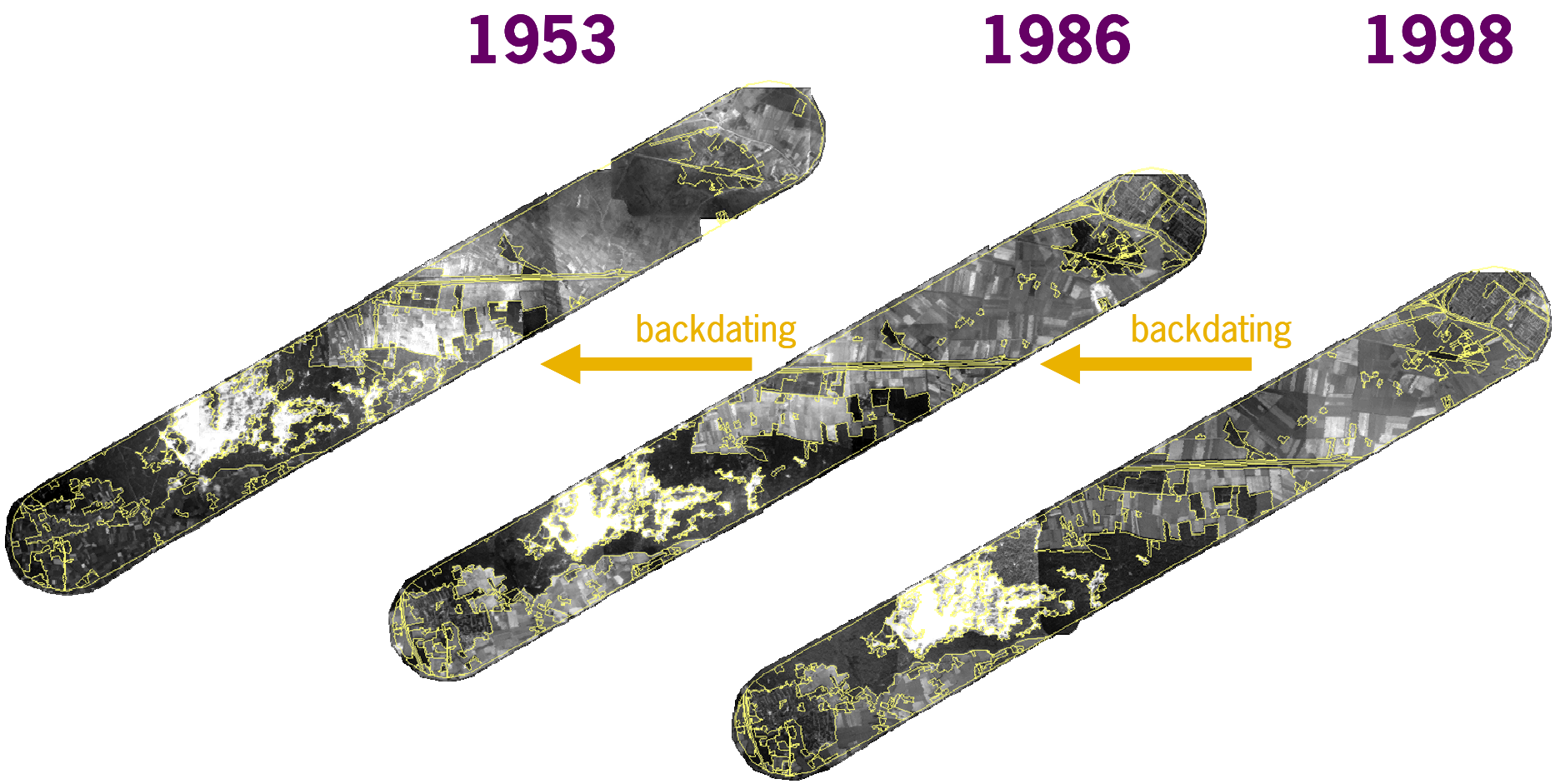


Figure 10. Demonstration for transect 1 (from s-Hertogenbosch to Loon op Zand through the Natura 2000 sites "Vlijmens Ven, Moerputten en Bossche Broek" en "Loonse en Drunense Duinen') of the backdating methodology for the land cover interpretation of aerial photographs of 1953, 1986 and 1998.The interpretations are displayed by the yellow lines.

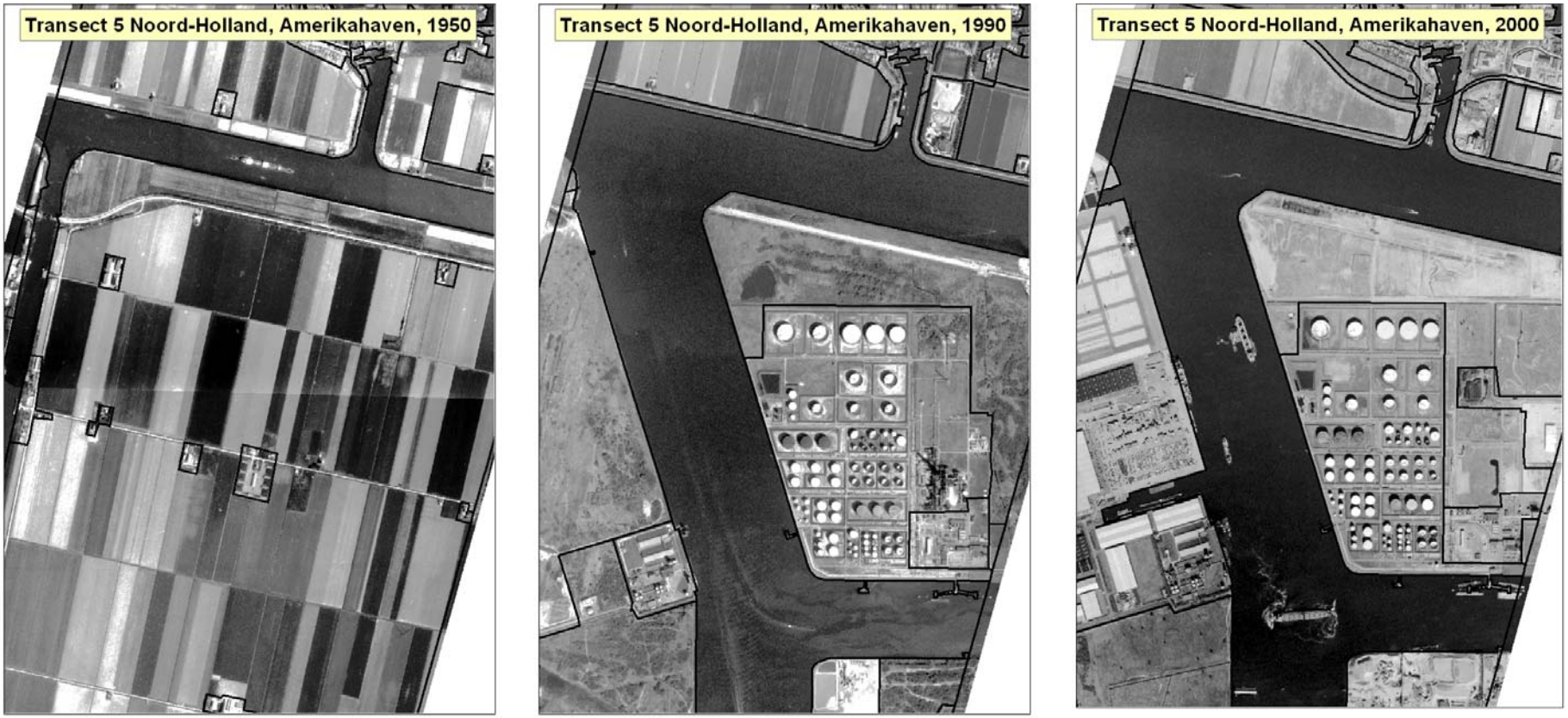


Figure 11. A detailed representation of the land cover dynamics identified on the sequential B&W AP's for 1950, 1990 and 2000. The area is located in the southern part of transect 5, North-west of Amsterdam, and covers a part of the Amerika haven (port) and the North-Sea Channel and shows the dramatic land cover changes including the new water infrastructure. The area is located very closely to the Natura2000 site "Polder Westzanen"a peatland are dominated by pastures with patches of mires and wet heaths.

4 Land Cover Changes

This chapter gives a summary of all major land cover changes for the sampled windows and transects analysed within the BIOPRESS project for the time period 1950-1990-2000. For a general description of the windows and transects see Chapter 2. Chapter 4 will show the significant land cover changes that took place in the second half of the last century. Most of these changes took place outside the Natura2000 sites, but there are also exceptions as in the case of the Boschplaat on the island Terschelling. In the first phase of the BIOPRESS project it became clear that especially in small and highly populated countries such as the Netherlands and Belgium endure severe land cover changes. Comparison of the historical aerial photographs with more recent aerial photographs reveals that not only the land cover has changed but also often the complete structure of the landscape. Land consolidation programmes, especially during the fifties and sixties, targeting a higher agricultural production, had large impacts on the structure of the landscape and resulted also in the loss of many small landscape elements and biotopes which continued to degrade even after that period. This chapter will start with a general sketch for the Netherlands, before we go to the windows and transects. For a complete and detailed overview of all land cover statistics and their visualisation in figures, see Appendix 5 (maps) and 6 (statistics) for the windows and Appendix 7 (maps) and 9 (statistics) for the transects.

4.1 Overview of land cover changes

The Netherlands is one of the most densely populated countries in the world (with 16 million people and up to approximately 1.000 inhabitants/km^2) and is highly industrialised. Its coastal location and the fact that a number of major rivers flow into the North Sea through the Netherlands make the country an important transport route both for shipping over the Rhine and the Meuse and for road transport to Germany, Belgium and beyond. Since 1900 there is a strong increase in built-up areas at the expense of agriculture and nature. *(Source: Environmental Data Compendium, http://arch.rivm.nl/environmentaldata).* **T**his is also shown by the historical topographic maps of the Netherlands. Within the Dutch project HGN historic topographical maps are being scanned, geometrically corrected and classified into national maps with a spatial resolution of 50 meters and 10 major land cover classes (Knol et al., 2004). These historical maps can be compared with more recent land cover databases, such as LGN (Thunnissen & de Wit, 2000). For this purpose LGN-4 has been transformed to the ten HGN land cover classes (see Figure 12).

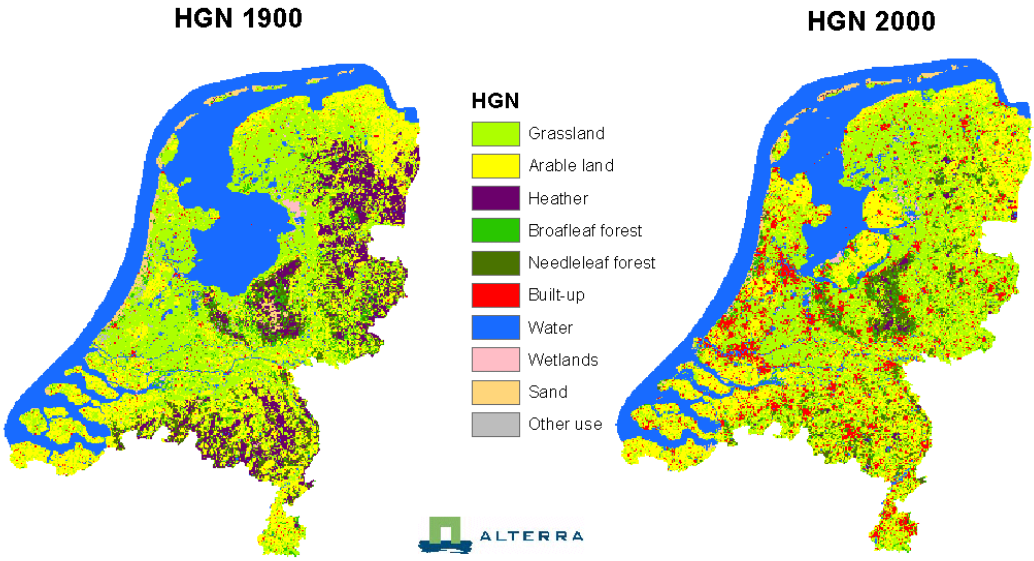


Figure 12. Historic land cover (HGN 1900) compared with the situation in 2000 (HGN2000 has been derived from LGN-4) for the Netherlands (Source: Alterra)

Figure 12 reveals clearly the dramatic changes in land cover during the last century. Especially, the amount of heather has disappeared for a large extent, with approximately 400 000 ha, and has been converted to agriculture. The growing population and it's urbanisation, with approximately 350 000 ha, had a huge impact on the developments in that period. In the figure below the statistics are given of for changes in land cover in the period 1900-2000.

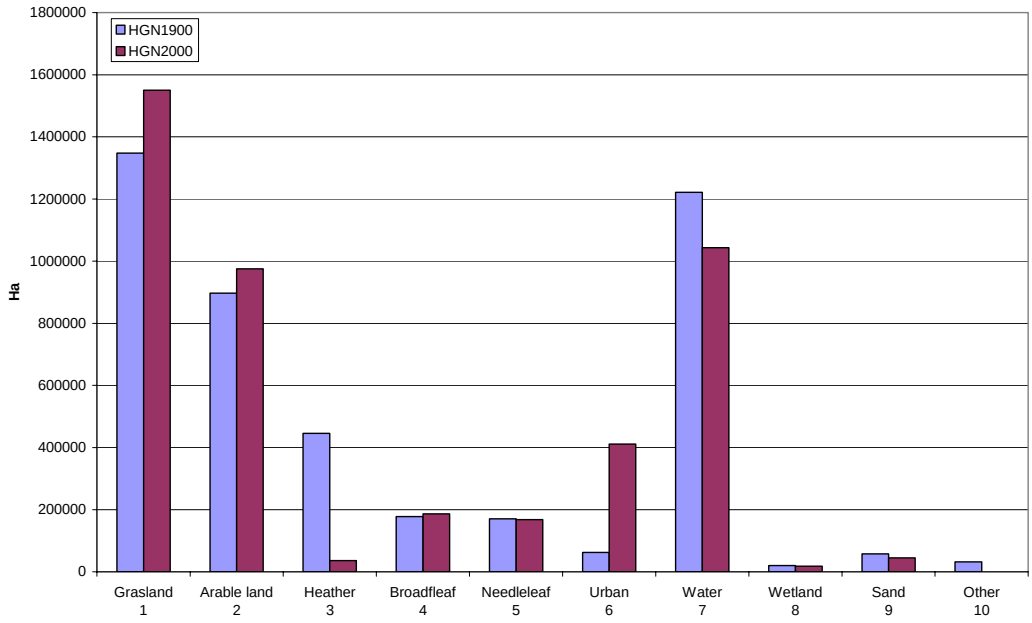


Figure 13. Historic land cover changes in the period 1900-2000 for the Netherlands. The statistics are derived from HGN1900 and 2000 (Knol et al. 2004)

From the HGN project it became clear that heather has been lost at the expanse of agriculture and coniferous forest, that urbanisation took place at the expanse of agriculture and that sand blown areas has been lost at the expanse of coniferous forest. Although the total amount of grassland and arable land has not changed dramatically, the agricultural land use practices have changed significantly in that period. Increasing mechanisation and intensification resulted in a continuous loss of jobs in the agricultural sector. Since 1960 the number of workers employed in agriculture and horticulture has fallen by 50% to a total of 282,000 in 2000. The number of farms has fallen from 300.000 in 1960 to 97,000 in 2000. Of those 97,000 farms, the majority (55,000) are livestock farms. The agricultural land per farm increased from 13.9 ha in 1980 to 20.1 ha per farm in 2000. *(Source: Environmental Data Compendium, http://arch.rivm.nl/environmentaldata).*

More reliable statistics are available since the fifties from the Central Bureau of Statistics (CBS). In Table 6 a summary is given of the changes in land cover since the fifties. Also this table indicates that the net change in agriculture is quite low (6%), compared with the enormous increase of built-up areas with 106% since the fifties. Also the amount in nature has dramatically declined, with 44%, in forty years time. This concern especially, peat bogs, heath, salt marshes and sand blown areas. The forests have been extended significantly with 83 540 ha in forty years time. This is especially due to afforestation with broadleaf and mixed forest. Note that the coniferous forests have even decreased with 13% in that period of time.

Table 6 Changes in acreage in land cover 1950-1990

		1950 hectares	**1990 hectares**	**change %**
Agriculture		**2,523,510**	**2,373,890**	**-5.9**
Forest		**245,850**	**329,390**	**34**
	Broadleaf	75,310	118,580	57.5
	Needle leaf	155,430	135,710	-12.7
	Mixed	15,110	75,100	397
Nature		**262,670**	**146,040**	**-44.4**
	Wetlands	43,600	47,530	9
	Salt marshes	24,980	10,080	-59.7
	Dunes & beaches	48,030	43,870	-8.7
	Heath	110,840	35,820	-67.7
	Sand blown areas	7,340	3,540	-51.8
	Peat bogs	27,880	5,200	-81.3
Urbanised		**262,770**	**541,010**	**105.9**
	built-up	97,850	133,210	36.1
	infrastructure	164,920	407,800	147.3
Water		**782,500**	**664,770**	**-15**
Total		**4,077,300**	**4,055,100**	**-0.5**

(source: CBS, Central Bureau for Statistics in the Netherlands. The table was published in the Dutch Natuurcompendium 2003)

What will follow now is a description of the land cover changes found within in the BIOPRESS windows (paragraph 4.2) and transects (paragraph 4.3) for the period 1950-1990. Appendices 5 and 7 show the land cover and land cover change maps for all Dutch windows and transects, respectively.

4.2 Windows

Window 7 "Noord-Brabant"

As mentioned already in Chapter 2, window 7 is an agricultural area between Den Bosch and Tilburg dominated by pastures (CORINE class 231) and complex cultivation patterns (class 242) which cover together 60% of the window. Coniferous forest (312), arable land (211) and discontinuous urban fabric (112) are other important classes, each covering more that 5% of the window, see also Appendix 6.

In total, 21% of the window has changed in the period 1950-1990, which is a huge area of approximately 190 km^2, see also Figure 14. Most changes occurred in the agricultural classes (118 km^2). The conversion of agricultural areas into artificial areas concerned 5.7% of the region (51 km^2), see also the figures in Appendix 6. This transformation concerns especially the conversion of complex cultivation patterns into discontinuous urban fabric with 22 km^2. Internal changes at CORINE level 1, e.g. from complex cultivation patterns and arable land into pastures (all belonging to CORINE class 2 "Agricultural areas" at level one), occupied large areas (respectively 80 and 14 km^2). These internal changes are considered to be less important since most of these changes are not permanently, and do have less impact on biodiversity.

Window 120 "Overijssel"

Window 120 is located in the Province Overijssel and covers some of the undulated parts of the Netherlands, amongst others the "Sallandse Heuvelrug", and contains cities such as Hellendoorn, Almelo, Rijssen en Raalte. Window 120 is the Dutch window with the highest percentage of agriculture, more than 70% of the area is occupied by agriculture. More specifically, pastures are covering more than 50% of the window. Other important classes, covering more than 5% of the window, are coniferous forest (312), arable land (211), complex cultivation patterns (242), land principally occupied by agriculture with significant amounts of natural vegetation (243). All artificial classes occupy together 6% of the window. For more details see also Appendix 6.

Only 12.1% of the surface area of window 120 has changed in the 1950-1990 period, see also Figure 14. The largest part concerns changes between agricultural classes (58 km^2). The largest change is the conversion of pastures into complex cultivation patterns. Only 23 km^2 changed from agricultural land into artificial areas. However, it is very significant since it means a doubling in artificial area. Further important changes are the conversion of moors and heath land into agricultural land and forest.

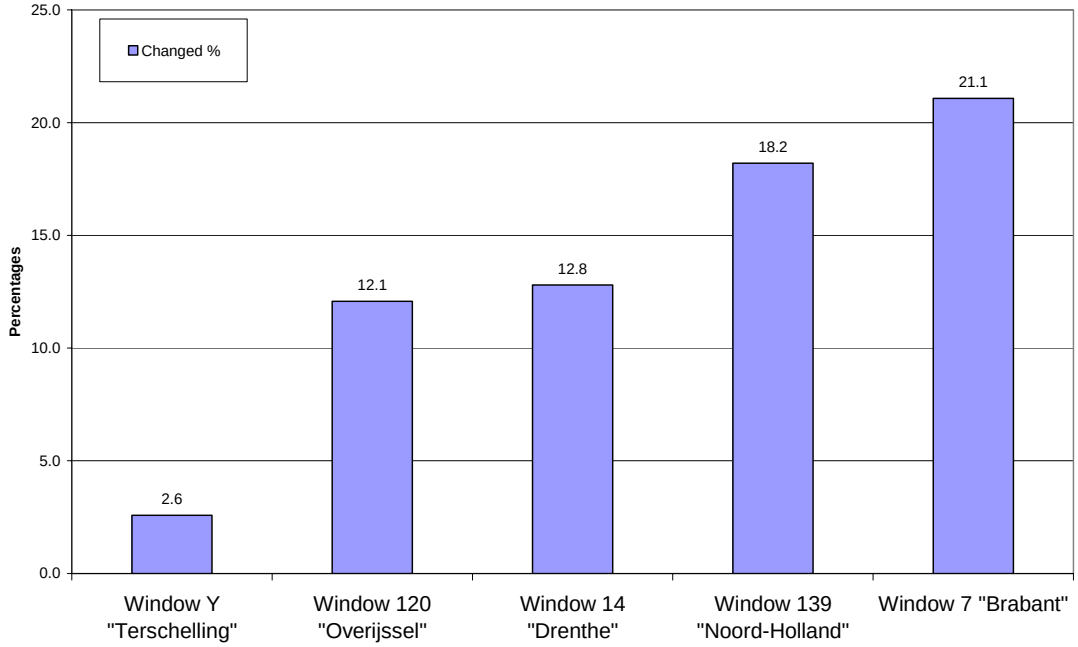


Figure 14. Land cover dynamics in percentages for the five windows over the period 1950 - 1990

Window 14 "Drenthe"

Windows 14A is located in the Provinces Drenthe with the Provincial capital in its centre and is dominated by agricultural land cover types such as pastures (29%), complex cultivation areas (25%) and arable land (18%), all together more than 60% of the area. Besides agriculture, the land cover classes coniferous and mixed forest and moors and heath land occupy each more than 5 % of the window's area (Appendix 6). Urban areas occupy less than 5% of the area. Figure 15 shows the land cover in 1950 and 1990 and reveals that the land cover changes are not dramatic, except for the fact that the Provincial capital Assen has significantly increased it's area for residential as well as for commercial and industrial functions.

Only 12.8% of the total area of window 14 changed its land cover in the 1950-1990 period (Figure 14). The largest part of changes concerns changes between agricultural classes (61 km^2). The largest land cover change is the conversion of pastures into complex cultivation patterns. Only 18 km^2 changed from agricultural land into artificial areas. However, it means a doubling of the artificial area!. Other important changes are the conversion of moors and heath land into agricultural land and forest area (respectively 21 km^2 and 16 km^2).

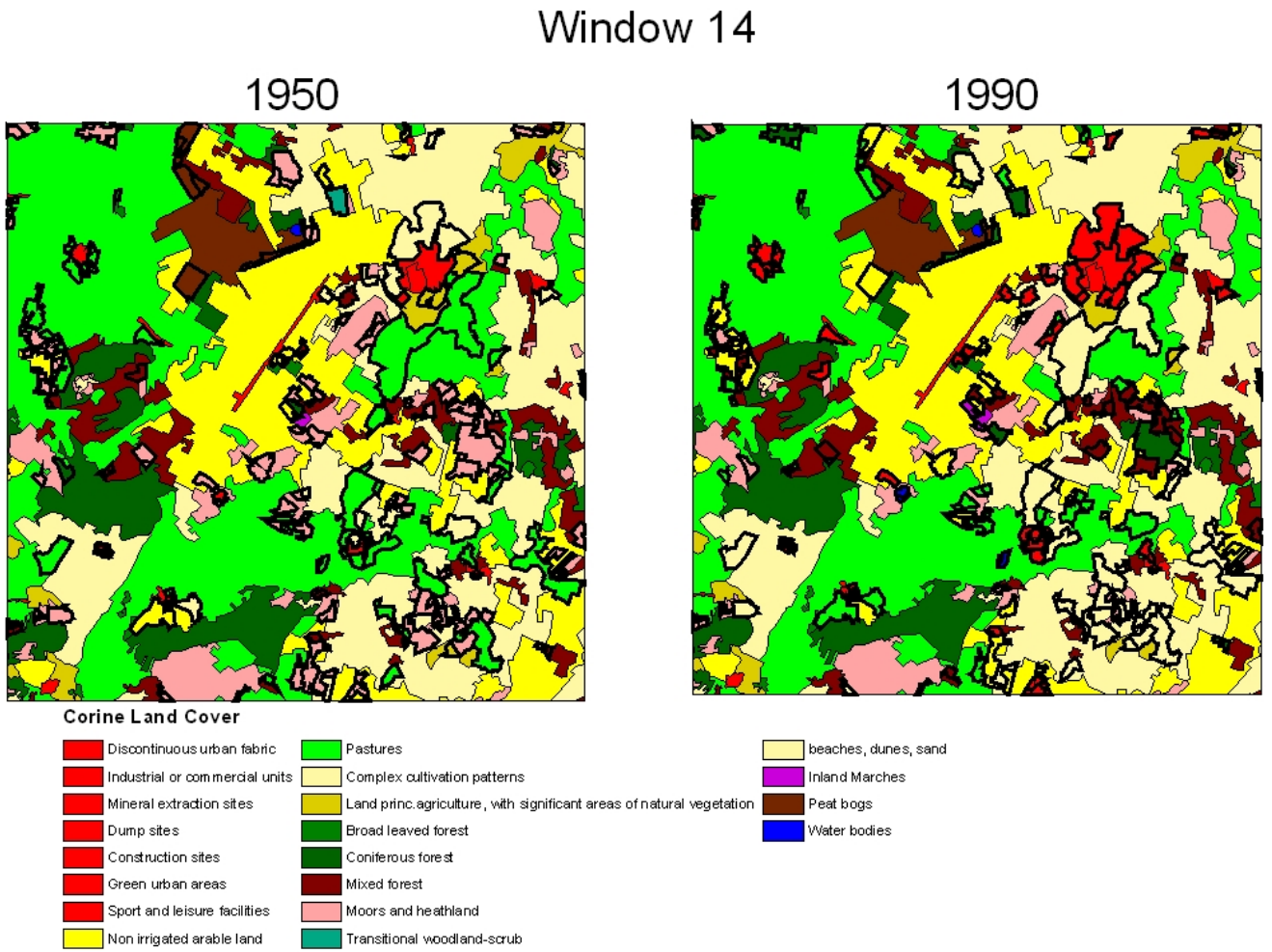


Figure 15. CORINE land cover for 1950 and 1990 for window 14 (black lines indicate changed areas). Window 14 is located in the Province Drenthe with the Provincial capital Assen in the Northwest corner. Other urban areas within the region are much smaller and are villages such as: Rolde, Norg, Veenhuizen, Dwingeloo, en Westerbork Note that the city Assen has almost doubled its extent in fourty years time.

Window Y "Friesland"
Window Y covers the Island Terschelling and the surrounding Wadden Sea and North Sea. The window consists for a large part out of intertidal flats (37%) and sea (44%). Other land cover types of importance, which cover more than 5% of the window, are natural grasslands (321) and beaches and dunes (331). Less than 0.5% of the window is covered by artificial areas. In the period 1950-1990 only 2.6% of the land cover changed, and is the window with the lowest amount of land cover changes. This also partly due to the fact that large part of the window consists out of sea. Most important changes are the conversion of beaches and dunes (331) and salt marshes (421) into natural grassland (0.5 km^2) and beaches and dunes into sea and ocean (0.4 km^2) (see Appendix 6).

Window 139 "Noord-Holland"
Window 139 is located in the Province Noord-Holland and is the most urbanised window with large cities as Amsterdam, Zaanstad, Purmerend, Beverwijk, Velsen, Zandvoort and Amstelveen. In 1990 only 46% of the area was occupied by agriculture. Pastures are dominating the area with 27%. Other important classes are arable land (211), discontinuous urban fabric (112), natural grasslands (321) and of course the sea (523), since the window covers a part of the Dutch coastline. All artificial classes together (Corine level 1 class 1"Artificial surfaces") are covering more than 35 % of the window (Appendix 6).

An 18.2% change in land cover occurred in the period 1950-1990, and belongs therewith to the windows with highest amount of change, see also Figure 14. Of the changes within this window the most important change was the conversion of agricultural land into artificial land (129 km^2), which can be expected in an area with one of the highest population density in the world. Some specific changes were the conversion of natural grassland into artificial land (4.8 km^2), agricultural land into water areas (6.2 km^2) and construction sites into discontinuous urban fabric (13.5 km^2).

4.3 Transects

A short description of the transects has already been given in Chapter 2 and concerns the transects summarized in the Table 7 below. The table also summarizes the Natura2000 sites that are being crossed by the transects. Figure 8 summarizes the percentage of each transect located within and outside Natura2000 sites, and varies from 11 to 87 percent. The degree to which the transect is located within a transect determines probably also the degree of land cover changes over the last fifty years. The following paragraphs summarises the land cover changes that have occurred within each transect over the last fifty years.

Table 7. Overview of the transects, location in Province and intersected Natura2000 sites

Transect	Province	Window	Natura2000 sites
1	Noord-Brabant	7	Loonse en Drunense duinen en de Brand
2	Noord-Holland	139_32	Vlijmens ven, Moerputten en Bossche Broek Kennemerduinen en Amsterdamse waterleiding-duinen Noordhollands Duinreservaat
3	Zuid-Limburg	Z	Savelsbos Bemelerberg en schiepersberg Geuldal
4	Noord-Brabant	7	Kampina en Oisterwijkse bossen en vennen
5	Noord-Holland	139_32	Wormer- en Jisperveld en Kalverpolder Polder Westzaan
6	Drenthe	14	Drentse Aa Fochteloerveen en Esmeer
7	Drenthe	14	Drents-Friese Wold Dwingelerveld
8	Overijssel	120	Vecht en Beneden-Regge Engbertsdijksvenen
9	Friesland	Y	Duinen Terschelling Waddenzee

Transect 1 "Loonse & Drunense Duinen"

The transect which is covered for 57.8% by the Natura2000 sites "Loonse & Drunense Duinen en de Brand" and "Vlijmens ven, Moerputten en Bossche Broek" is mainly an agricultural area with a significant amount of forest and semi-natural areas. Coniferous forest covers 22.2% and dunes 6.4% of the area, see Appendix 9. It is a relatively stable transect with only 23.6% of changes between 1950 – 2000 (Figure 17 and Figure 18). The most important changes are the conversion of agricultural land into artificial areas (3.6 km^2). Also the conversion of wetlands and agricultural land into forest (1.3 km^2 or 4%) is an important feature for the period 1950 – 2000.

Transect 2 "Kennemer Duinen"

More than 60% of the transect is covered by the Natura2000 site Kennemerduinen and Noordhollands Duinreservaat. The transect is covered for almost 60% covered by semi-natural and forest areas and nearly 30% by urban areas (mainly port and industrial areas) in 2000. Agricultural areas are almost absent. Forty percent is covered by natural grasslands (Appendix 9). Also this transect is relatively stable with 32.9% of changes between 1950 and 2000. The number of changes in transect 2 is comparable with transect 1. The higher number of changes in transect 2 is mainly due to the higher number of internal changes, i.e. changes within CORINE level 1 class (Figure 17). In this case mainly internal changes within the forest and semi-natural classes (7.4%). Transect 2 has one artificial centre which has a major pressure on its surroundings (Hoogovens, an industrial centre near IJmuiden and the cities of Velsen and Beverwijk). Major land cover changes are conversion of agricultural areas and natural grassland into artificial areas (1.9 km2 for each one) for the period 1950 – 2000.

Transect 3 "Bemelerberg"

The transect is located in a more undulated part of the Netherlands with some small Natura2000 sites covering 11% of the transect (see Figure 8). More than 60% is covered by arable land (211), pastures (231) and fruit trees (222). Also 17.8% is covered by discontinuous urban fabric (112). More than 55% of the land cover in the transect has changed in the period 1950-2000. However, major changes were internal changes (11.1 km^2 or 35.5%), next to the conversion of agricultural land into urban areas (4.6 km^2 or 14.6%), see Figure 17. The biggest land cover change (at level 3) was the disappearance of fruit trees and berry plantations (932 ha), changed the character of the landscape to a large extent.

Transect 4 "Kampina"

Transect 4 and transect 1 are both located within Window 7. The Natura2000 site within transect 4 is "Kampina and Oisterwijkse bossen en venen" which cover nearly 40% of the transect. Nearly 40% of the transect is covered by forest and semi-natural areas (mainly mixed forest and heathland), more than 30% by agricultural land (pastures and arable land) and 25% by artificial areas (mainly discontinuous urban fabric). The amount of changes (19 km^2) is slightly overestimated since half of the land cover changes are changes between pastures/arable land (231/211) and farmed land (621 – ambiguous class) (see Appendix 9 & Figure 17). So, in fact a considerable part are not "real" changes. The conversion of agricultural land into artificial area (mainly discontinuous urban fabric) is the most important change (3.8 km^2 or 11.5% of transect area).

Transect 5 "Jisperveld"

Nearly 30% of transect 5 is covered by the Natura2000 sites "Wormer & Jisper veld" and "Polder Westzaan". Transect 5 is the most urbanised transect with more than 40% covered by artificial areas. The landscape outside the urbanised zone is for a large part dominated by pastures (31.5%) dissected by many water channels and bodies (19.2%). More than 40% of the land cover changed between 1950 and 2000 (Figure 18). By far the most important change is the change from agricultural land into artificial land (>10 km^2) (Figure 17). Also an important change is the conversion of arable land into water courses (1.8 km^2). A spatial representation of land cover for 1950, 1990 and 2000 and the land cover changes for the periods 1950-1990 and 1990 -2000 is presented in Figure 16.

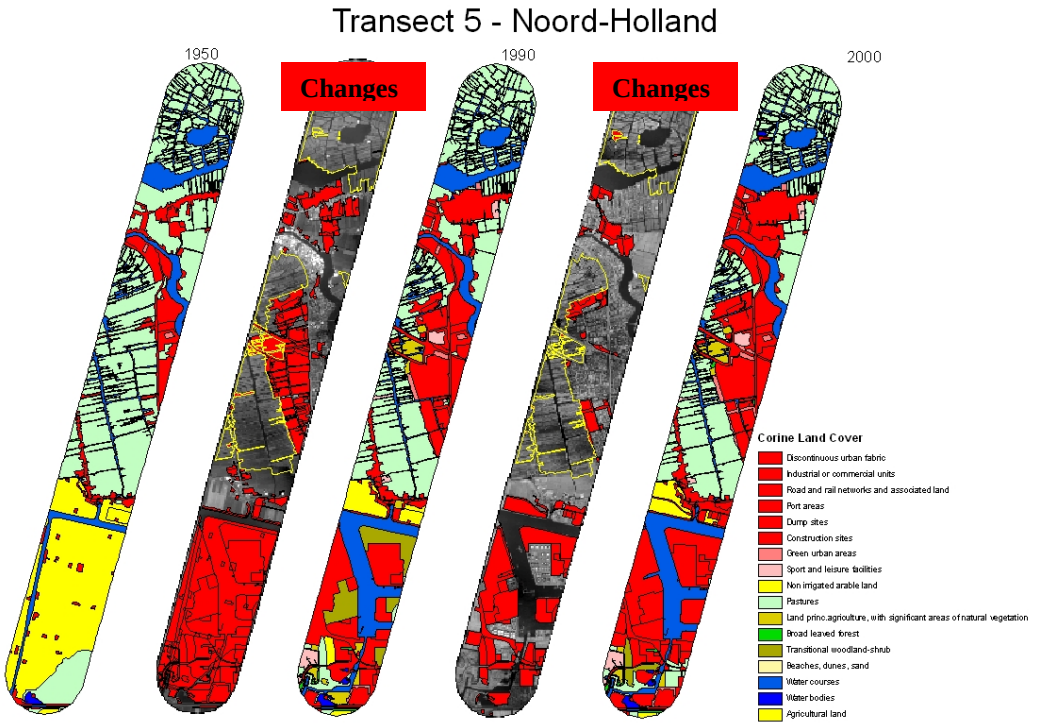


Figure 16. Land cover changes in transect 5, North of Amsterdam, for the time periods 1950, 1990 and 2000. In between are the land cover changes (in red) for the periods 1950-1990 and 1990-2000. The yellow lines represent the Natura2000 sites. It is obvious that the majority of land cover changes took place outside the Natura2000 sites, but occupied most of the agricultural land in between for urbanisation

Transect 6 "Drentse Aa"

More than 35% of the transect's area is covered by the Natura2000 sites "Fochteloërveen en Esmeer" and "Drentse Aa". The transect is located in an agricultural area (45%), with considerable parts of urban, forest and semi-natural areas (see Figure 7). Arable land with 27.1% is the most important land cover class, next to discontinuous urban fabric with 13.9%, within the transect. Transect 6 is one of the transects with the highest amount of land cover changes for the period 1950 – 2000 (>60%). However, 27.6% changes are changes between the ambiguous class farmed land (621) and pastures (231), arable land (211) or land principally occupied by agriculture, with significant parts of natural vegetation (243) (see also transect 4). Most important change is the conversion of agricultural land into artificial areas (>8 km^2 or >24%) (Figure 17). Other important changes are the conversion of moors and heath land (322), peatbogs (411) and agricultural land into forest (respectively 0.6 km^2, 0.9 km^2 and 1.6 km^2).

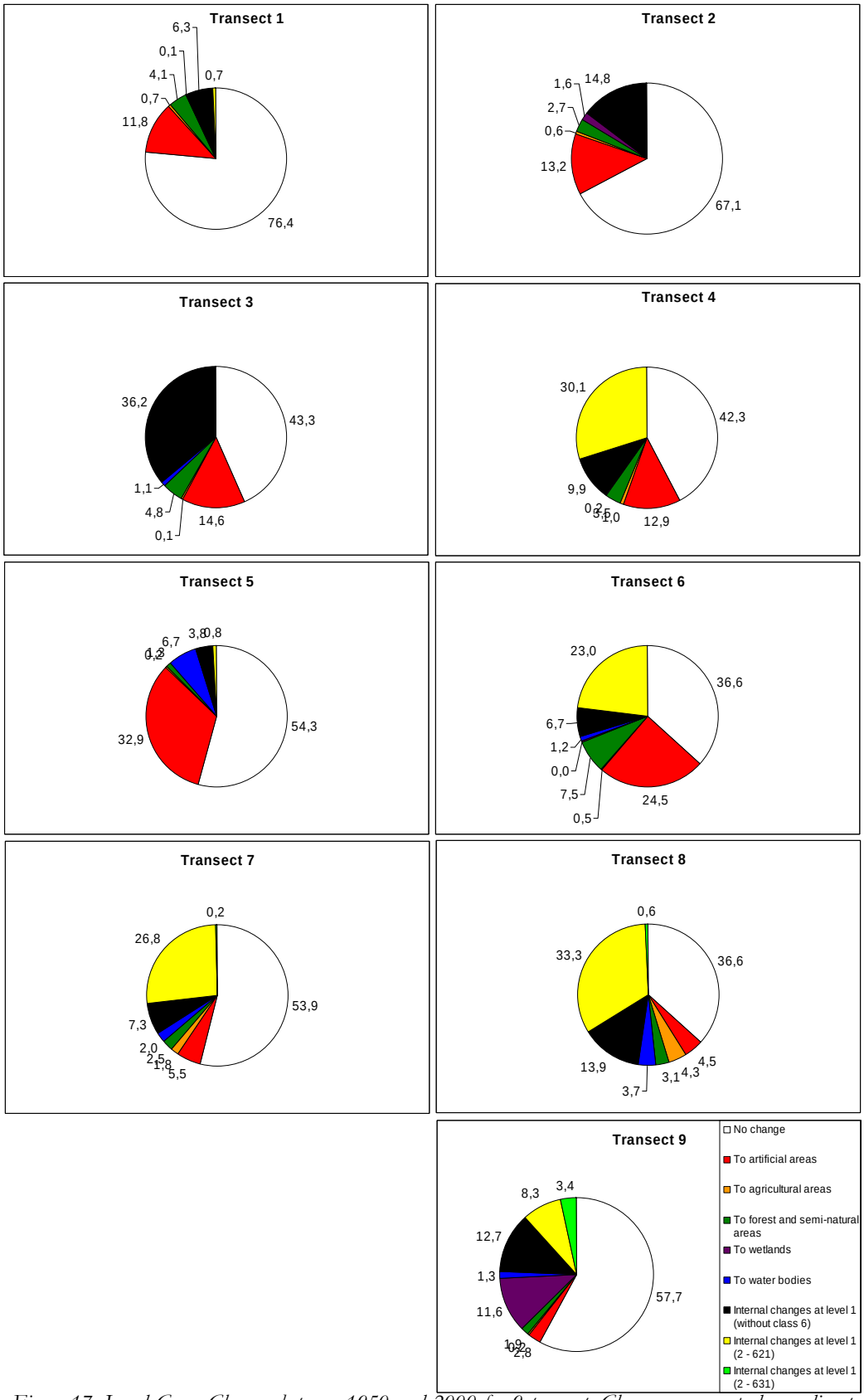


Figure 17. Land Cover Changes between 1950 and 2000 for 9 transect. Changes are grouped according to the 2000 land cover (CORINE level 1)

Transect 7 "Dwingelerveld"

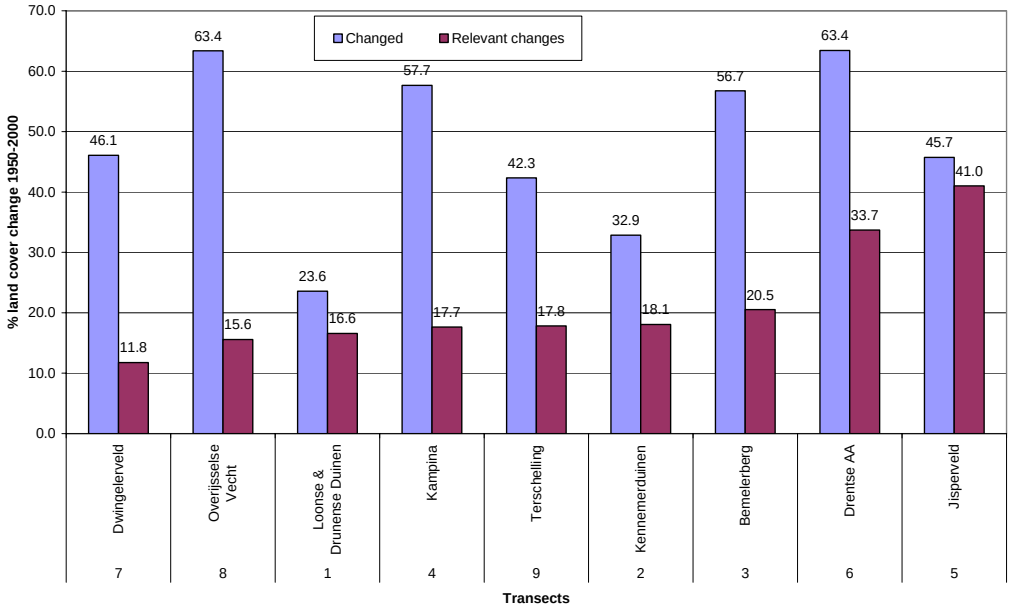
Almost 60% of the transect is located with the Natura2000 site "Dwingelerveld" and "Drents-Friese Wold". Large parts of transect 7 are covered by forests and semi-natural land cover types (>50%). Farmed land (621) and moors and heath land (322) are the major land cover classes (see Appendix 9). The land cover changed with 46.1% in the period 1950 – 2000. However, the largest part of changes are not "real" changes as it are changes between the ambiguous class farmed land (621) and the other agricultural classes (8.8 km^2). Most important changes are the conversion of agricultural land into artificial areas (1.2 km^2) and moors and heathland into forest (0.5 km^2).

Transect 8 "Overijsselse Vecht"

Almost half of transect 8 is located in the Natura2000 sites "Engbertsdijksvenen" and "Vecht & Beneden-Regge". Transect 8 is for almost half part covered by agricultural areas and for 1/3 by forest and semi-natural areas. The largest land cover classes are coniferous forest (23.3%) and arable land 22.1%). More than 60% of the transect area changed in land cover type. It's one of the transects with the highest change percentage. However, a large amount of changes are internal changes, i.e. mainly changes between farmed land (621 – ambiguous class) and other agricultural classes (11 km^2) (Figure 17). Other important changes are the conversion of moors and heatland into artificial areas (0.25 km^2) and forest (2.7 km^2). Also the change of agricultural areas (mainly farmed land - 621) into artificial areas is of importance (1.0 km^2). The conversion of peatbogs into farmed land (0.7 km^2) and water bodies (0.8 km^2) need also to be mentioned as important changes related to biodiversity.

Transect 9 "Terschelling"

The Natura2000 sites "Waddenzee" and "Duinen Terschelling" are covering 87% of transect 9. Transect 9 is the less urbanised transect. Only 4% is covered by artificial areas (discontinuous urban fabric and recreational areas) and almost 12% by agricultural land. By far, the most important land covers are sparsely vegetated dunes (333) and salt marshes (see Appendix 9). More than 40% of transect's area its land cover changed in the last 50 years. This number is overestimated, because 8.3 and 3.4% changes are internal changes between ambiguous classes farmed land (621) and forest land (631) and the other agricultural and forest classes. Dynamic (semi-)natural processes are the actor to most of the other land cover changes (see Hazeu et al., 2002). Most prominent is the conversion of beaches and dunes into salt marshes (3.8 km^2).



	1990 – 2000		1950 - 1990		1950 - 2000	
	km2	%	km2	%	km2	%
transect 1	1.4	4.2	7.0	21.1	7.8	23.6
transect 2	2.0	6.0	9.9	29.7	11.0	32.9
transect 3	6.2	19.9	17.5	55.9	17.8	56.7
transect 4	4.6	13.9	18.6	56.3	19.0	57.7
transect 5	6.2	18.9	14.1	42.7	15.1	45.7
transect 6	5.9	17.9	20.6	62.4	21.0	63.4
transect 7	1.7	5.2	14.7	44.3	15.3	46.1
transect 8	5.9	17.7	21.2	63.9	21.0	63.4
transect 9	1.9	5.8	13.7	41.4	14.0	42.3

Figure 18. Total land cover changes for all transects between 1990-2000, 1950-1990 and 1950-2000 (km2 and %). Upper part of figure shows percentages of total change per transect grouped as all changes and relevant changes for the period 1950 - 2000

4.3.1 Rate in land cover changes

The land cover change dynamics are lower in the period 1990-2000 than the rate in changes in the period 1950-1990 (Figure 18). But if one takes into consideration that the first time period (1950-1990) is four times longer than the second time period (1990-2000), the rate in changes do differ much less. For example for transect 6 "Drentse Aa", four times the percentage change in the period 1990-2000 (4*17.9) is 71.6% which is even larger than the 62.4% over the period 1950-1990. In other words, the land cover changes in the last ten years (1990-2000) are much severer than one first would thought.

Another remark concerns the total number of changes for the period 1950 –2000, which is not equal to the summation of changes for the periods 1950-1990 and 1990-

2000. Some changes disappear again for the entire period (1950-2000), due to the fact that the original land cover type turns back after a period of change, e.g. pasture – arable land – pasture (1950-1990-2000). So, the area changed twice, once from its original (1950) to a new land cover type in 1990 and afterwards back into its original land cover type in the period 1990-2000.

4.3.2 Changes inside versus outside Natura2000 sites

It is interesting to analyse to which degree the land cover changes took place inside versus outside the Natura2000 sites, and comparing it for the type of changes. A first analysis is made for the 1950-2000 period indicates that 74% of all land cover changes took place outside the Natura2000 sites. However, within the Natura2000 sites there is still a 26% land cover change in the last fifty years, which is probably more than one would first expect. Of course, it was expected that a higher amount of land cover changes would take place outside the Natura2000 sides, which is being confirmed by the analysis.

If we analyse the types of changes occurring inside and outside the Natura2000 sites, the trends are significantly different, see Figure 19. If we take the degree of urbanisation we see that of the total amount of land cover changes 27.5% concerns changes to artificial areas outside Natura2000 sites, while only 1% concerns changes to artificial areas inside Natura2000 sites. One could conclude already that the Natura2000 sites have been reasonably well protected within the last fifty years for the Netherlands.

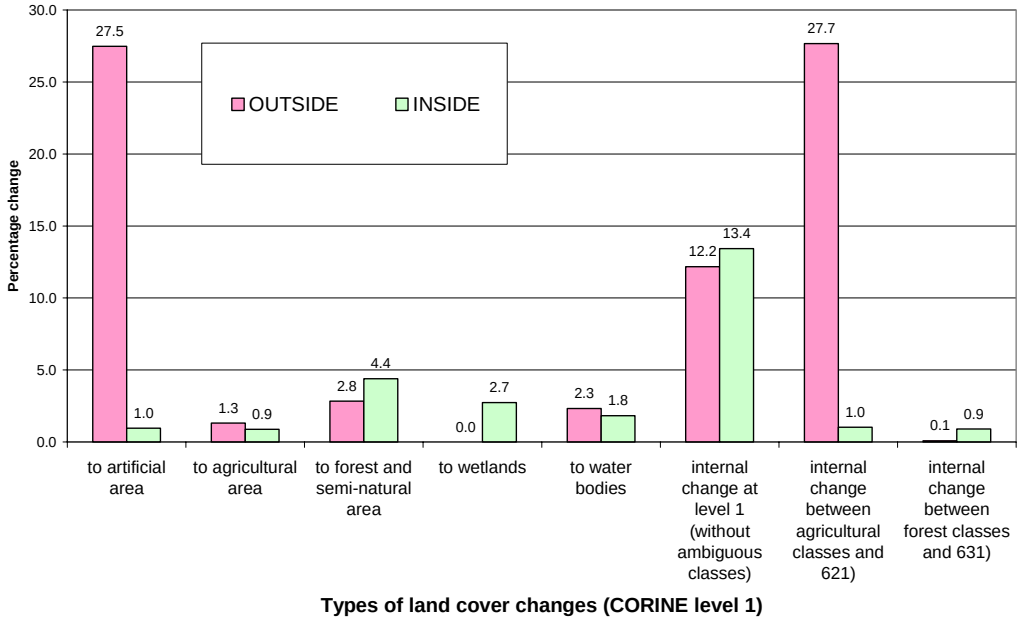


Figure 19. Types of changes occurring inside and outside Natura2000 sites. The changes are expressed in percentages change and are in total 100% (summation of inside and outside changes). A 74% of all land cover changes occurred outside the Natura2000 sites

In Appendix 10 presents all land cover changes divided into inside and outside Natura2000 sites for the 9 Dutch transects. The range for the 9 transects is from 59% (transect 8) to 95% (transect 5). Changes inside the Natura2000 sites concern mainly changes of land into forest and semi-natural areas, wetlands, water bodies and internal changes. Land cover changes are grouped to Corine level 1. Changes outside the Natura2000 sites concern changes of land cover into artificial areas and internal changes. Transect 1, 2, 5 are mainly characterised by land cover changes into artificial areas. The other transects have a combination of internal changes and changes into artificial areas. If we take afforestation and related changes we see that a higher percentage of change (4.4%) is taking place inside the Natura2000 sites than outside (2.8%). Moreover, all land cover changes to wetlands are occurring inside Natura2000 sites.

4.4 Comparison of windows and transects

4.4.1 Land cover types

The interpretation of land cover for the windows and transects does not reveal large differences in number of classes and types of land cover. Only, that ambiguous classes (see paragraph 3.3.1) do not exist for the window backdating. Without counting the ambiguous classes there is only a slight tendency to have (1 to 3) more land cover classes in the transect interpretations. One exception is transect nine ("Terschelling"), which has 20 land cover classes compared to 10 land cover classes in the related Window Y. This is mainly due to the fact that there is more differentiation in artificial, forest and semi-natural land cover classes. In general, the same land cover types are detected in the transect and window interpretations as can be seen comparing Appendix 6 and 9.

4.4.2 Land cover changes

The total number of land cover changes (%) between 1950 and 1990 is much higher for the transects than for the window (see Table 8 and Appendix 6c and 9c). The difference is for a large part caused by a higher number of internal changes (i.e. changes within one class at CORINE level 1). The internal changes detected in the transects outnumber the ones for the windows, mainly due to the introduction of the ambiguous classes in the transect interpretation. For the other classes (1 – 5), the number of changes detected in the transects are only slightly higher. The number of changes into artificial areas and into forest and semi-natural areas are 1-4% higher for the transects. The selection of transects (from urban centres into Natura2000 sites) and higher level of detail in case of the transect interpretation are explanations for this difference. Exceptions are transects 6 and 5 which are significant higher than detected in the corresponding windows. The orientation of transects to urban centres (Assen and port area Amsterdam) is the explanation. The opposite is the case for transect 2. This transect is mainly situated in the dune area which is protected for a long time, causing an under estimation of changes into artificial areas. Another

difference between the detected changes in window Y and transect 9 is the underestimation of land cover changes into wetlands. Lack of expert knowledge may be an explanation.

Table 8. Land cover changes (%) for both windows and corresponding transects (1950-1990). The changes are grouped to Corine level 1

	Window	Transect		Window	Transect		Window	Transect		Window	Transect	Window	Transect
	7	1	4	139	2	5	14	6	7	120	8	Y	9
1	6,3	10,8	11,4	14,9	12,2	25,5	2,5	19,7	5	2,8	3,5	0,1	2,5
2	0,3	0,7	1,1	0,0	0,6	0,2	2,9	0,8	1,3	1,8	4,3	0,0	0,3
3	0,7	3,6	2,2	0,4	2,9	4,6	0,2	4,6	1,7	0,5	3	0,7	1,4
4	0,0	0,1	0	0,1	0	0	0,1	0	0	0,0	0	0,0	11,8
5	0,4	0	0,4	0,7	1,2	6,7	0,1	1	1,7	0,0	3,6	0,9	1
6	13,4	6	41,2	2,1	12,8	5,8	7,0	36,2	34,6	6,9	49,5	0,9	24,4
Total	21,1	21,1	56,3	18,2	29,7	42,8	12,8	62,4	44,3	12,1	63,9	2,6	41,4

1 = land cover changes from all classes to artifical classes in 1990
2 = land cover changes from all classes to agricultural classes in 1990
3 = land cover changes from all classes to forest and semi-natural classes in 1990
4 = land cover changes from all classes to wetland classes in 1990
5 = land cover changes from all classes to water body classes in 1990
6 = internal land cover changes, i.e. from an agricultural into another agricultural classes in 1990

5 Discussion and conclusion

BIOPRESS is an EC-FP5 research project that supports the GMES 'Global Monitoring for Environment and Security' Programme. It aims to provide the EU-user community with quantitative information on the land cover dynamics in the surroundings of Natura2000 sites for the last fifty years and how these changes affect the environment and biodiversity in Europe. This report describes the work and the results for the Netherlands of the first phase of the BIOPRESS project. The results for the second phase and for the rest of Europe will be published in other publications within the BIOPRESS team.

The first phase of BIOPRESS concentrated on the methodological and operational aspects of selection, acquisition, processing and interpretation of recent and historical aerial photographs to obtain information about historic land cover dynamics in the surrounding of Natura2000 sites. For the Netherlands, land cover change statistics were derived for 5 windows (30km by 30km) for 1950 and 1990 (scale 1:100.000) and 9 transects (2km by 15km) for 1950, 1990 and 2000 (scale 1:20.000).

The selection of the windows in the Netherlands was based on the following criteria: 1) the location of clusters of Natura2000 sites (to get as much possible information about the land cover dynamics in and around Natura2000 sites), 2) the Dutch landscape types and 3) to cover as much habitat types as possible. All these criteria were met except for the fact that finally no windows were analysed in the hilly uplands and sea clay region. Transects, as a sub-sampling, were selected in each of the 5 windows, along a pressure gradient. The two windows in Zeeland and Limburg were not implemented but for the last one a transect was selected (see Table 1 and Figures 4 and 5). Subsequently, for the selected windows and transects aerial photographs were acquired for the reference years 1950, 1990 and 2000, and thereafter processed and interpreted in terms of land cover classes according to the CORINE land cover nomenclature. The photo-processing and interpretation of all 70 windows in Europe was done by GISAT on a scale 1:100.0000 and by Alterra for the nine Dutch transects on a scale 1:20.000.

A first major conclusion from the analysis of historic aerial photographs is that the Netherlands endured severe land cover changes over the last fifty years but with a high spatial variation. For the five Dutch windows land cover changes in the period 1950 – 1950 range from almost 3% up to more than 20% of their total area. Most land cover dynamics occurred within the agricultural domain which implies e.g. changes from pastures to arable land and vice versa. From level one of the CORINE land cover nomenclature these are considered as "internal changes within the same major class". These changes can be reversed relatively easily.

A much more significant change is the land cover change from agricultural land into artificial areas. The artificial areas increased their area with 50 to 165% for the various windows over the time period 1950-1990. The fast rate of urbanisation had

major impacts on the landscape and its biodiversity, not only through the loss of precious habitats but also due to increased fragmentation of remaining habitats and a increasing rate of recreation in remaining semi-natural areas. Moreover, the process of urbanisation is irreversible. The process of urbanisation is one of the most important processes that changed the Dutch landscape. A strong correlation exists between sampling windows having a high degree of artificial areas and the area occupied by new urban areas. In addition, it can be concluded from Figure 14 and Appendix 6 that highly urbanised areas show a higher degree of land cover change dynamics. The windows located in Noord-Holland and in Noord-Brabant, with large cities, show the highest degree of land cover change while on the island Terschelling the land cover changes of the last fifty years were relatively small with 3%.

Natural habitats such as moors and heathland lost significant part of their acreage with respectively 11%, 39% and 46% for the windows Noord-Brabant, Overijssel and Drenthe. These land cover changes are also supported by other information sources such as HGN and CBS.

Land cover analysis at a more detailed level of transects (scale 1:20.000) presents a slightly different picture, namely, the land cover dynamics are higher at the transect level than at the window level. Land cover changes as a percentage of the total transect area ranged from 24% to 63% for the period 1950-2000. Moreover, there exists large differences in types of changes between the transects. Some transects such as Bemelerberg, Kampina, Drentse Aa, Dwingelerveld and Overijsselse Vecht, are characterised by high proportions of internal changes, meaning changes within the same class at level one of the CORINE nomenclature. This also concerned mainly changes within the agricultural domain. Focusing on more relevant changes, meaning no internal changes, the range of land cover changes is between 12 and 41% for the transects. Here also, the most important change is the conversion of agricultural land into artificial areas. Transect 9 "Terschelling" is the only exception with the land cover change from beaches and dunes into salt marshes as the most important change.

Differences in number and type of changes detected between the transect and window interpretations are explained by the following factors:

- more expert knowledge used in the transect interpretation
- level of detail of interpretation
- introduction of ambiguous classes in the transect interpretation (e.g. land cover changes between arable land and farmed land are registered as land cover change)
- the location and orientation of transects (oriented from a Natura2000 site to an urban centre, i.e. along a land cover change gradients).

In general, it be concluded that for the windows as well as for the transects that artificial areas and water bodies increased their area very strongly, while agricultural areas, and wetlands lost in area.

If we analyse land cover dynamics inside versus outside Natura2000 sites we see that most land cover changes took place outside the Natura2000 sites. A 74% of all land cover changes took place in the areas outside the Natura2000 sites which means a 26% of land cover changed inside the Natura2000 sites. Major changes inside the Natura2000 sites were internal changes, changes into forest and semi-natural areas and into wetlands. Outside the Natura2000 sites the main types of changes were changes between agricultural classes and farmed land (ambiguous class 621), changes into artificial areas and internal changes.

If we analyse the rate in land cover change in the periods 1950-1990-2000 the land cover change dynamics are lower in the period 1990-2000 than the changes in the period 1950-1990. But if one takes into consideration that the first time period (1950-1990) is four times longer than the second time period (1990-2000), the rate in changes do differ much less. For example for transect 6 "Drentse Aa", four times the percentage change in the period 1990-2000 (4*17.9) is 71.6% which is even larger than the 62.4% over the period 1950-1990. In other words, the land cover changes in the last ten years (1990-2000) are much severer than one first would think.

In Appendix 8 we have made a qualitative start to relate land cover changes with pressures on biodiversity. We tried to fit the land cover changes of the Dutch transects in the **DPSIR** framework (EEA, 1999). The framework provides a standard methodology to describe environmental pressures and their ecological impacts. **D**riving forces of environmental change (e.g. industrial production), **P**ressures on the environment (e.g. discharges of waste water), **S**tate of the environment (e.g. water quality in rivers and lakes), **I**mpacts on population, economy, ecosystems (e.g. water unsuitable for drinking) and **R**esponse of the society (e.g. watershed protection) are described. Urbanisation, farming intensification, land abandonment and afforestation were the guiding pressures in our descriptions of the transects. Atmospheric deposition, water pollution, ground water manipulation, recreation and agricultural practices (e.g. use of pesticides and fertilizers) appeared to be other important pressures on biodiversity. In the second phase of the BIOPRESS project the relation between land cover changes and pressures on biodiversity will be analysed in more detail.

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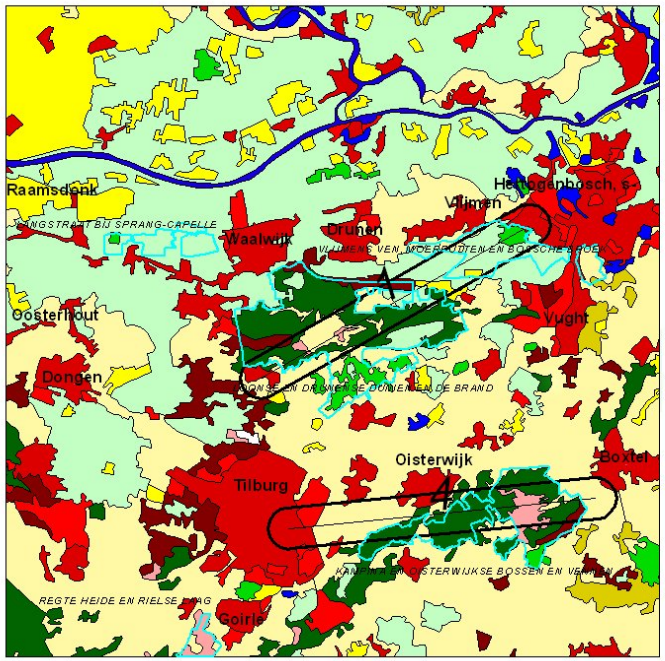
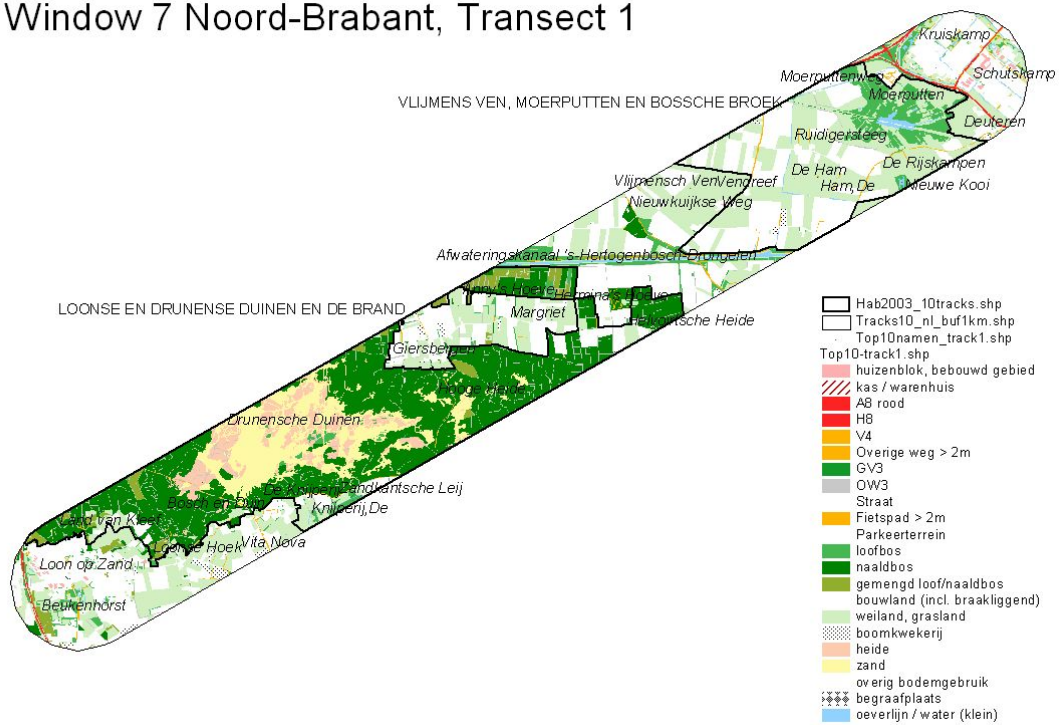
Appendix 1 Location and description of the transects and windows

Window 7 "Noord-Brabant" and Transects 1 "Loonse & Drunense Duinen" and Transect 4 "Kampina".

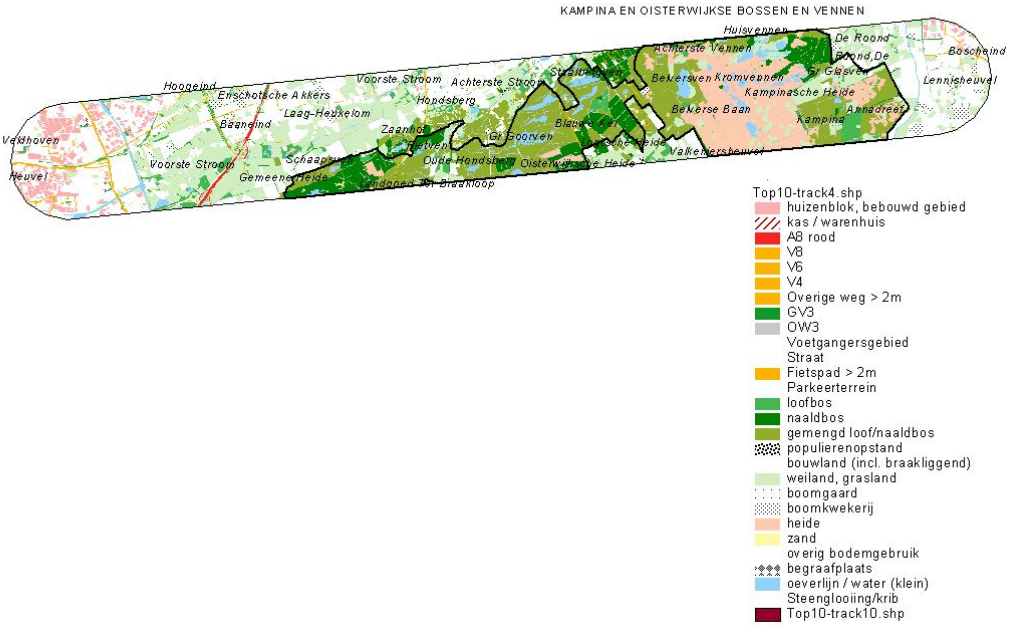
Window 7 "Noord-Brabant" with transect 1 "Loonse & Drunense Duinen" and transect 4 "Kampina"	
Natura2000 sites within window	Loonse en Drunense duinen en de Brand, Vlijmens ven, Moerputten en Bossche Broek, Langstraat, Kampina and Oisterwijkse bossen en vennen
Natura2000 sites within transect	Loonse en Drunense duinen en de Brand, Vlijmens ven, Moerputten en Bossche Broek (transect 1); Kampina and Oisterwijkse bossen en vennen (transect 4)
Habitattypes within transect	<u>Transect 1 "Loonse & Drunense Duinen"</u> 91E0 * Alluvial forests with Alnus glutinosa and Fraxinus excelsior (Alno-Padion, Alnion incanae, Salicion albae) 2310 (64.1_x_31.223) - Dry sandy heaths with Calluna and Genista 2330 (64.1_x_35.2) - Open grassland with Corynephorus and Agrostis of continental dunes 3140 (22.12_x_22.44) - Hard oligo-mesotrophic waters with benthic vegetation of chara formations 6410 (37.31) - Molinia meadows on chalk and clay (Eu-Molinion) 6510 (38.2) - Lowland hay meadows (Alopecurus pratensis, Sanguisorba officinalis) <u>Transect 4 "Kampina"</u> 4010 (31.11) - Northern Atlantic wet heaths with Erica tetralix 4030 (31.2) - Dry heaths (all subtypes) 3110 (22.11_x_22.31) - Oligotrophic waters containing very few minerals of Atlantic sandy plains with amphibious vegetation 3130 (22.12_x_(22.31_&_22.32)) - Oligotrophic waters in medio-European and perialpine area with amphibious vegetation 3160 (22.14) - Dystrophic lakes 7210 * Calcareous fens with Cladium mariscus and species of the Caricion davallianae
Major land cover types at level 1 and level 3 for the window in 1950 and 1990.	1950: level 1: Agricultural areas (76.4%) level 3: Complex cultivation patterns (242) (43.9%) 1990: level 1: Agricultural areas (70%) level 3: Complex cultivation patterns (242) (32.3%)
Major land cover types at level 1 and level 3 for transects in 1950 and 2000.	<u>Transect 1 "Loonse & Drunense Duinen"</u> 1950: level1: Agricultural areas (56.6%) level 3: Farmed land (621) (56.5%) 2000: level 1: Agricultural areas (44.8%) level 3: Farmed land (621) (44.1%)

	Transect 4 "Kampina" 1950: level 1: Agricultural areas (44.2%) level 3: Farmed land (621)(42.0%) 2000: level 1: Forest and semi-natural areas (39.3%) level 3: Mixed forest (313) (17.8%)
Major land cover changes within window	Total percentage changed is 21.1% Internal changes level 1: Agricultural changes (18.8%) level 3: Complex cultivation pattern (242) – Pastures (231) (8.9%) External changes level 1: Agricultural areas – Artificial areas (5.7%) level 3: Complex cultivation pattern (242) – Discontinuous urban fabric (112)(2.4%)
Major land cover changes within transect	Transect 1 "Loonse & Drunense Duinen": Total percentage changed is 23.6% External changes: level 1: Agricultural areas – Artificial areas (10.8%) level 3: Farmed land (621) – discontinuous urban fabric (112) (6.8%) Transect 4 "Kampina": Total percentage changed is 57.7% Internal changes level 1: Agricultural changes (31.3%) level 3: Farmed land (621) – Pastures (231) (15.4%) External changes Level 1: Agricultural areas - Artificial areas (11.5%) Level 3: Farmed land (621) – Discontinuous urban fabric (112)(5.1%)


Raamsdonk
Waalwijk
Drunen
Vlijmen
Oosterhout
Vught
Dongen
Oisterwijk
Boxtel
Tilburg
Goirle
Habitat_10windows.shp
Buffer 1 of Tracks10_nl.shp
Tracks10_nl.shp
Corine86_10windows_nl.shp
Continuous urban fabric
Discontinuous urban fabric
Industrial or commercial units
Road and rail networks and associated land
Port areas
Airports
Mineral extraction sites
Construction sites
Green urban areas
Sport and leisure facilities
Non irrigated arable land
Fruit trees and berry plantations
Pastures
Complex cultivation patterns
Land princ.agriculture, with significant areas of natural veg
Broad leaved forest
Coniferous forest
Mixed forest
Natural grasslands
Moors and heathland
beaches, dunes, sand
Inland Marches
Salt Marches
Intertidal flats
Water courses
Water bodies
Alterra_sites.shp


Window 7 Noord-Brabant, Transect 1
VLIJMENS VEN, MOERPUTTEN EN BOSSCHE BROEK
LOONSE EN DRUNENSE DUINEN EN DE BRAND
Kruiskamp
Schutskamp
Moerputten
Deuteren
Ruidigerstreep
De Ham
Ham,De
De Rijskampen
Nieuwe Kooi
Vlijmensch VenVendreef
Nieuwkuijkse Weg
Afwateringskanaal 's-Hertogenbosch-Drongelen
Margriet
Drunensche Duinen
Kniveni,De
Vita Nova
Loon op Zand
Beukenhorst
Hab2003_10tracks.shp
Tracks10_nl_buf1km.shp
Top10namen_track1.shp
Top10-track1.shp
huizenblok, bebouwd gebied
kas / warenhuis
A8 rood
H8
V4
Overige weg > 2m
GV3
OW3
Straat
Fietspad > 2m
Parkeerterrein
loofbos
naaldbos
gemengd loof/naaldbos
bouwland (incl. braakliggend)
weiland, grasland
boomkwekerij
heide
zand
overig bodemgebruik
begraafplaats
oeverlijn / water (klein)

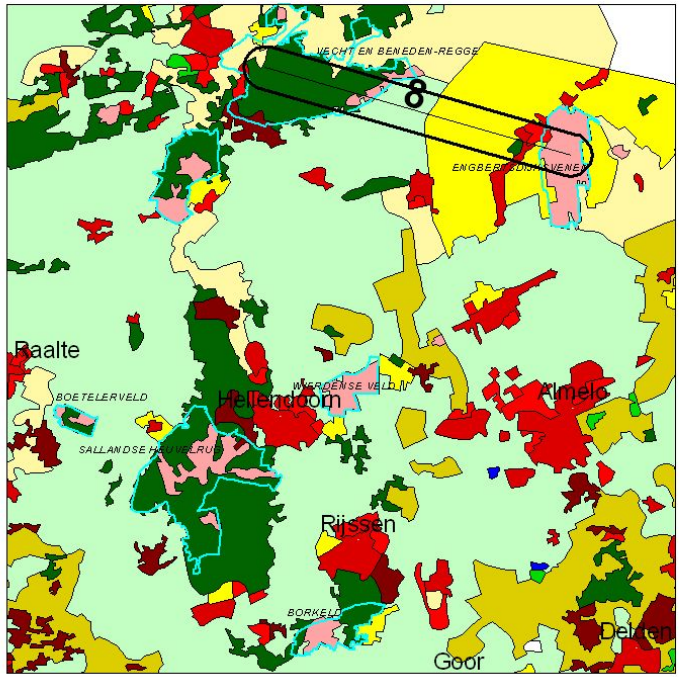
Window 7 Noord-Brabant, Transect 4



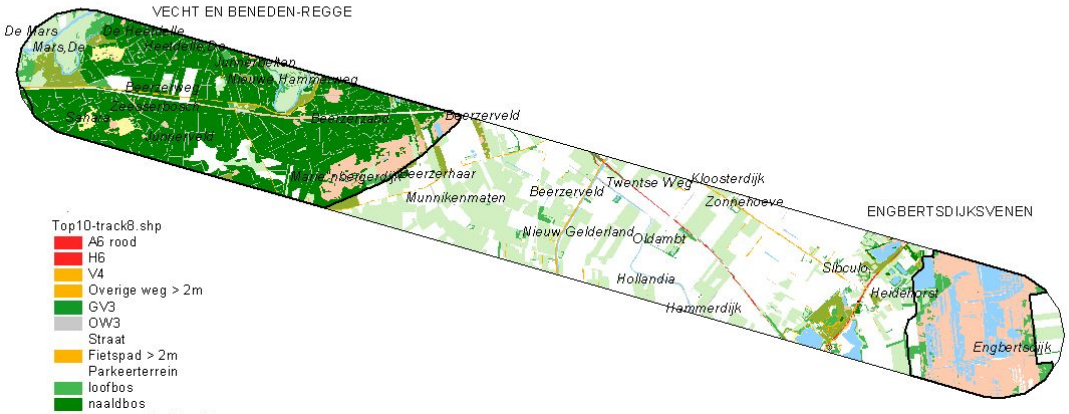
Window 120 "Overijssel" and Transect 8 "Overijsselse Vecht".

Window 120 "Overijssel" with transect 8 "Overijsselse Vecht"	
Natura2000 sites within window	Vecht en Beneden-Regge, Engbertsdijksvenen, Wierdense veld, Boeterlerveld, Borkeld and Sallandse Heuvelrug
Natura2000 sites within transect	Vecht en Beneden-Regge, Engbertsdijksvenen
Habitattypes within transect	6230 (35.1) - Species-rich Nardus grasslands, on siliceous substrates in mountain areas (and submountain areas, in continental Europe) 91E0 * Alluvial forests with Alnus glutinosa and Fraxinus excelsior (Alno-Padion, Alnion incanae, Salicion albae) 4010 (31.11) - Northern Atlantic wet heaths with Erica tetralix 6430 (37.7_&_37.8) - Eutrophic tall herbs 2320 (64.1_x_31.227) - Dry sandy heaths with Calluna and Empetrum nigrum 4030 (31.2) - Dry heaths (all subtypes) 5130 (31.88) - Juniperus communis formations on calcareous heaths or grasslands 7120 (51.2) - Degraded raised bogs (still capable of natural regeneration) 7150 (54.6) - Depressions on peat substrates (Rhynchosporion)
Major land cover types at level 1 and level 3 for the window in 1950 and 1990.	1950: level 1: Agricultural areas (77.1%) level 3: Pastures (231) (52.9%) 1990: level 1: Agricultural areas (75.8%) level 3: Pastures (231) (51.5%)
Major land cover types at level 1 and level 3 for transects in 1950 and 2000.	1950: level1: Agricultural areas (48.1%) level 3: Farmed land (621) (43.1%) 2000: level 1: Agricultural areas (47.6%) level 3: Coniferous forest (312) (23.3%)
Major land cover changes within window	Total percentage changed is 12.1% Internal changes level 1: Agricultural changes (6.5%) level 3: Pastures (231) – Complex cultivation patterns (242) (3.3%) External changes level 1: Agricultural areas – Artificial areas (2.7%) level 3: Pastures (231) – Discontinuous urban fabric (112)(0.9%)
Major land cover changes within transect	Total percentage changed is 63.4% Internal changes level 1: Agricultural changes (34.2%) level 3: Farmed land (621) – Arable land (211) (20.5%)

	External changes level 1: : Agricultural areas – Artificial areas (2.9%) level 3: Peat bogs (412) - Water bodies (512)(2.6%)



Window 120 Overijssel, Transect 8



Top10-track8.shp
- A6 rood
- H6
- V4
- Overige weg > 2m
- GV3
- OW3
- Straat
- Fietspad > 2m
- Parkeerterrein
- loofbos
- naaldbos
- gemengd loof/naaldbos
- populierenopstand
- bouwland (incl. braakliggend)
- weiland, grasland
- boomgaard
- boomkwekerij
- heide
- zand
- overig bodemgebruik
- begraafplaats
- oeverlijn / water (klein)
- Top10-track10.shp

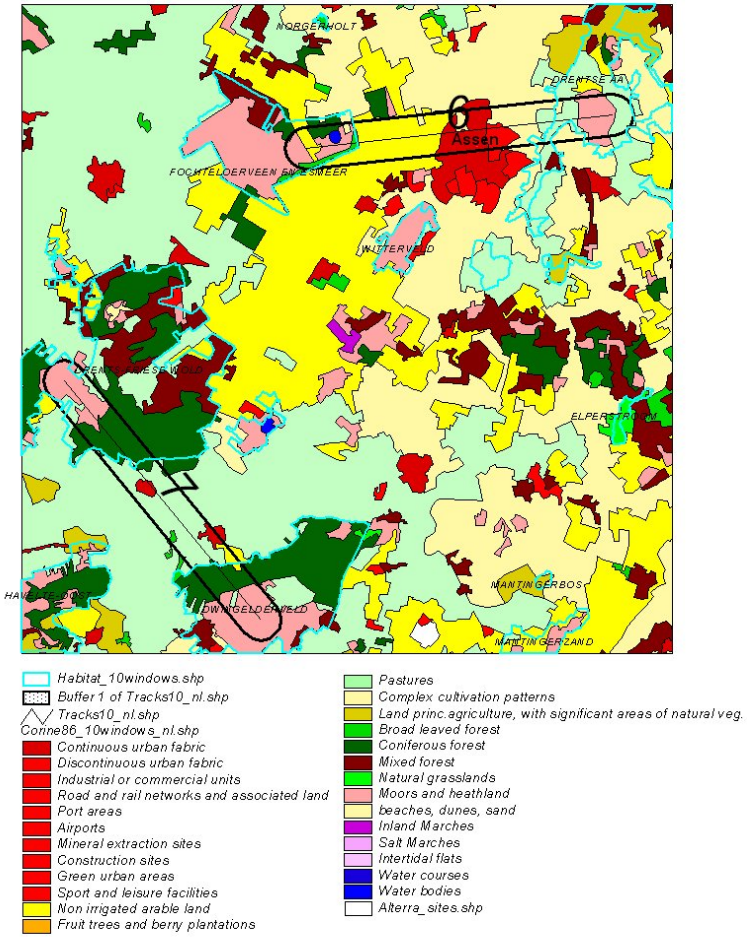
IIIstad_93
- Tracks10_nl_buf1km.shp
- Tracks10_nl.shp
- Habitat_10windows.shp
- Alterra_sites.shp

Corine86_10windows_nl.shp
- Continuous urban fabric
- Discontinuous urban fabric
- Industrial or commercial units
- Road and rail networks and associated land
- Port areas
- Airports
- Mineral extraction sites
- Construction sites
- Green urban areas
- Sport and leisure facilities
- Non irrigated arable land
- Fruit trees and berry plantations
- Pastures
- Complex cultivation patterns
- Land princ.agriculture, with significant areas of natural veg.
- Broad leaved forest
- Coniferous forest
- Mixed forest
- Natural grasslands
- Moors and heathland
- beaches, dunes, sand
- Inland Marches
- Salt Marches
- Intertidal flats
- Water courses
- Water bodies

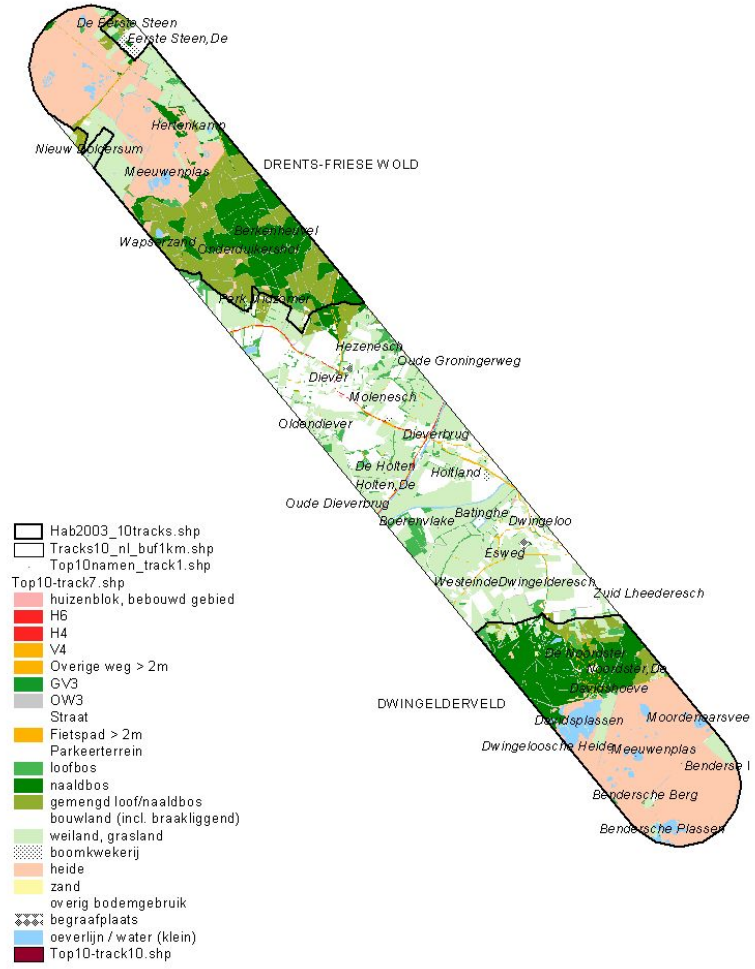
Window 14A "Drenthe" and Transect 6 "Drentse Aa" and Transect 7 "Dwingelerveld".

Window 14 "Drenthe" with transect 6 "Drentse Aa" and transect 7 "Dwingelerveld"	
Natura2000 sites within window	Norgerholt, Drentse Aa, Fochteloerveen en Esmeer, Witterveld, Elperstroom, Drents-Friese Wold, Mantingerbos, Mantingerzand and Dwingelerveld
Natura2000 sites within transect	Drentse Aa, Fochteloerveen en Esmeer (transect 6); Drents-Friese Wold, Dwingelerveld (transect 7)
Habitattypes within transect	Transect 6 "Drentse Aa" 6230 (35.1) - Species-rich Nardus grasslands, on siliceous substrates in mountain areas (and submountain areas, in continental Europe) 91E0 * Alluvial forests with Alnus glutinosa and Fraxinus excelsior (Alno-Padion, Alnion incanae, Salicion albae) 7230 Alkaline fens 9160 (41.24) - Sub-Atlantic (Stellario-Carpinetum) oak-hornbeam forests 4010 (31.11) - Northern Atlantic wet heaths with Erica tetralix 4030 (31.2) - Dry heaths (all subtypes) 7120 (51.2) - Degraded raised bogs (still capable of natural regeneration) 2310 (64.1_x_31.223) - Dry sandy heaths with Calluna and Genista 2330 (64.1_x_35.2) - Open grassland with Corynephorus and Agrostis of continental dunes 3130 (22.12_x_(22.31_&_22.32)) - Oligotrophic waters in medio-European and perialpine area with amphibious vegetation 6410 (37.31) - Molinia meadows on chalk and clay (Eu-Molinion) 9190 (41.51) - Old acidophilous oak woods with Quercus robur on sandy plains Transect 7 "Dwingelerveld" 6230 (35.1) - Species-rich Nardus grasslands, on siliceous substrates in mountain areas (and submountain areas, in continental Europe) 4010 (31.11) - Northern Atlantic wet heaths with Erica tetralix 2320 (64.1_x_31.227) - Dry sandy heaths with Calluna and Empetrum nigrum 4030 (31.2) - Dry heaths (all subtypes) 5130 (31.88) - Juniperus communis formations on calcareous heaths or grasslands 7150 (54.6) - Depressions on peat substrates (Rhynchosporion) 2310 (64.1_x_31.223) - Dry sandy heaths with Calluna and Genista 2330 (64.1_x_35.2) - Open grassland with Corynephorus and Agrostis of continental dunes 3110 (22.11_x_22.31) - Oligotrophic waters containing very few minerals of Atlantic sandy plains with amphibious vegetation 3130 (22.12_x_(22.31_&_22.32)) - Oligotrophic waters in medio-European and perialpine area with amphibious vegetation 3160 (22.14) - Dystrophic lakes 9190 (41.51) - Old acidophilous oak woods with Quercus robur on sandy plains
Major land cover types at level 1 and level 3 for the window in 1950 and 1990.	1950: level 1: Agricultural areas (73.4%) level 3: Pastures (231) (31.8%) 1990: level 1: Agricultural areas (74%)

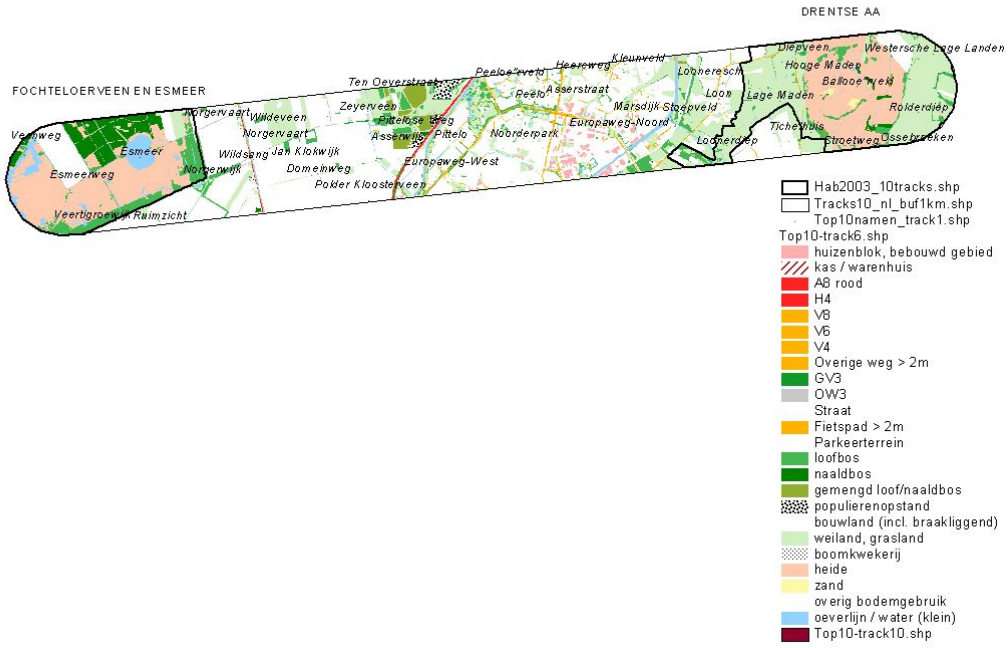
	level 3: Pastures (231) (28.8%)
Major land cover types at level 1 and level 3 for transects in 1950 and 2000.	Transect 6 "Drentse Aa" 1950: level 1: Agricultural areas (74.2%) level 3: Farmed land (621) (44.8%) 2000: level 1: Agricultural areas (45.0%) level 3: Arable land (211) (27.1%) Transect 7 "Dwingelerveld" 1950: level 1: Forest and semi-natural areas (55%) level 3: Moors and heathland (322) (26.5%) 2000: level 1: Forest and semi-natural areas (52.1%) level 3: Farmed land (621) (26.6%)
Major land cover changes within window	Total percentage changed is 12.8% Internal changes level 1: Agricultural changes (6.8%) level 3: Pastures (231) - Complex cultivation patterns (242) (3.5%) External changes level 1: Agricultural areas – Artificial areas (2.0%) level 3: Moors and heathland (322) – Complex cultivation patterns (241)(1.1%)
Major land cover changes within transect	Transect 6 "Drentse Aa": Total percentage changed is 63.4% Internal changes level 1: Agricultural changes (27.6%) level 3: Farmed land (621) – Arable land (211)(19.7%) External changes: level 1: Agricultural areas – Artificial areas (24.3%) level 3: Farmed land (621) – Discontinuous urban fabric (112) (10.3%) Transect 7 "Dwingelerveld": Total percentage changed is 46.1% Internal changes level 1: Agricultural changes (28.6%) level 3: Arable land (211)- Farmed land (621)(13.4%) External changes level 1: Agricultural areas – Artificial areas (3.7%) level 3: Arable land (211) – Discontinuous urban fabric (112) (1.8%)



Window 14A Drenthe, Transect 7

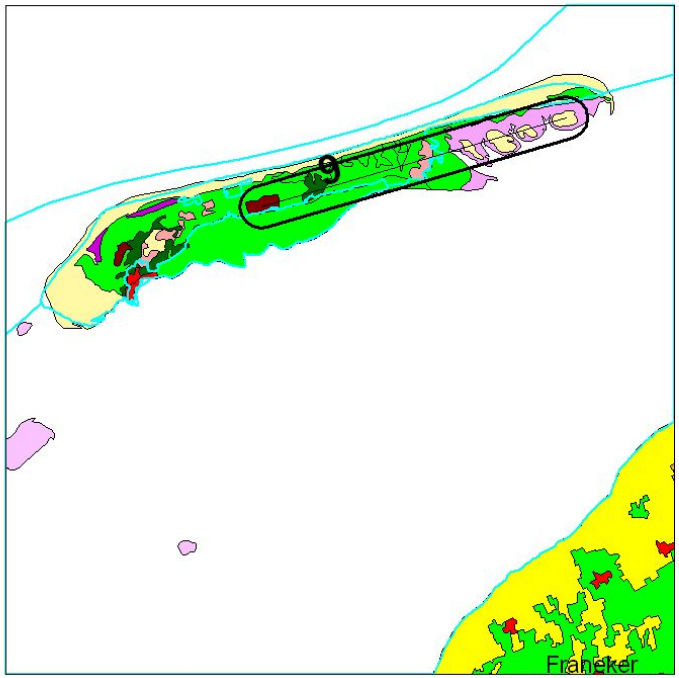


Window 14A Drenthe, Transect 6

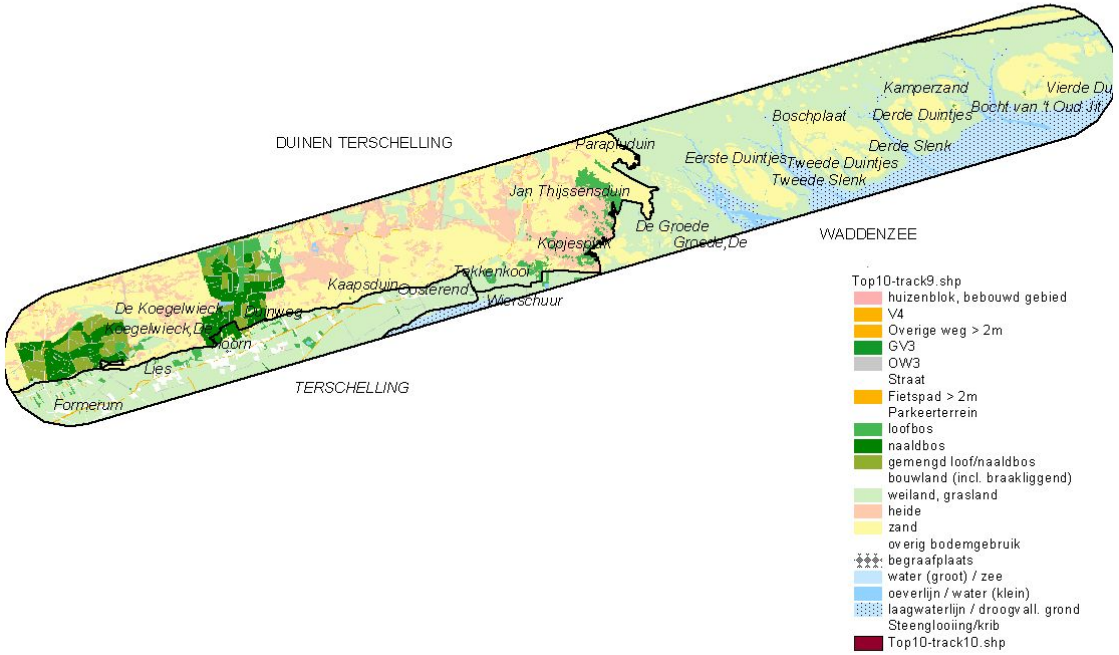


Window Y "Friesland" and Transect 9 "Terschelling".

Window Y "Friesland" with transect 9 "Terschelling"	
Natura2000 sites within window	Duinen Terschelling, Waddenzee
Natura2000 sites within transect	Duinen Terschelling, Waddenzee
Habitattypes within transect	1130 (13.2) - Estuaries 1310 (15.11) - Salicornia and other annuals colonizing mud and sand 1320 (15.12) - Spartina swards (Spartinion) 1330 (15.13) - Atlantic salt meadows (Glauco-Puccinellietalia) 2110 (16.211) - Embryonic shifting dunes 2120 (16.212) - Shifting dunes along the shoreline with Ammophila arenaria (white dunes) 2190 (16.31_->_16.35) - Humid dune slacks 1110 (11.25) - Sandbanks which are slightly covered by sea water all the time 1140 (14) Mudflats and sanflats not covered by seawater at low tide 2130 * Fixed coastal dunes with herbaceous vegetation ('grey dunes') 2140 (16.23) - Decalcified fixed dunes with Empetrum nigrum 2160 (16.25) - Dunes with Hyppophae rhamnoides 2170 (16.26) - Dunes with Salix arenaria 2180 (16.29) - Wooded dunes of the Atlantic coast
Major land cover types at level 1 and level 3 for the window in 1950 and 1990.	1950: level 1: Water bodies (43.8%) level 3: Sea and ocean (523) (43.8%) 1990: level 1: Water bodies (44.3%) level 3: Sea and ocean (523) (44.3%)
Major land cover types at level 1 and level 3 for transects in 1950 and 2000.	1950: level 1: Forest and semi-natural areas (61.4%) level 3: Sparsely vegetated areas (333) (24.1%) 2000: level 1: Forest and semi-natural areas (50.9%) level 3: Sparsely vegetated areas (333) (29.6%)
Major land cover changes within window	Total percentage changed is 2.6% External changes level 1: Forest and semi-natural areas – Water bodies (0.9%) level 3: Beaches and dunes (331) – Sea and ocean (523) (0.9%)
Major land cover changes within transect	Total percentage changed is 42.3% Internal changes level 1: Forest and semi-natural changes (3-3) (14.0%) External changes level 1: Forest and semi-natural – Wetlands (3-4) (11.5%) level 3: Beaches and dunes (331) – Salt marshes (421) (11.3%)



Window Y Terschelling, Transect 9

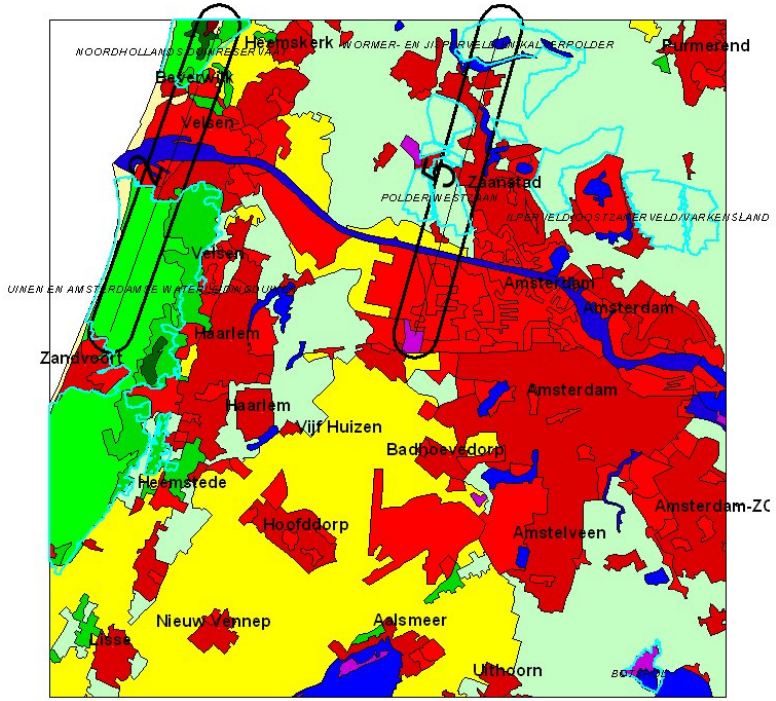


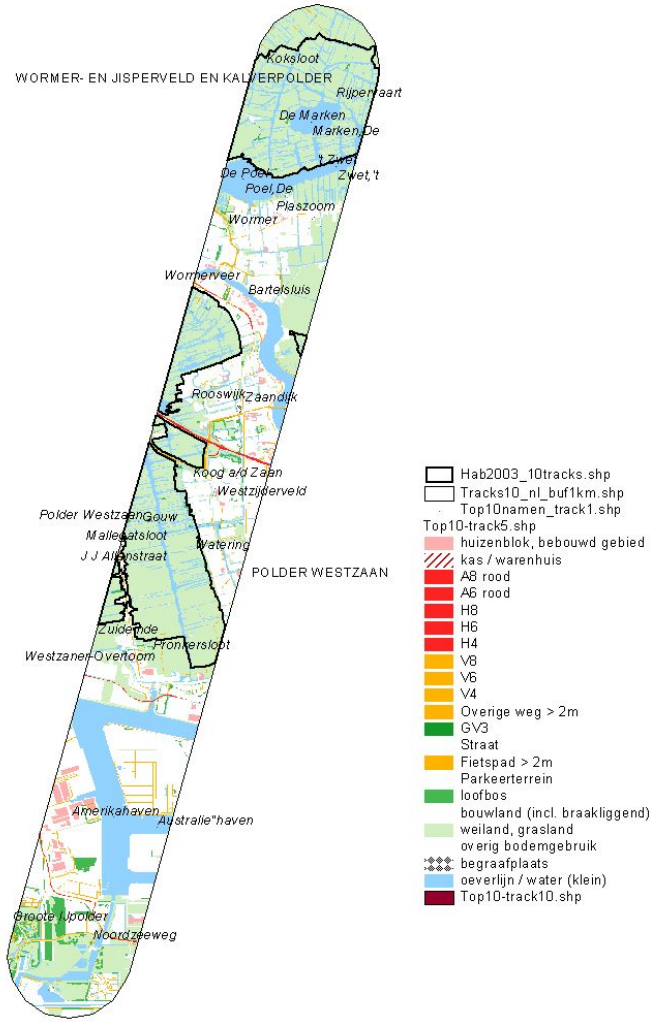
Window 139 "Noord-Holland" and Transect 2 "Kennemer Duinen" and Transect 5 "Jisperveld".

Window 139 "Noord-Holland" with transect 2 "Kennemer Duinen" and transect 5 "Jisperveld"	
Natura2000 sites within window	Kennemerduinen en Amsterdamse waterleidings duinen, Noordhollands Duinreservaat, Wormer- en Jisperveld en Kalverpolder, Polder Westzaan, "Ilperveld, Oostzanerveld en Varkensland" and Botshol
Natura2000 sites within transect	Kennemerduinen en Amsterdamse waterleidings duinen, Noordhollands Duinreservaat (transect 2); Wormer- en Jisperveld en Kalverpolder, Polder Westzaan (transect 5)
Habitattypes within transect	Transect 2 "Kennemer Duinen" 2120 (16.212) - Shifting dunes along the shoreline with Ammophila arenaria (white dunes) 2190 (16.31_->_16.35) - Humid dune slacks 2130 * Fixed coastal dunes with herbaceous vegetation ('grey dunes') 2160 (16.25) - Dunes with Hyppophae rhamnoides 2170 (16.26) - Dunes with Salix arenaria 2180 (16.29) - Wooded dunes of the Atlantic coast 2150 * Atlantic decalcified fixed dunes (Calluno-Ulicetea) Transect 5 "Jisperveld" 4010 (31.11) - Northern Atlantic wet heaths with Erica tetralix 6430 (37.7_&_37.8) - Eutrophic tall herbs 7140 (54.5) - Transition mires and quaking bogs
Major land cover types at level 1 and level 3 for the window in 1950 and 1990.	1950: level 1: Agricultural areas (61.5%) level 3: Pastures (231) (34.2%) 1990: level 1: Agricultural areas (46%) level 3: Pastures (231) (26.6%)
Major land cover types at level 1 and level 3 for transects in 1950 and 2000.	Transect 2 "Kennemer Duinen" 1950: level1: Forest and semi-natural areas (65.1%) level 3: Natural grasslands (321) (48.3%) 2000: level 1: Forest and semi-natural areas (58.9%) level 3: Natural grasslands (321) (40%) Transect 5 "Jisperveld" 1950: level 1: Agricultural areas (74.0%) level 3: Pastures (231) (48.2%) 2000: level 1: Artificial areas (44.0%) level 3: Pastures (231) (31.5%)

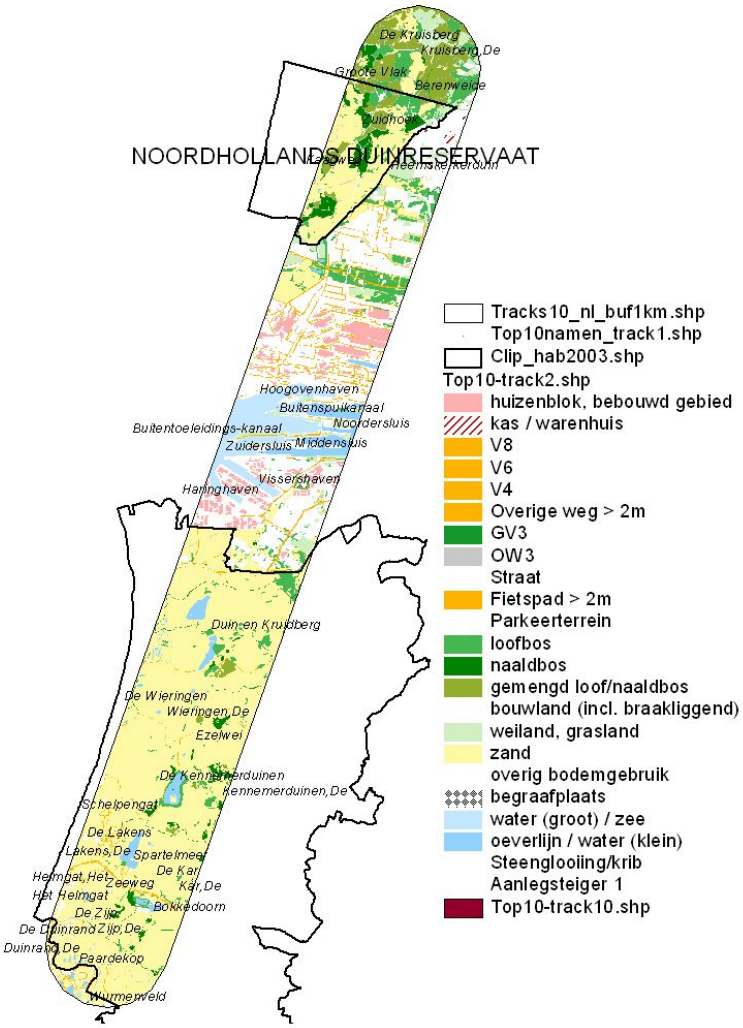
Major land cover changes within window	Total percentage changed is 18.2% External changes level 1: Agricultural areas – Artificial areas (14.3%) level 3: Pastures (231) – Discontinuous urban fabric (112) (3.8%)
Major land cover changes within transect	<u>Transect 2 "Kennemer Duinen":</u> Total percentage changed is 32.9% Internal changes level 1: Forest and semi-natural changes (7.4%) External changes: level 1: Forest and semi-natural areas – Artificial areas (7.3%) level 3: Arable land (211) – Industrial and commercial units (121) (3.0%) <u>Transect 5 "Jisperveld":</u> Total percentage changed is 45.7% External changes: level 1: Agricultural areas – Artificial areas (31.3%) level 3: Pastures (231) – Discontinuous urban fabric (112) (8.8%)

Window 139_32 A Noord-Holland, Transect 5



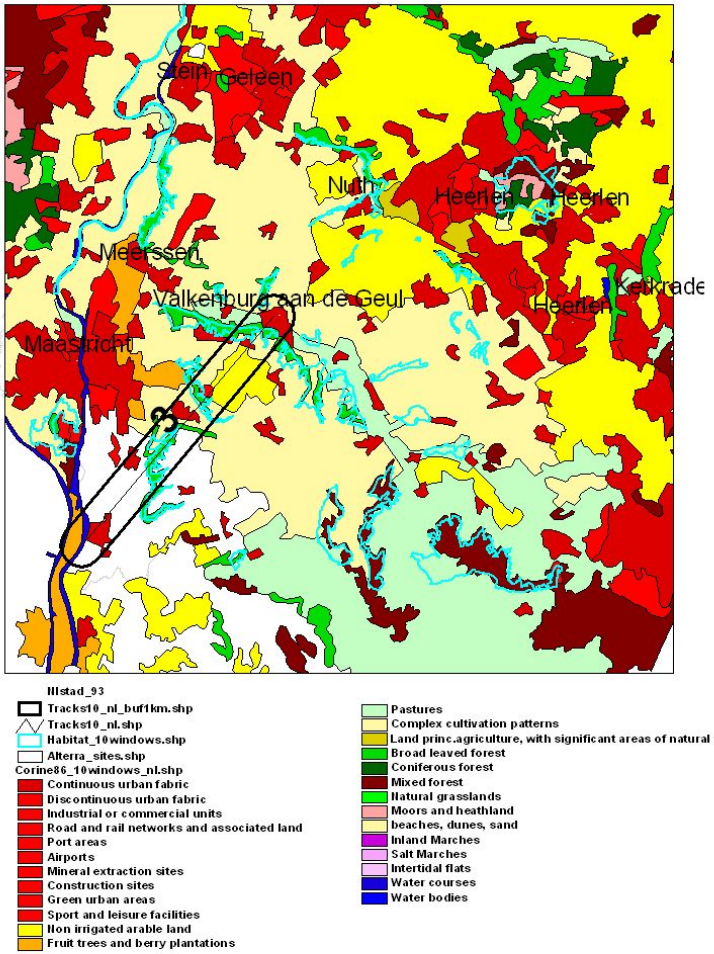


Window 139_32 A Noord-Holland, Transect 2

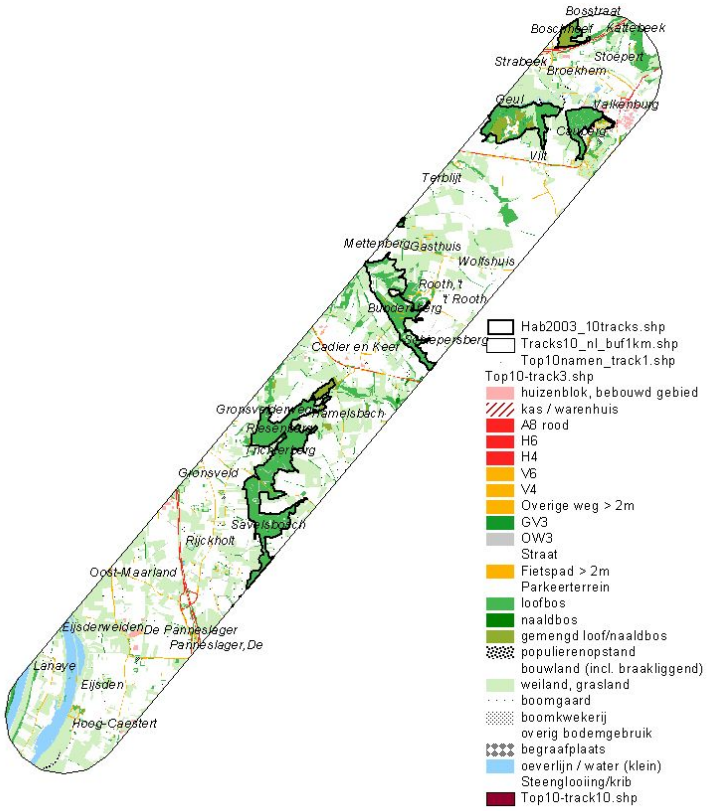


Window Z "Limburg" and Transect 3 "Bemelerberg"

Window Z "Limburg" with transect 3 "Bemelerberg"	
Natura2000 sites within window	n.a.
Natura2000 sites within transect	Savelsbos, Bemelerberg en Schiepersberg, Geuldal
Habitattypes within transect	6230 (35.1) - Species-rich Nardus grasslands, on siliceous substrates in mountain areas (and submountain areas, in continental Europe) 91E0 * Alluvial forests with Alnus glutinosa and Fraxinus excelsior (Alno-Padion, Alnion incanae, Salicion albae) 3260 (24.4) - Floating vegetation of Ranunculus of plain, submountainous rivers 6110 (34.11) * Rupiculous calcareous or basophilic grasslands of the Alysso-Sedion albi 6130 Calaminarian grasslands of the Violetalia calaminariae 6210 (34.31) Semi-natural dry grasslands and scrubland facies on calcerous substrates (Festuco-Brometalia) (*important orchid sites) 7220 (54.12) *Petrifying springs with tufa formation (Cratoneurion) 7230 Alkaline fens 9110 (41.11) - Acidophilous (Luzulo-Fagetum) beech forests 9160 (41.24) - Sub-Atlantic (Stellario-Carpinetum) oak-hornbeam forests
Major land cover types at level 1 and level 3 for the window in 1950 and 1990.	n.a.
Major land cover types at level 1 and level 3 for transects in 1950 and 2000.	1950: level 1: Agricultural areas (82.3%) level 3: Fruit and berry plantations (222) (38.9%) 2000: level 1: Agricultural areas (63.0%) level 3: Arable land (211) (29.2%)
Major land cover changes within window	n.a.
Major land cover changes within transect	Total percentage changed is 56.7% Internal changes level 1: Agricultural changes (35.5%) level 3: Fruit and berry plantations (222) – Arable land (211) (10.1%) External changes level 1: Agricultural areas – Artificial areas (14.6%) level 3: Fruit and berry plantations (222) – Discontinuous urban fabric (112) (10.1%)



Window Z Zuid-Limburg, Transect 3



Appendix 2 Geometric correction of AP's in ERDAS Imagine.

Geometric correction Aerial Photographs using ERDAS Imagine

Geometric correction model: Numerical restitution
(Numerieke ontschranking)

Sander Mücher en John Stuiver
Versie 2.2: 8 –7–2003

P:\BioPress\data\tracks\transect1\1998\test\Geometric correction Aerial Photographs using ERDAS Imagine.doc

Preparation data

AP

Scanned aerial photographs are 24/16 M in color depth. When you import the data into ERDAS Imagine, select only band 1. In this way, the scanned tiff file is reduced from ±120 MB to ±40 MB. When you have set, in the import options, the compression to runlength and the number of bands to 1, you can use the batch options to import all the tiff files in the directory.

DEM

The Dutch Digital Elevation Model, AHN, is being used. AHN is defined in centimetres and needs to be transformed into the standard unit metres. Dividing the AHN Grid file by 100 in ArcInfo, changes the units and the data format into respectively metres and floating point. The DEM cannot have no-data values. Unfortunately, this happens in many cases. Therefore, an interpolation of the DEM to the no-data values is needed. At this moment, we have used the EUCALLOCATION command in Arc GRID. This is a Euclidian interpolation. This command calculates for each cell the zone of the closest source cell (in Euclidean distance). Even better is to use ENVI. Under <topographic data> use: replace bad values. You have to make a mask before you can replace the bad values.

REF

As geo-reference data, we use the digital topographic maps of the Netherlands. In an ERDAS imagine viewer, we can load a shapefile. Use the C1 value in the symbology editor to display the data.

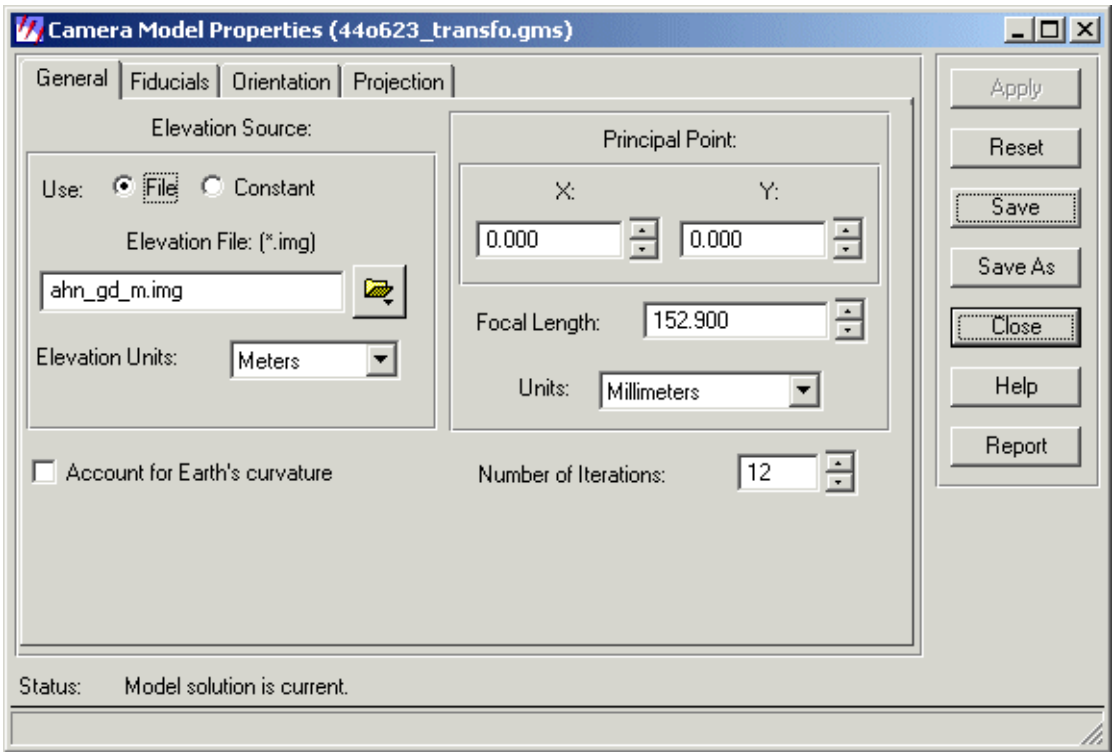
The projection parameters that we use in ERDAS Imagine are:

PROJECTION STEREOGRAPHIC
SPHEROID BESSEL
UNITS METERS
PARAMETERS
1
0
05 23 15
52 09 22
155000
463000

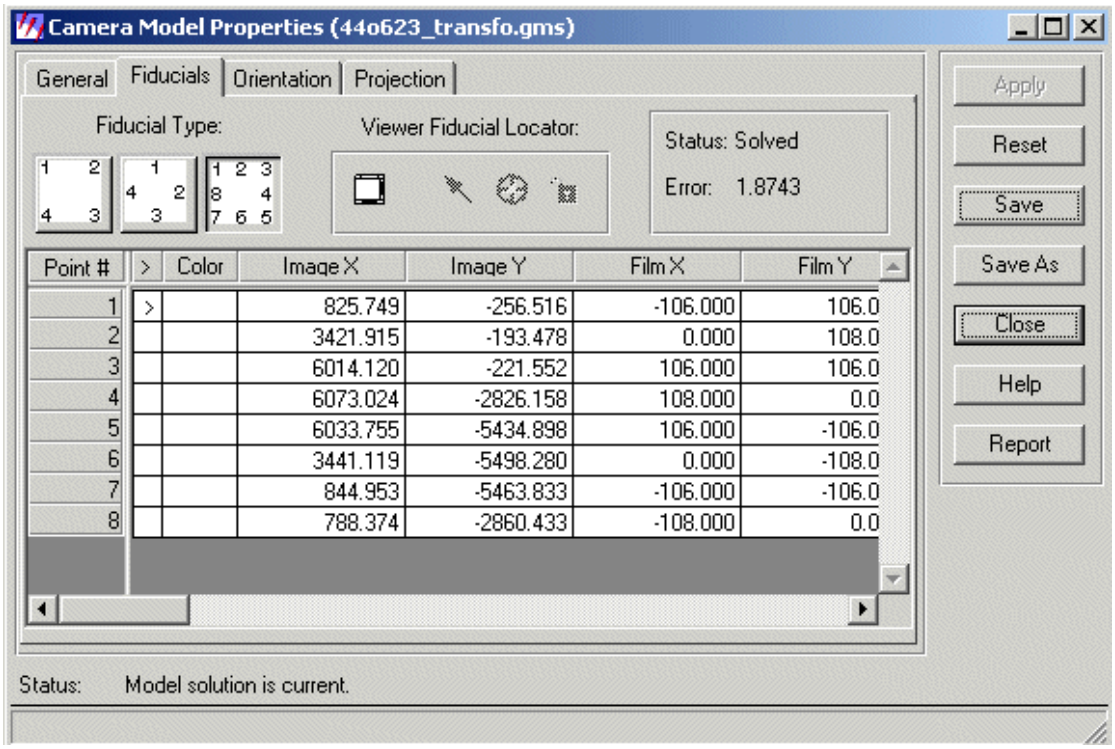
Geometric correction in ERDAS Imagine

Load the AP (aerial photograph) in a viewer and open under <raster> geometric correction and choose <camera>. You can select existing model (e.g. P:\BioPress\data\tracks\transect1\1998\test\ 44o623_transfo.gms)

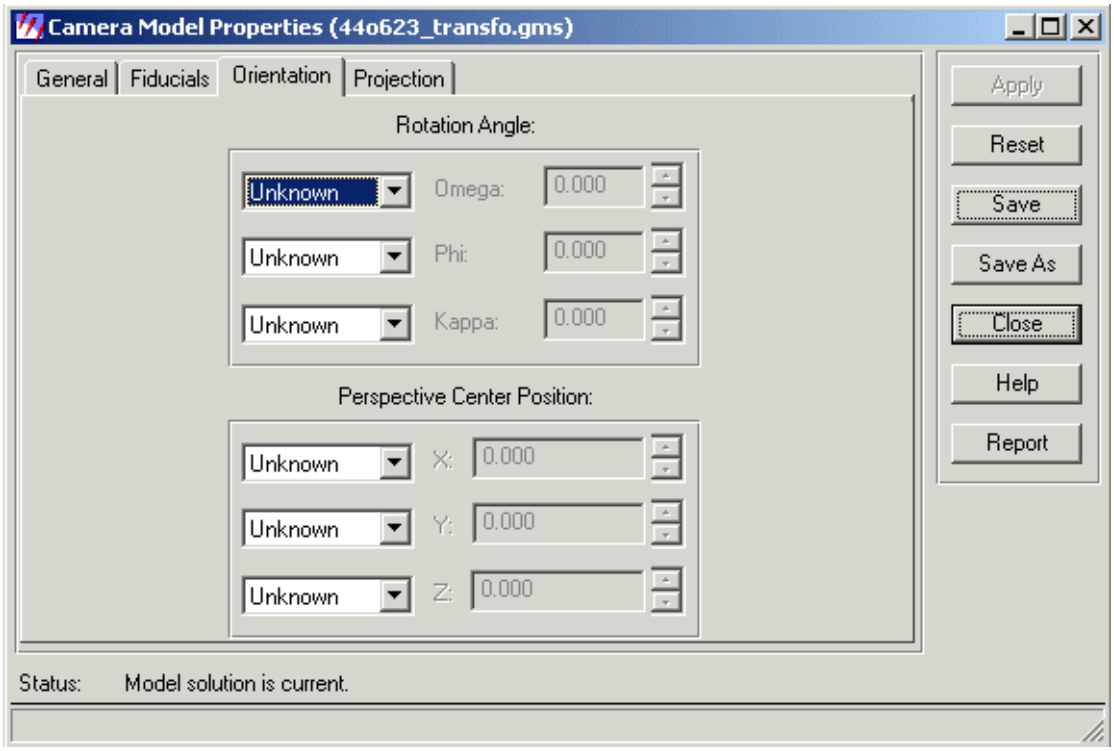
Start with the general properties. Load the DEM. If you have no DEM and the terrain is flat, you can use a constant value. Note that elevation units are in meters.

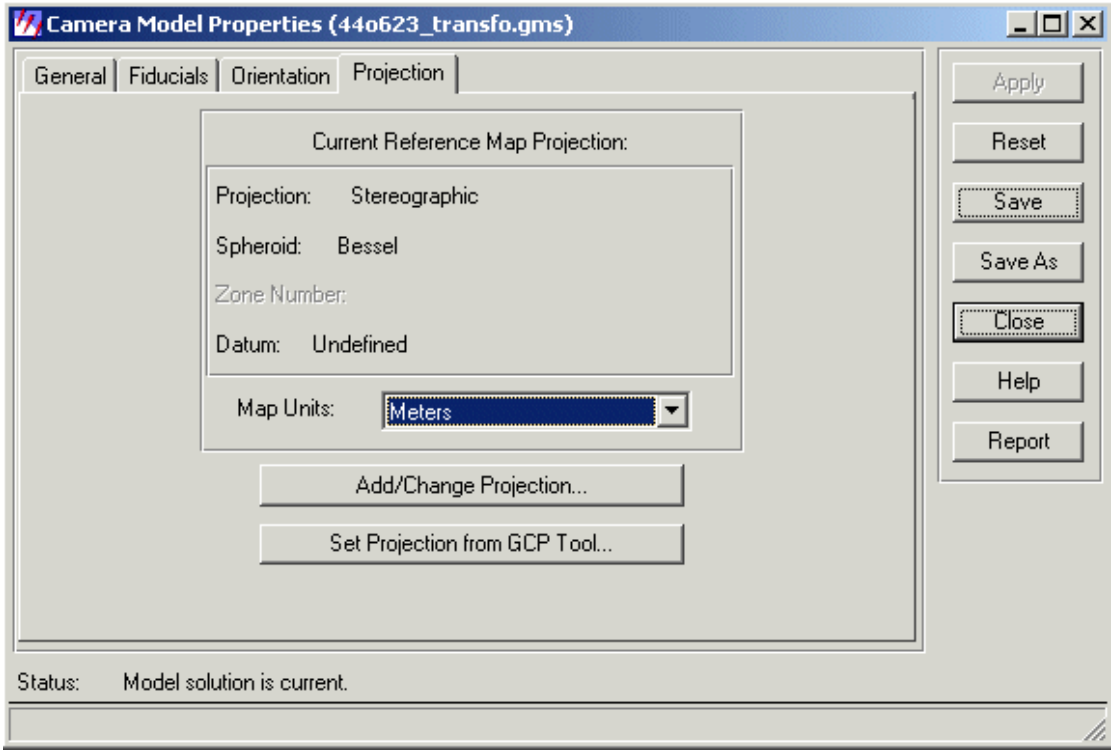


Number of fiducial points/marks will be in most instances 4. See Annex I for calculation of the fiducial marks. See Annex II for characteristics of the aerial photographs for the Netherlands. Use the viewer fiducial locator to identify the location of the fiducial marks on the AP. This has to be repeated for every AP.

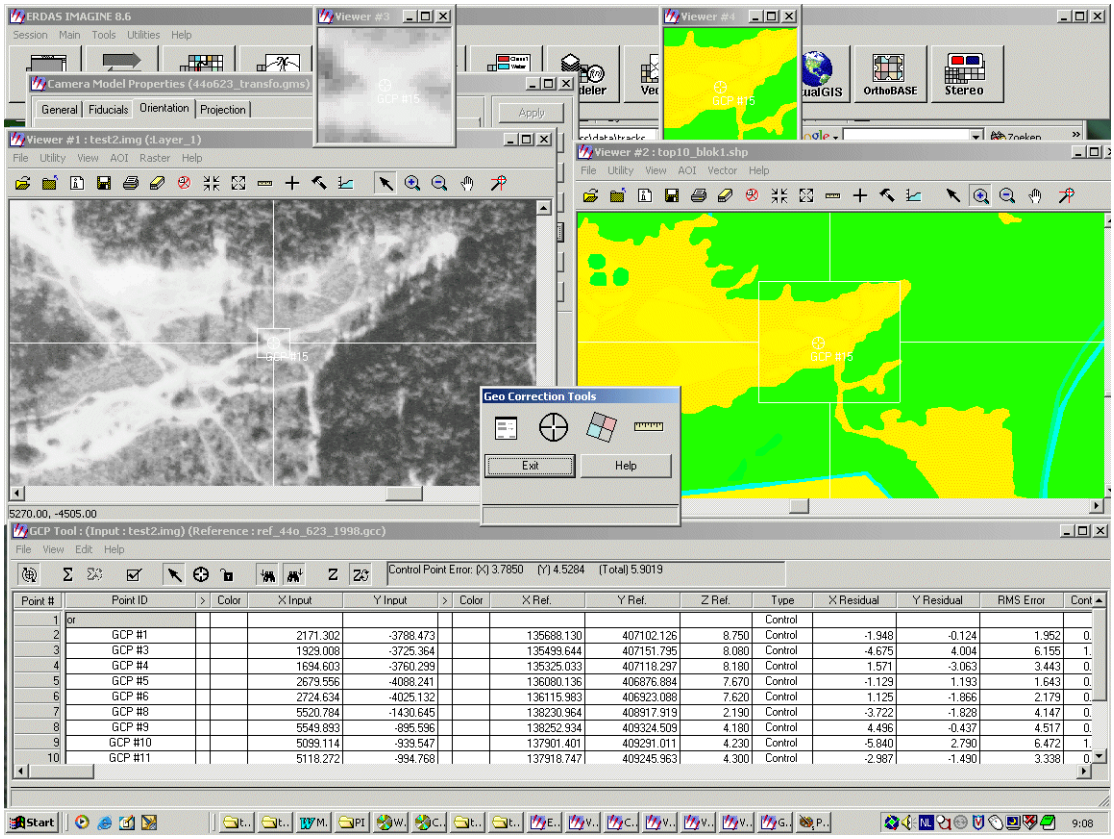


Orientation of the camera is set to unknown.


Camera Model Properties (44o623_transfo.gms)
General
Fiducials
Orientation
Projection
Rotation Angle:
Unknown
Omega:
0.000
Unknown
Phi:
0.000
Unknown
Kappa:
0.000
Perspective Center Position:
Unknown
X:
0.000
Unknown
Y:
0.000
Unknown
Z:
0.000
Apply
Reset
Save
Save As
Close
Help
Report
Status:
Model solution is current.


Camera Model Properties (44o623_transfo.gms)
General
Fiducials
Orientation
Projection
Current Reference Map Projection:
Projection:
Stereographic
Spheroid:
Bessel
Zone Number:
Datum:
Undefined
Map Units:
Meters
Add/Change Projection...
Set Projection from GCP Tool...
Apply
Reset
Save
Save As
Close
Help
Report
Status:
Model solution is current.

Then start the GCP (ground control point) editor to select ground control points (GCP's) in the AP. Select vector layer in new viewer (optional) and choose a reference data set (eg. top10_blok1.shp).



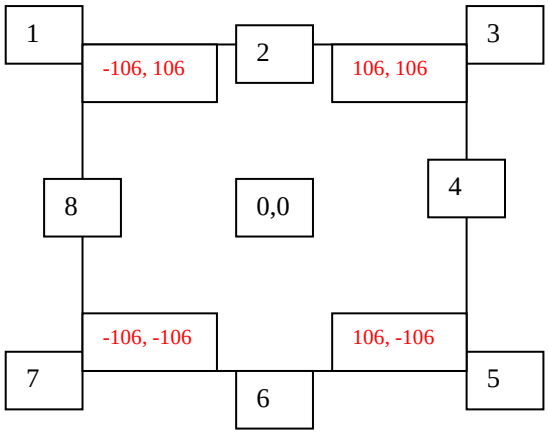
When sufficient GCP's have been located in a stratified manner over the image, the Image Resample Dialog window can be opened to calculate the newly rectified aerial photograph.

Annex I Calculation Fiducial Marks

The fiducial marks have been calculated for the AP of the years 1953, 1986 and 1998. This has been done using Arc/Info.

Using the command <register> and <rectify>.

Arc: Register *.tif # # composite 1 2 3
Link actions



Register 4 known fiducial points (1,3,5,7) and after register save and quit. Look at *.tfw. And use rectify for affine transformation.

Arc: rectify *.tif *_io.tif NEAREST

Now the 4 missing fiducial marks can be read.

Note that the coordinates can be calculated roughly by measuring the distance between the fiducial points in mm and divide the number by 2. In the case of the AP of 1996, the distance is about 21 cm (210 mm / 2 = 105)

B&W luchtfoto's TDN

1 Luchtfotos rond 1950 (1953 en 1955)

Camera RC 8
Schaal 1:20.000
Focal length 210.23
Average flight height

Fiducial Marks

Point	Film X (mm)	Film Y (mm)
1	-81.5	-81.5
2	-81.5	81.5
3	81.5	81.5
4	81.5	-81.5

2 Luchtfotos 1986

Camera RC10
Schaal 1:18000
Focal length 151.64
Average flight height

Fiducial Marks

Point	Film X (mm)	Film Y (mm)
1	-106	-106
2	106	106
3	-106	106
4	106	-106

3 Luchtfotos 1998

Fiducial: **o** e.g.45W_504_1998

Camera RC20
Schaal 1:18000
Focal length 152.90
Average flight height

Fiducial Marks

Point	Film X (mm)	Film Y (mm)
1	-106.000	-106.000
2	-110.000	0.000
3	-106.000	106.000
4	0.000	110.000
5	106.000	106.000
6	110.000	0.000
7	106.000	-106.000
8	0.000	-110.000

***** e.g. 44O_723_1998

Camera Delta Phot (failliet)
Schaal 1:18000
Focal lengt 152.14
Average flight height

Point	Film X (mm	Film Y (mm	ERDAS
1	-110.000	110.000	7
2	-112.000	0.000	8
3	-110.000	110.000	1
4	0.000	112.000	2
5	110.000	110.000	3
6	112.000	0.000	4
7	110.000	-110.000	5
8	0.000	-112.000	6

Comments
AP 1948: 70/85 fiducial marks – transect 4.

Appendix 3 Number and time steps of AP's used in transect interpretation.

	2000		1990		1950		Total
Transect 1	1998	14	1986	13	1953	12	39
Transect 2	2001/2002	19	1990	19	1958	27	65
Transect 3	1999	15	1989	15	1949	20	50
Transect 4	1998/1999	15	1988/1989	15	1948/1955	17	47
Transect 5	2001/2002	16	1989	16	1958	22	54
Transect 6	2000	15	1989	18	1950/1952	19	52
Transect 7	2000/2001	14	1989	15	1950	24	53
Transect 8	2000	17	1989	18	1950/1951	20	55
Transect 9			1989	16			16
Total		125		145		161	431

Appendix 4 Definition of Corine Land Cover classes.

Description of the most important CORINE land cover classes. (Source: Bossard, M., J. Feranec, and J. Otahel, 2000).

1.1.1 Continuous urban fabric
Most of the land is covered by structures and the transport network. Building, roads and artificially surfaced areas cover more than 80% of the total surface. Non-linear areas of vegetation and bare soil are exceptional.

1.1.2 Discontinuous urban fabric
Most of the land is covered by structures. Building, roads and artificially surfaced areas associated with vegetated areas and bare soil, which occupy discontinuous but significant surfaces.
Extension: Between 30 to 80 % of the total surface should be impermeable
.
1.2.1 Industrial and commercial units
Artificially surfaced areas (with concrete, asphalt, tarmacadam, or stabilised, e.g. beaten earth) without vegetation occupy most of the area, which also contains buildings and/or vegetation.

1.2.2. Roads and rail networks and associated land
Motorways and railways, including associated installations (stations, platforms, embankments).
Minimum width for inclusion: 100 m.

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

1.2.4 Airports
Airports installations: runways, buildings and associated land. Extension: This class includes associated lands (mainly grassland).

1.3.1 Mineral extraction sites
Areas with open-pit extraction of construction material (sandpits, quarries) or other minerals (open-cast mines). Includes flooded gravel pits, except for river-bed extraction.

1.3.2 Dump sites
Public, industrial or mine dump sites. This class includes dump sites of raw materials or liquid wastes

1.3.3. Construction sites
Spaces under construction development, soil or bedrock excavations, earthworks

1.4.1 Urban green areas
Areas with vegetation within urban fabric, includes parks and cemeteries with vegetation and mansions and their grounds.

1.4.2 Sport and leisure facilities
Camping grounds, sports grounds, leisure parks, golf courses, racecourses; etc
Includes formal parks not surrounded by urban areas.

2.1.1 Non-irrigated arable land
Cereals, legumes, fodder crops, root crops and fallow land. Includes flowers and fruit trees

(nurseries cultivation) and vegetables, whether open field, under plastic or glass (includes market gardening). Includes aromatic, medicinal and culinary plants. Does not include permanent pastures

Extension: This class includes flower, fruit trees (nurseries) and vegetable cultivation. Includes other annually harvested plants with more than 75 % of the area under a rotation system. Part of this class are the plots of arable land with area of several hectares reaching tens (hundreds) of ha.

2.1.2. Permanently irrigated land

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

2.1.3 Rice fields

Land prepared for rice cultivation. Flat surfaces with irrigation channels. Surfaces periodically flooded.

2.2.1 Vine yards

Areas planted with vines. Extension: Vineyard areas are classified as 221 if the vineyard parcels exceed 50 % of the area and/or they determine the land use of the area.

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

2.3.1 Pastures

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

Extension: Grazing used by cattle. Pastures can be described as extensively used grasslands with presence of farm structure such as: fences, shelters, enclosures, watering places, drinking trough, or regular agricultural works: mowing, drainage, hay making, agricultural practices, manuring.

2.4.3. Land principally occupied by agriculture with significant natural vegetation

Areas principally occupied by agriculture, interspersed with significant natural areas (including wetlands and water bodies, out crops).

2.4.4. Agro-forestry areas

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

3.1.1. Broad-leaved forest

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

Extension: this class includes areas with a crown cover of more than 30 % or a 500 subjects/ha density for plantation structure, broad-leaved trees represent more than 75 % of the planting pattern. In case of young plants or seedlings the proportion of broad-leaved plants to be considered is at least 75 % of the total amount of plants.

3.1.2 Coniferous forest

Vegetation formation composed principaly of trees, including shrub and bush understoreys, where coniferous species predominate.

Extension: Coniferous trees represent more than 75 % of the formation. In case of young plants or seedlings, the proportion of coniferous plants to be considered is at least 75 % of the total amount of plants and their texture is very similar to a surrounding coniferous forest texture.

3.1.3 Mixed forest

Vegetation formation composed principally of trees, including shrub and bush understoreys, where neither broad-leaved nor coniferous species predominate.

Extension: Mixed forests with a crown cover of more than 30 % or a 500 subjects/ha density for plantation structure. The share of coniferous or broad-leaved species does not exceed 25 % in the canopy closure.

3.2.1 Natural grasslands

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

Extension: Natural grasslands are areas with herbaceous vegetation (maximum height is 150 cm and gramineous species are prevailing) which cover at least 75 % of the surface covered by vegetation which developed under a minimum human interference (not mowed, fertilized or stimulated by chemicals which might influence production of biomass); here belong for instance grass formations of protected areas, karstic areas, military training fields, etc. (even though the human interference cannot be altogether discarded in quoted areas, it does not suppress the natural development or species composition of the meadows), areas of shrub formations of scattered trees.

3.2.2 Moors and heath lands

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

Extension: This class includes temperate shrubby area vegetation (climax stage of development): includes dwarf forest trees with a 3 m maximum height in climax stage.

3.2.3 Sclerophyllous vegetation

Bushy sclerophyllous vegetation, includes maquis and garrigue. In case of shrub vegetation areas composed of sclerophyllous species such as Juniperus oxycedrus and heathland species such as Buxus spp. or Ostrya carpinifolia with no visible dominance (each species occupy about 50% of the area), priority will be given to sclerophyllous vegetation and the whole area will be assigned class 323.

Extension: This class includes evergreen sclerophyllous bushes and scrubs which compose maquis, garrigue, mattoral and phrygana.

3.2.4 Transitional woodland-scrub

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

Extension: Areas of natural developmental forest formations (young broad–leaved and coniferous wood species with herbaceous vegetation and dispersed solitary trees) for instance; in abandoned meadows and pastures or after calamities of various origin, part of this class may be also various degenerative stages of forest caused by industrial pollution, etc.

3.3.1 Beaches, sand, dunes

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

Extension: This class includes supra-littoral beaches and dunes developed at the back of the beach from high water mark towards land.

3.3.2 Bare rocks

Scree, cliffs, rock outcrops, including active erosion, rocks and reef flats situated above the high-water mark.

3.3.3 Sparsely vegetated areas

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

Extension: Scattered vegetation is composed of gramineous and/or ligneous and semi-ligneous species for determining the ground cover percentage, excluding cryptograms.

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.

4.1.1 Inland marshes.
Low-lying land usually flooded in winter, and more or less saturated by water all year round.
Extension: This class includes non-forested areas of low-lying land flooded or liable to flooding by fresh, stagnant or circulating water. Covered by specific low ligneous, semi-ligneous or herbaceous vegetation.

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

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 parcellation and embankment systems.

4.2.3 Intertidal flats
Generally unvegetated expanses of mud, sand or rock lying between high and low water marks. 0 m contour on maps.

5.1.1 Water courses
Natural or artificial water-courses serving as water drainage channels. Includes canals. Minimum width for inclusion: 100 m.

5.1.2 Water bodies
Natural or artificial stretches of water.

5.2.1 Coastal lagoons
Stretches of salt or brackish water in coastal areas which are separated from the sea by a tongue of land or other similar topography. These water bodies can be connected to the sea at limited points, either permanently or for parts of the year only

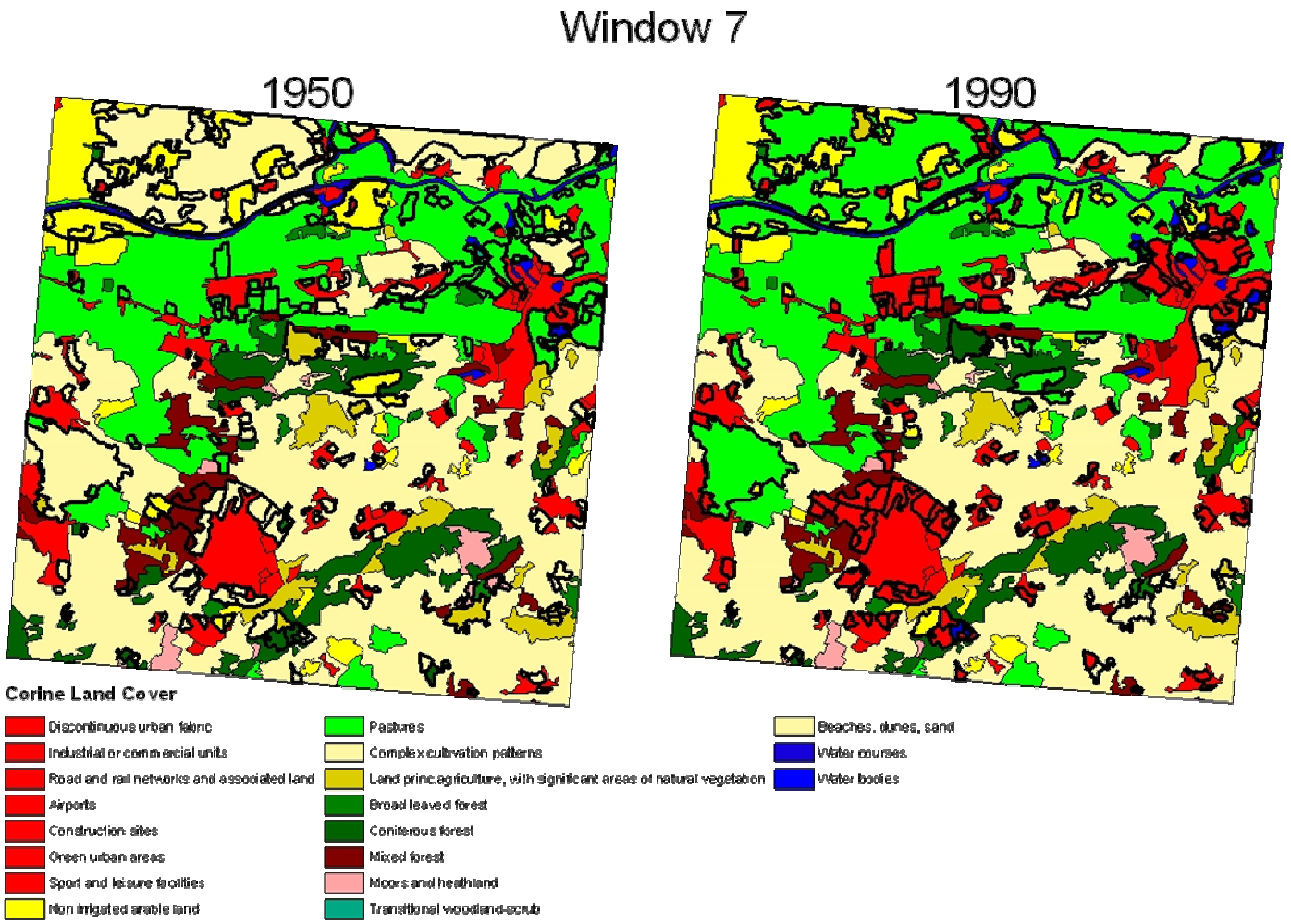
5.2.2 Estuaries
The mouth of a river within which the tide ebbs and flows.

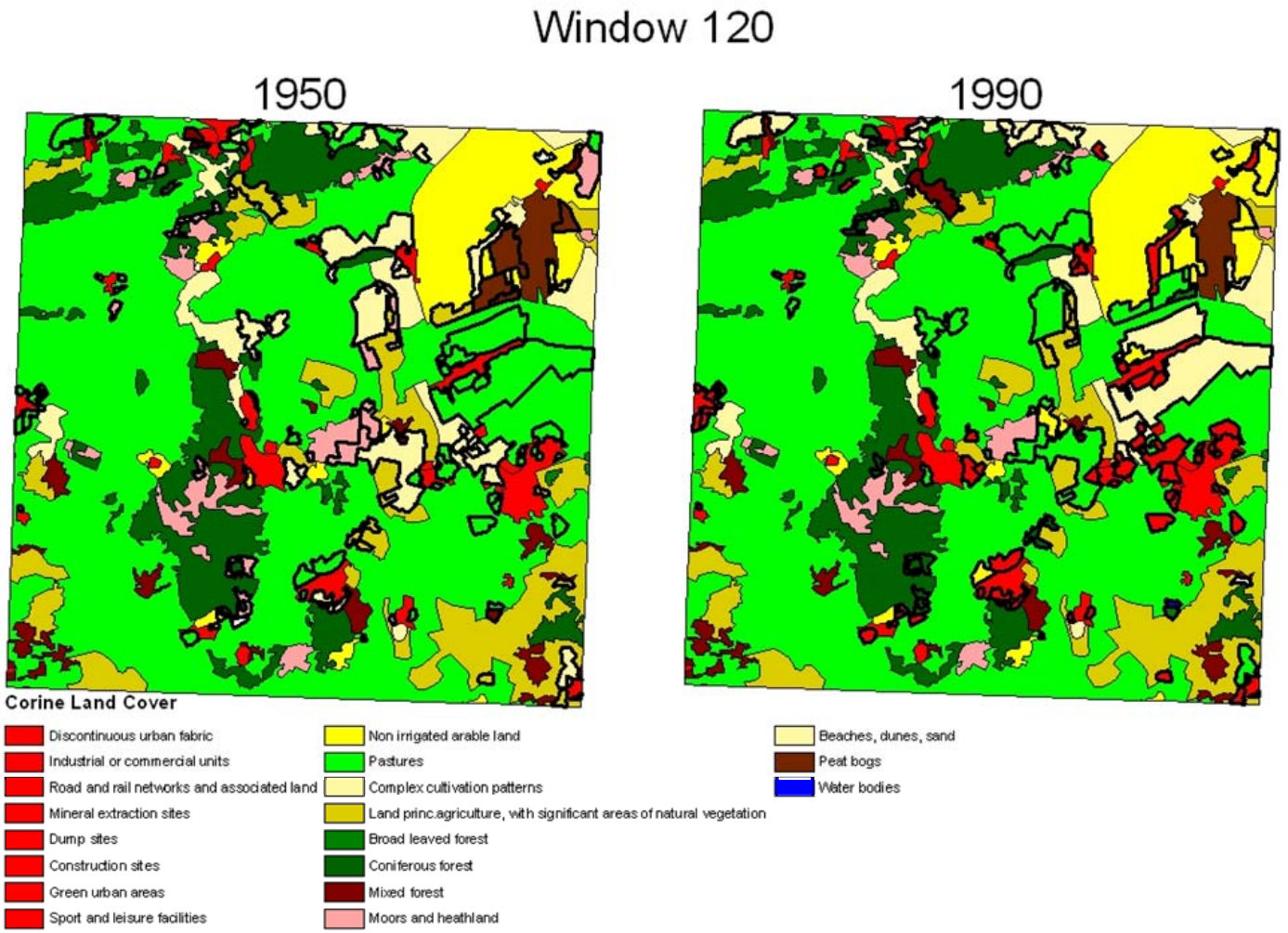
5.2.3 Sea and ocean
Zone seaward of the lowest tide limit.

(Source: Bossard, M., J. Feranec, and J. Otahel, 2000.)

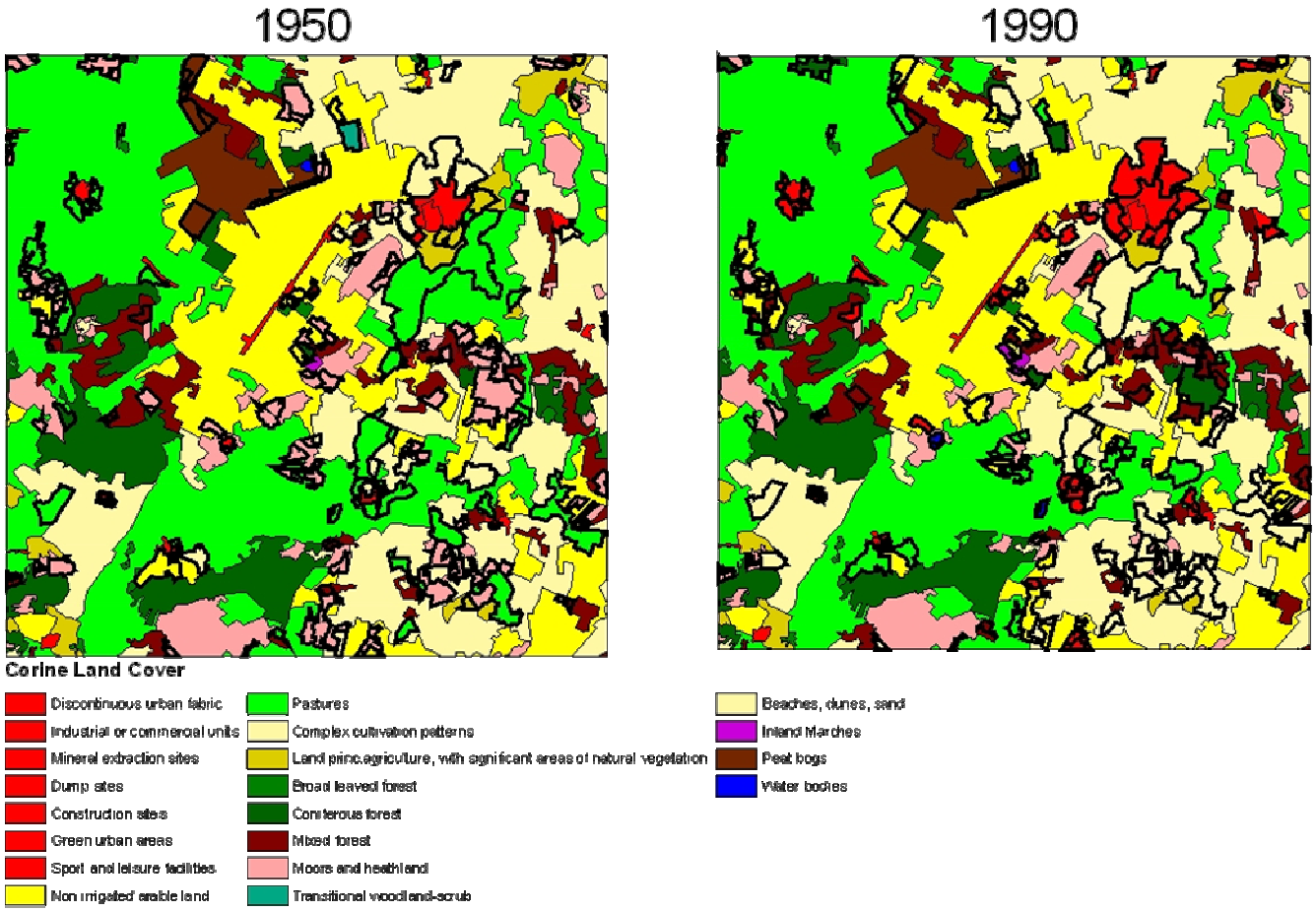
Appendix 5 Maps of land cover and land cover changes of 5 Dutch windows (1950 – 1990).

Window 7 "Noord-Brabant"
Window 120 "Overijssel"
Window 14 "Drenthe"
Window Y "Friesland"
Window 139 "Noord-Holland"


Window 7
1950
1990
Corine Land Cover
Discontinuous urban fabric
Industrial or commercial units
Road and rail networks and associated land
Airports
Construction sites
Green urban areas
Sport and leisure facilities
Non irrigated arable land
Pastures
Complex cultivation patterns
Land princ.agriculture, with significant areas of natural vegetation
Broad leaved forest
Coniferous forest
Mixed forest
Moors and heathland
Transitional woodland-scrub
Beaches, dunes, sand
Water courses
Water bodies

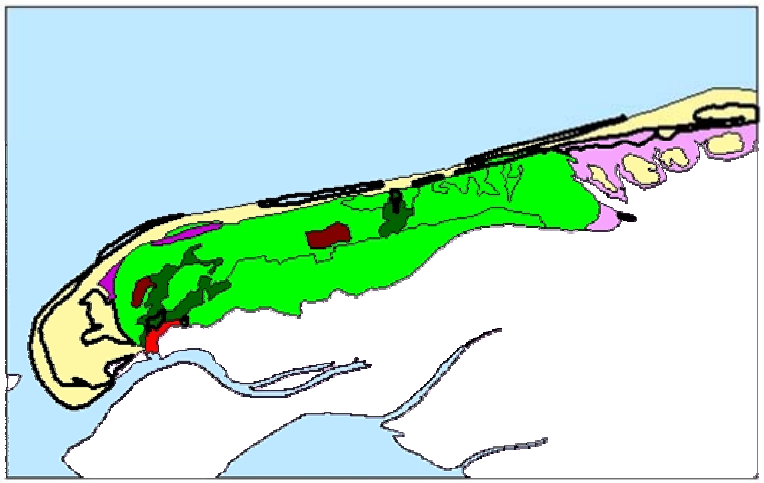

Window 120
1950
1990
Corine Land Cover
Discontinuous urban fabric
Industrial or commercial units
Road and rail networks and associated land
Mineral extraction sites
Dump sites
Construction sites
Green urban areas
Sport and leisure facilities
Non irrigated arable land
Pastures
Complex cultivation patterns
Land princ.agriculture, with significant areas of natural vegetation
Broad leaved forest
Coniferous forest
Mixed forest
Moors and heathland
Beaches, dunes, sand
Peat bogs
Water bodies

Window 14

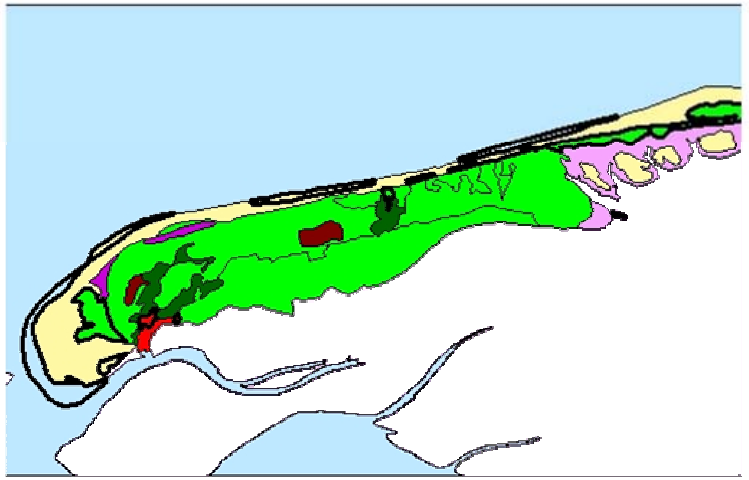

1950
1990
Corine Land Cover
Discontinuous urban fabric
Industrial or commercial units
Mineral extraction sites
Dump sites
Construction sites
Green urban areas
Sport and leisure facilities
Non irrigated arable land
Pastures
Complex cultivation patterns
Land princ.agriculture, with significant areas of natural vegetation
Broad leaved forest
Coniferous forest
Mixed forest
Moors and heathland
Transitional woodland-scrub
Beaches, dunes, sand
Inland Marches
Peat bogs
Water bodies

Window Y

1950



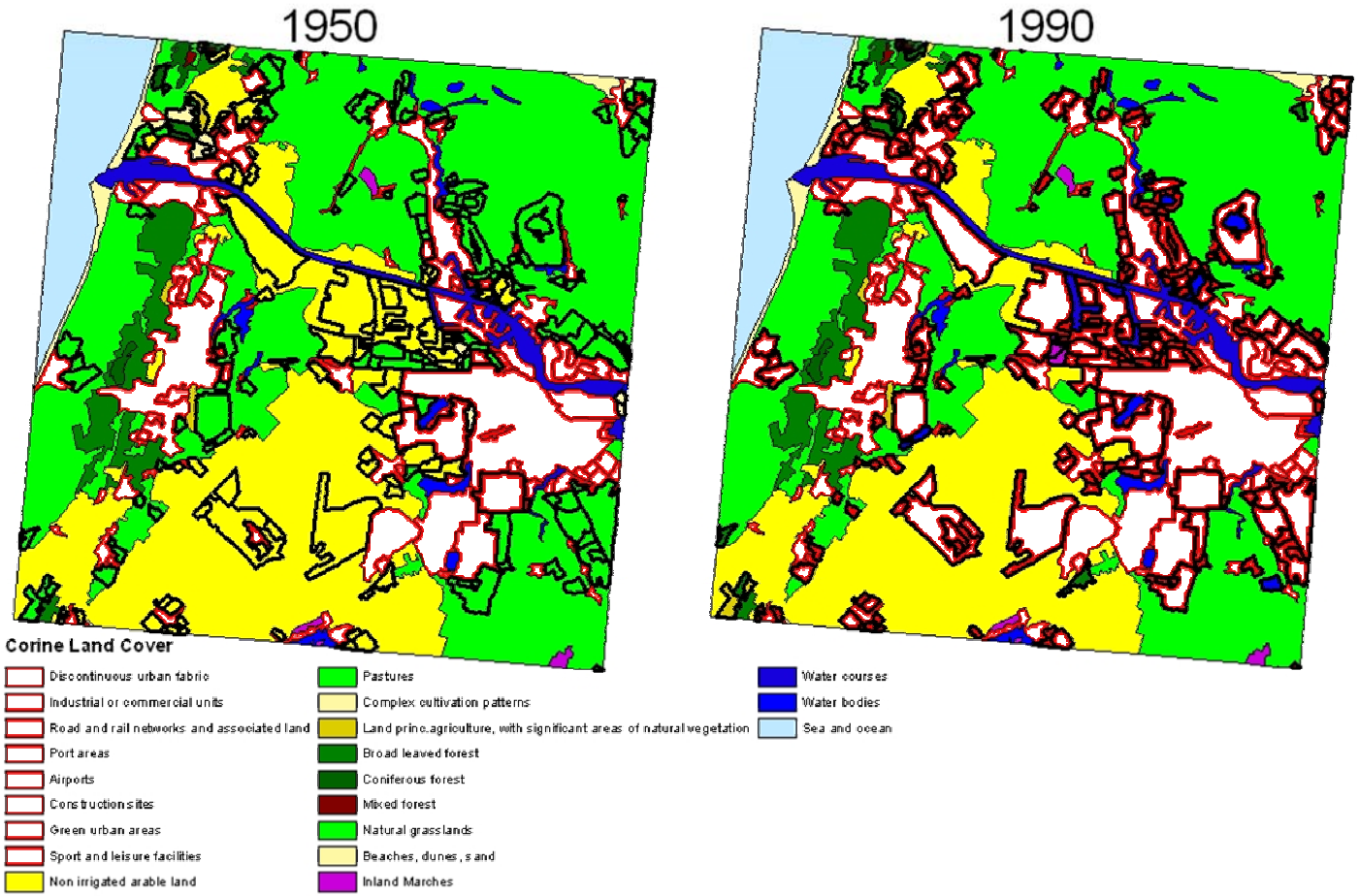
1990



Corine Land Cover

Discontinuous urban fabric	Natural grasslands	Intertidal flats
Pastures	Beaches, dunes, sand	Sea and ocean
Coniferous forest	Inland Marches	
Mixed forest	Salt Marches	

Window 139


1950
1990
Corine Land Cover
Discontinuous urban fabric
Industrial or commercial units
Road and rail networks and associated land
Port areas
Airports
Construction sites
Green urban areas
Sport and leisure facilities
Non irrigated arable land
Pastures
Complex cultivation patterns
Land princ.agriculture, with significant areas of natural vegetation
Broad leaved forest
Coniferous forest
Mixed forest
Natural grasslands
Beaches, dunes, sand
Inland Marches
Water courses
Water bodies
Sea and ocean

Appendix 6 Land cover statistics of 1950 and 1990 and land cover change matrices (1950-1990) of 5 Dutch windows.

Appendix 6a. Land Cover Statistics of five Dutch windows (1950 and 1990).

	Window 7				Window 14				Window 120				Window 139				Window Y			
	1950		1990		1950		1990		1950		1990		1950		1990		1950		1990	
	km	%	km	%	km	%	km	%	km	%	km	%	km	%	km	%	km	%	km	%
112	69,6	7,7	105,6	11,7	11,3	1,3	25,9	2,9	29,1	3,2	44,1	4,9	108,2	12,0	171,5	19,1	0,6	0,1	0,9	0,2
121	5,8	0,6	19,0	2,1	0,0	0,0	2,1	0,2	1,3	0,1	8,1	0,9	14,0	1,6	30,2	3,4	0,0	0,0	0,0	0,0
122	0,6	0,1	2,8	0,3	0,0	0,0	0,0	0,0	0,0	0,0	0,3	0,0	2,3	0,3	4,7	0,5	0,0	0,0	0,0	0,0
123	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	12,3	1,4	16,6	1,8	0,0	0,0	0,0	0,0
124	4,3	0,5	4,3	0,5	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	5,9	0,7	14,8	1,6	0,0	0,0	0,0	0,0
131	0,0	0,0	0,0	0,0	0,3	0,0	0,8	0,1	0,0	0,0	0,8	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
132	0,0	0,0	0,0	0,0	0,0	0,0	0,9	0,1	0,0	0,0	0,3	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
133	1,9	0,2	1,1	0,1	0,3	0,0	0,0	0,0	0,0	0,0	0,3	0,0	15,9	1,8	17,5	1,9	0,0	0,0	0,0	0,0
141	1,8	0,2	2,3	0,3	1,2	0,1	1,6	0,2	0,4	0,0	0,6	0,1	7,4	0,8	17,0	1,9	0,0	0,0	0,0	0,0
142	4,6	0,5	10,2	1,1	0,3	0,0	4,1	0,5	3,1	0,3	4,6	0,5	13,2	1,5	41,1	4,6	0,0	0,0	0,0	0,0
211	61,3	6,8	54,8	6,1	153,7	17,1	163,4	18,2	57,1	6,3	66,0	7,3	237,3	26,4	170,4	18,9	0,0	0,0	0,0	0,0
231	197,6	22,0	256,3	28,5	286,4	31,8	259,5	28,8	476,6	52,9	463,5	51,5	308,0	34,2	239,3	26,6	19,4	4,1	19,4	4,1
242	395,5	43,9	291,1	32,3	200,8	22,3	226,3	25,1	71,9	8,0	69,6	7,7	6,0	0,7	1,8	0,2	0,0	0,0	0,0	0,0
243	33,5	3,7	28,1	3,1	19,5	2,2	17,2	1,9	88,8	9,9	83,4	9,3	2,1	0,2	2,7	0,3	0,0	0,0	0,0	0,0
311	7,6	0,8	8,8	1,0	3,6	0,4	5,1	0,6	0,7	0,1	2,3	0,3	28,2	3,1	31,3	3,5	0,0	0,0	0,0	0,0
312	56,5	6,3	57,0	6,3	63,9	7,1	70,4	7,8	100,0	11,1	104,0	11,6	3,5	0,4	2,7	0,3	4,5	0,9	4,0	0,9
313	34,2	3,8	31,5	3,5	50,9	5,7	58,8	6,5	22,2	2,5	23,3	2,6	0,5	0,1	0,7	0,1	1,5	0,3	1,5	0,3
321	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	52,3	5,8	47,7	5,3	27,6	5,9	31,8	6,7
322	9,0	1,0	8,0	0,9	84,0	9,3	45,0	5,0	32,0	3,6	19,4	2,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
324	0,3	0,0	0,0	0,0	1,1	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
331	3,8	0,4	3,8	0,4	0,5	0,1	0,5	0,1	0,7	0,1	0,0	0,0	6,0	0,7	6,0	0,7	27,1	5,8	21,9	4,6
411	0,0	0,0	0,0	0,0	0,5	0,1	1,1	0,1	0,0	0,0	0,0	0,0	2,0	0,2	3,0	0,3	1,1	0,2	1,1	0,2
412	0,0	0,0	0,0	0,0	21,4	2,4	16,3	1,8	16,3	1,8	9,2	1,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
421	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	8,4	1,8	7,2	1,5
423	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	174,9	37,1	174,6	37,0
511	8,5	0,9	8,5	0,9	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	20,4	2,3	23,3	2,6	0,0	0,0	0,0	0,0
512	3,9	0,4	7,0	0,8	0,3	0,0	1,0	0,1	0,0	0,0	0,3	0,0	9,7	1,1	12,9	1,4	0,0	0,0	0,0	0,0
523	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	44,8	5,0	44,8	5,0	206,2	43,8	209,0	44,3
Total	900,1		900,1		900,0		900,0		900,1		900,1		900,1		900,1		471,4		471,4	

Appendix 6b. Land cover change matrices of five Dutch windows for the period of 1950 – 1990 (ha).

Window 7 “Noord-Brabant”

	AREA [ha]	CODE90																			
	CODE50	112	121	122	124	133	141	142	211	231	242	243	311	312	313	322	324	331	511	512	SUM
Discontinuous urban fabric	112	**6957**																			6957
Industrial or commercial units	121		**576**																		576
Road and rail networks and associated land	122			**55**																	55
Airports	124				**433**																433
Construction sites	133	**179**	**7**																		186
Green urban areas	141						**178**														178
Sport and leisure facilities	142							**457**													457
Non-irrigated arable land	211	**272**				**81**			**4376**	**1384**										**15**	6128
Pastures	231	**746**	**643**	**86**		**27**		**160**	**617**	**16245**	**828**	**38**	**39**		**101**					**231**	19761
Complex cultivation patterns	242	**2196**	**426**	**137**			**55**	**209**	**485**	**7998**	**27764**	**217**		**27**		**14**				**23**	39551
Land principally occupied by agriculture with significant areas of natural vegetation	243		**55**					**71**			**226**	**2554**	**65**	**306**	**73**						3350
Broad-leaved forest	311		**28**								**11**		**722**								760
Coniferous forest	312							**121**			**115**			**5369**						**48**	5654
Mixed forest	313	**209**	**160**								**60**				**2972**	**22**					3424
Moors and heathland	322										**105**		**33**			**758**					897
Transitional woodland/shrub	324												**25**								25
Beaches, dunes, sands	331																	**376**			376
Water courses	511																		**851**		851
Water bodies	512																			**386**	386
	SUM	10558	1896	278	433	109	232	1019	5479	25626	29110	2809	884	5702	3146	795		376	851	702	90005

Window 120 “Overijssel”

	AREA [ha]	CODE90																		
	CODE50	112	121	122	131	132	133	141	142	211	231	242	243	311	312	313	322	324	412	512	SUM
Discontinuous urban fabric	112	2910																			2910
Industrial or commercial units	121		127																		127
Road and rail networks and associated land	122																				
Mineral extraction sites	131																				
Dump sites	132																				
Construction sites	133																				
Green urban areas	141							36													36
Sport and leisure facilities	142								314												314
Non-irrigated arable land	211	14			25				22	5509	64	79									5714
Pastures	231	793	343				29	25	44	259	43201	2937								25	47656
Complex cultivation patterns	242	610	344								2275	3941			19						7189
Land principally occupied by agriculture with significant areas of natural vegetation	243	79		29		35					195		8163		107	276					8883
Broad-leaved forest	311													66							66
Coniferous forest	312								46						9955						10000
Mixed forest	313				50									109		2058					2217
Moors and heathland	322									361	398		178		321		1940				3199
Transitional woodland/shrub	324								32	39											70
Peat bogs	412									434	219			53					919		1625
Water bodies	512																				
	SUM	4406	814	29	75	35	29	61	457	6602	46353	6958	8341	228	10402	2334	1940		919	25	90008

Window 14 “Drenthe”

	AREA [ha]	CODE90																				
	CODE50	112	121	131	132	133	141	142	211	231	242	243	311	312	313	322	324	331	411	412	512	SUM
Discontinuous urban fabric	112	1131																				1131
Industrial or commercial units	121																					
Mineral extraction sites	131																				26	26
Dump sites	132																					
Construction sites	133						25															25
Green urban areas	141						118															118
Sport and leisure facilities	142							33														33
Non-irrigated arable land	211	78			34				14921	271	6				18				40			15367
Pastures	231	434	27						375	24554	3123	49			42						33	28638
Complex cultivation patterns	242	783	185	35			19	50	58	417	18515		14		11							20085
Land principally occupied by agriculturewith significant areas of natural vegetation	243	113						110	21		35	1673										1953
Broad-leaved forest	311	10								14			341									365
Coniferous forest	312								33					6284		59			10			6386
Mixed forest	313							145	27	29			15		4819	60						5095
Moors and heathland	322	41		49	52			69	630	518	947		57	646	932	4382			18	43	14	8397
Transitional woodland/shrub	324													114								114
Beaches, dunes, sands	331																	48				48
Moors and heathland	411																		46			46
Peat bogs	412								272	146			80		57					1589		2144
Water bodies	512																				28	28
	SUM	2590	212	84	86		162	407	16337	25949	22626	1722	506	7044	5878	4502		48	113	1633	102	90000

Window Y “Friesland”

	AREA [ha]	CODE90										
	CODE50	112	231	312	313	321	331	411	421	423	523	SUM
Discontinuous urban fabric	112	62										62
Pastures	231	6	1923				8					1937
Coniferous forest	312	25	16	405								446
Mixed forest	313				145							145
Natural grasslands	321					2701	63					2764
Beaches, dunes, sands	331					350	1932				430	2712
Inland marshes	411							111				111
Salt marshes	421					126			713			839
Intertidal flats	423						29		6	17460		17495
Sea and ocean	523						156				20467	20624
	SUM	93	1939	405	145	3178	2189	111	719	17460	20897	47136

Window 139 “Noord-Holland”

	AREA [ha]	CODE90																				
	CODE50	112	121	122	123	124	133	141	142	211	231	242	243	311	312	313	321	331	411	511	512	523	SUM
Discontinuous urban fabric	112	10824																					10824
Industrial or commercial units	121		1340				58																1398
Road and rail networks and associated land	122			226																			226
Port areas	123				1233																		1233
Airports	124					595																	595
Construction sites	133	1353	90		67			17	66														1593
Green urban areas	141							739															739
Sport and leisure facilities	142								1321														1321
Non-irrigated arable land	211	1473	570	42	230	873	1221	329	1374	17036				136		20			51	321	55		23732
Pastures	231	3407	616	202	77		442	504	1109		23932		137	83					49		242		30800
Complex cultivation patterns	242		230		51		34	107				180											602
Land principally occupied by agriculturewith significant areas of natural vegetation	243												129	80									209
Broad-leaved forest	311		34											2785									2819
Coniferous forest	312														274		71						346
Mixed forest	313															51							51
Natural grasslands	321	98	138			7			242					47			4703						5234
Beaches, dunes, sands	331																	599					599
Inland marshes	411																		203				203
Water courses	511																			2010	28		2038
Water bodies	512																				969		969
Sea and ocean	523																					4477	4477
	SUM	17154	3018	469	1659	1475	1754	1696	4111	17036	23932	180	267	3131	274	71	4774	599	303	2331	1294	4477	90007

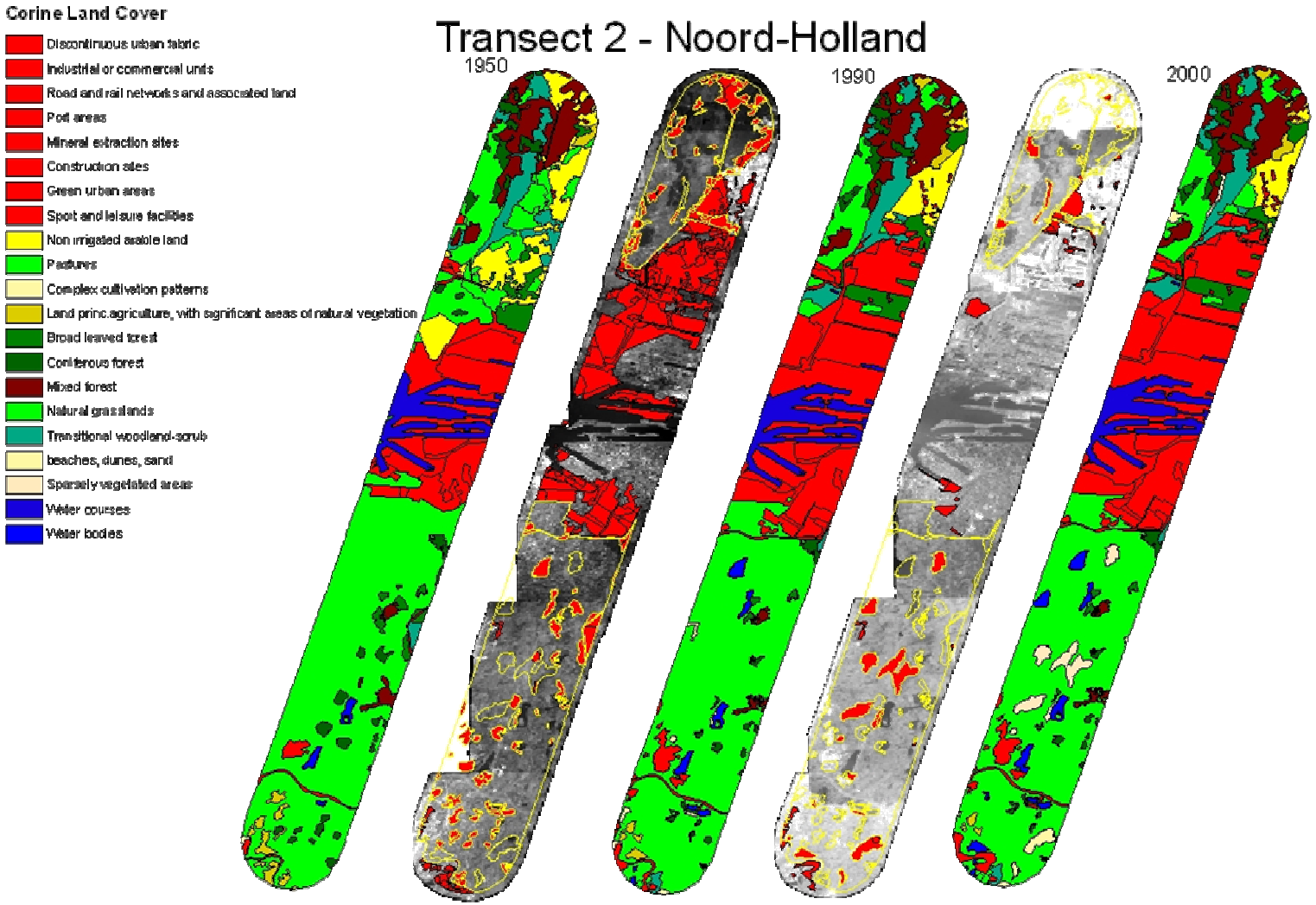
Appendix 6c. Land cover changes of five Dutch windows for the period of 1950 – 1990 (as % of 1950 land cover).

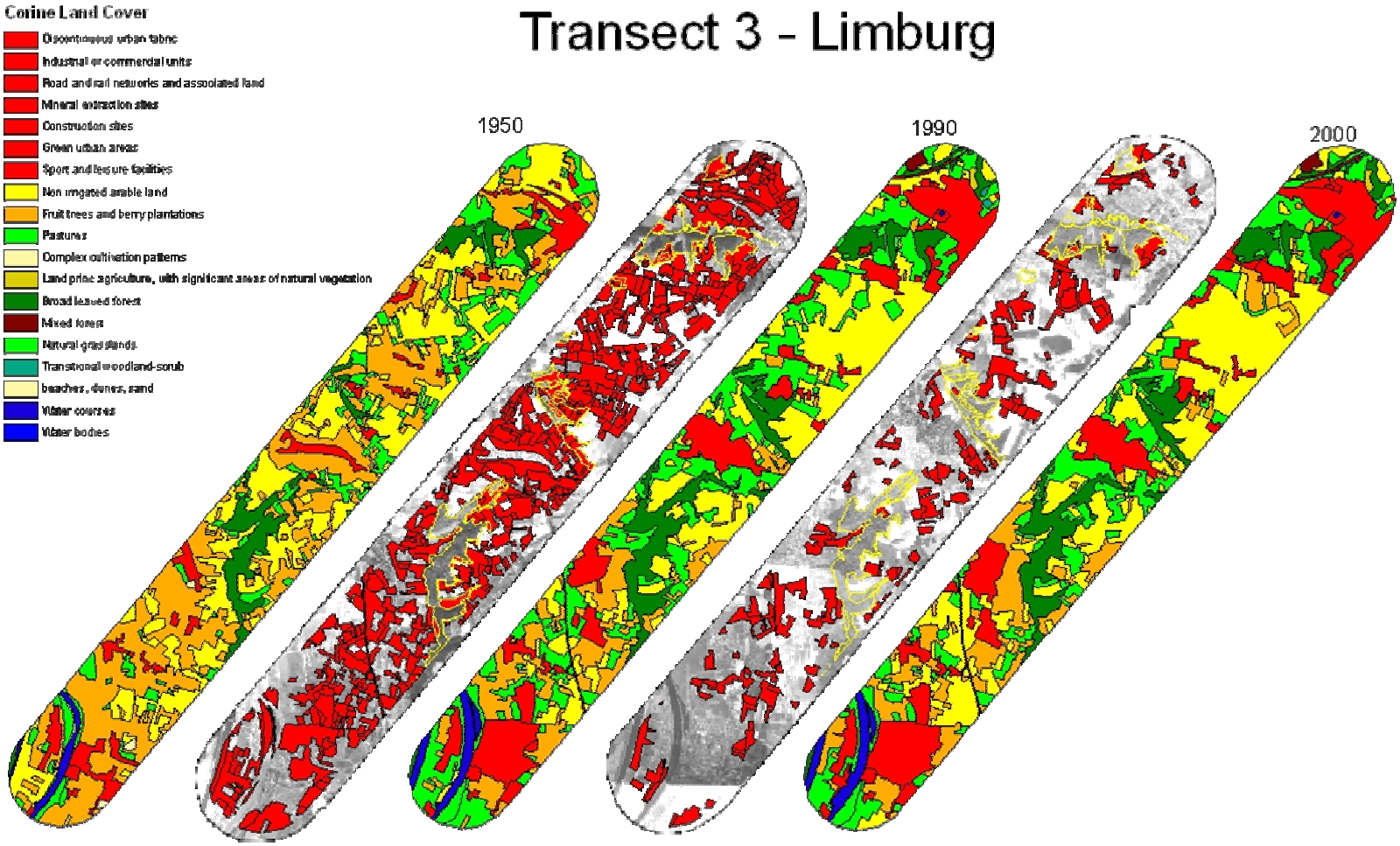
		7(Brabant)	120(Overijssel)	14(Drenthe)	139(Holland)	Y "Friesland"
CORINE land cover class name	Code	Change (%)	Change (%)	Change (%)	Change (%)	Changes (%)
continuous urban fabric	111					
discontinuous urban fabric	112	51,8	51,4	128,9	58,5	49,8
industrial and commercial units	121	229,0	539,3		115,9	
road and rail networks and associated	122	405,5			108,0	
port areas	123				34,5	
airports	124				148,0	
mineral extraction sites	131			222,7		
dump sites	132					
construction sites	133	-41,6		-100,0	10,1	
green urban areas	141	30,7	70,8	37,5	129,3	
port and leisure facilities	142	122,9	45,4	1122,0	211,3	
non-irrigated arable land	211	-10,6	15,5	6,3	-28,2	
permanently irrigated land	212					
rice fields	213					
vineyards	221					
fruit trees and berry plantation	222					
olive groves	223					
pastures	231	29,7	-2,7	-9,4	-22,3	0,1
annual cops associated with permane	241					
complex cultivation patterns	242	-26,4	-3,2	12,7	-70,2	
land principally occupied by agricultur	243	-16,1	-6,1	-11,8	27,3	
agro-forestry areas	244					
broad-leaved forest	311	16,3	244,9	38,7	11,1	
coniferous forest	312	0,8	4,0	10,3	-20,7	-9,3
mixed forest	313	-8,1	5,3	15,4	38,2	
natural grasslands	321				-8,8	15,0
moors and heath lands	322	-11,3	-39,4	-46,4		
sclerophyllous vegetation	323					
transitional woodland-scrub	324	-100,0	-100,0	-100,0		
beaches, sand, dunes	331			0,0		-19,3
bare rocks	332					
sparsely vegetated areas	333					
burnt areas	334					
glaciers and perpetual snow	335					
inland marshes	411			146,3	49,6	
peat bogs	412		-43,5	-23,8		
salt marshes	421					-14,3
salines	422					
intertidal flats	423					-0,2
water courses	511				14,4	
water bodies	512	81,9		257,5	33,6	
coastal lagoons	521					
estuaries	522					
sea and ocean	523					1,3

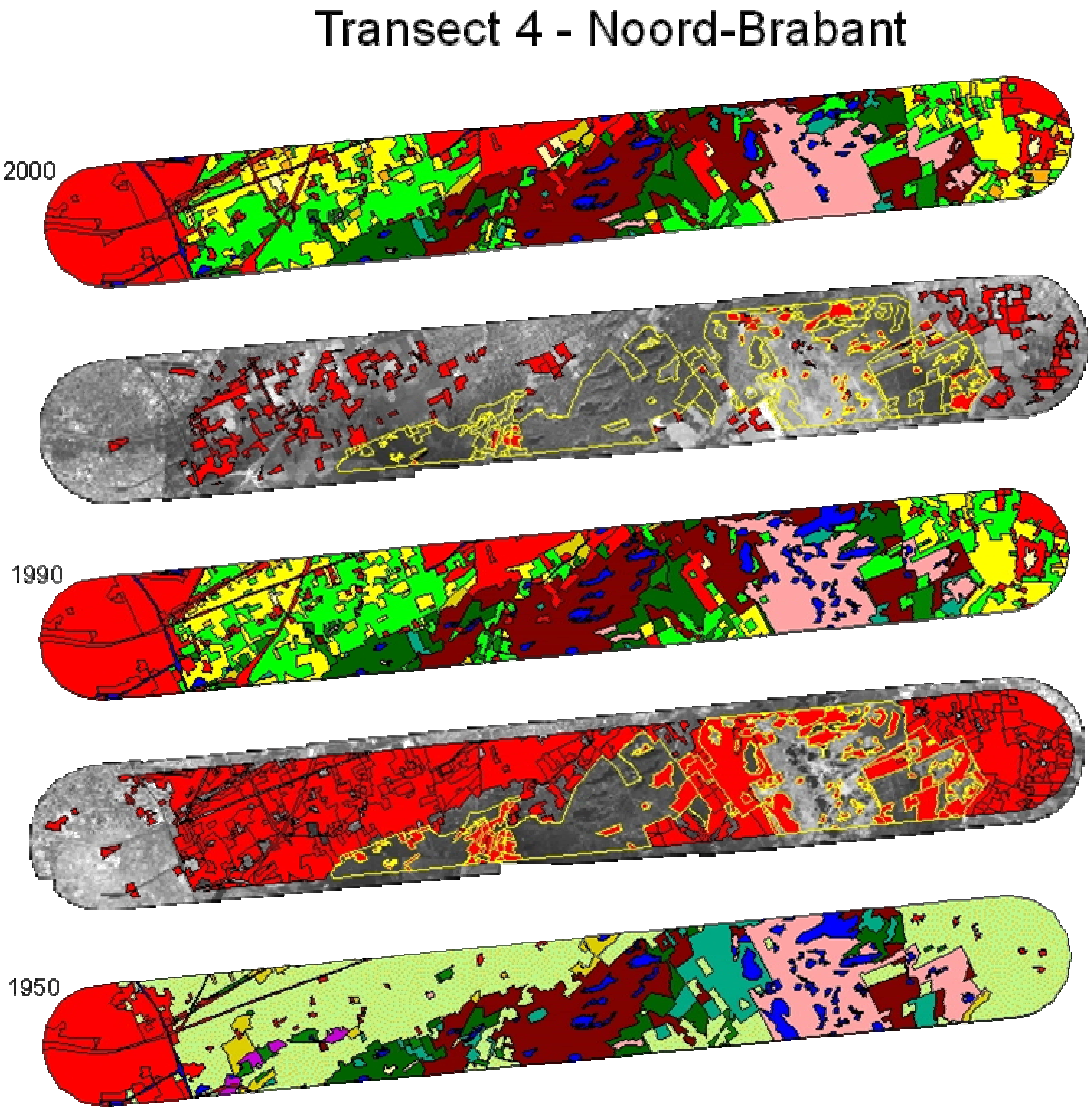
Appendix 7 Maps of land cover and land cover changes of 9 Dutch transects.

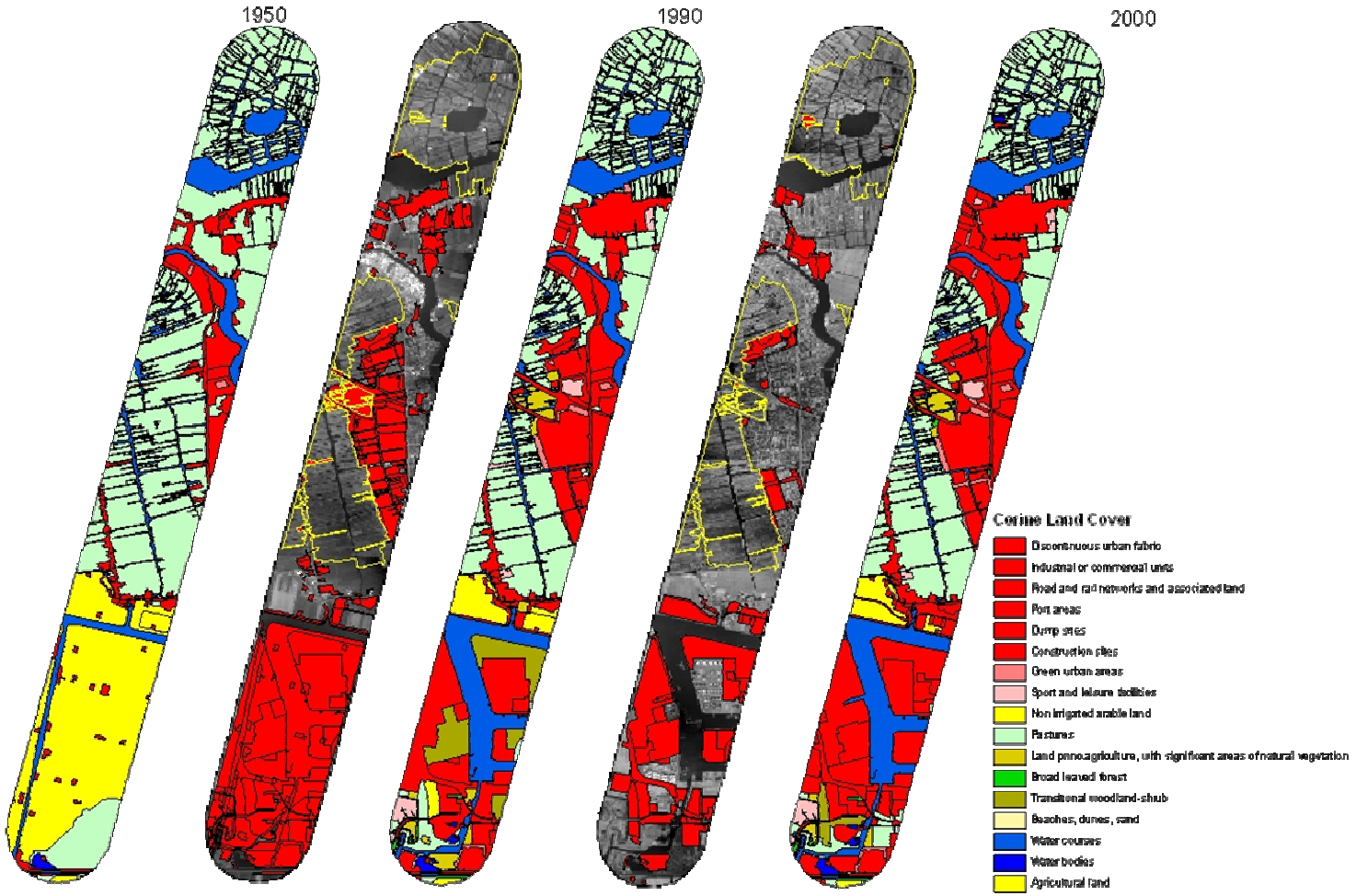
Transect 1 "Loonse &Drunense Duinen" – Noord-Brabant
Transect 2 "Kennemer Duinen" – Noord-Holland
Transect 3 "Bemelerberg" – Limburg
Transect 4 "Kampina" – Noord-Brabant
Transect 5 "Jisperveld" – Noord-Holland
Transect 6 "Drentse Aa" - Drenthe
Transect 7 "Dwingelerveld" – Drenthe
Transect 8 "Overijsselse Vecht" – Overijssel
Transect 9 "Terschelling" – Friesland

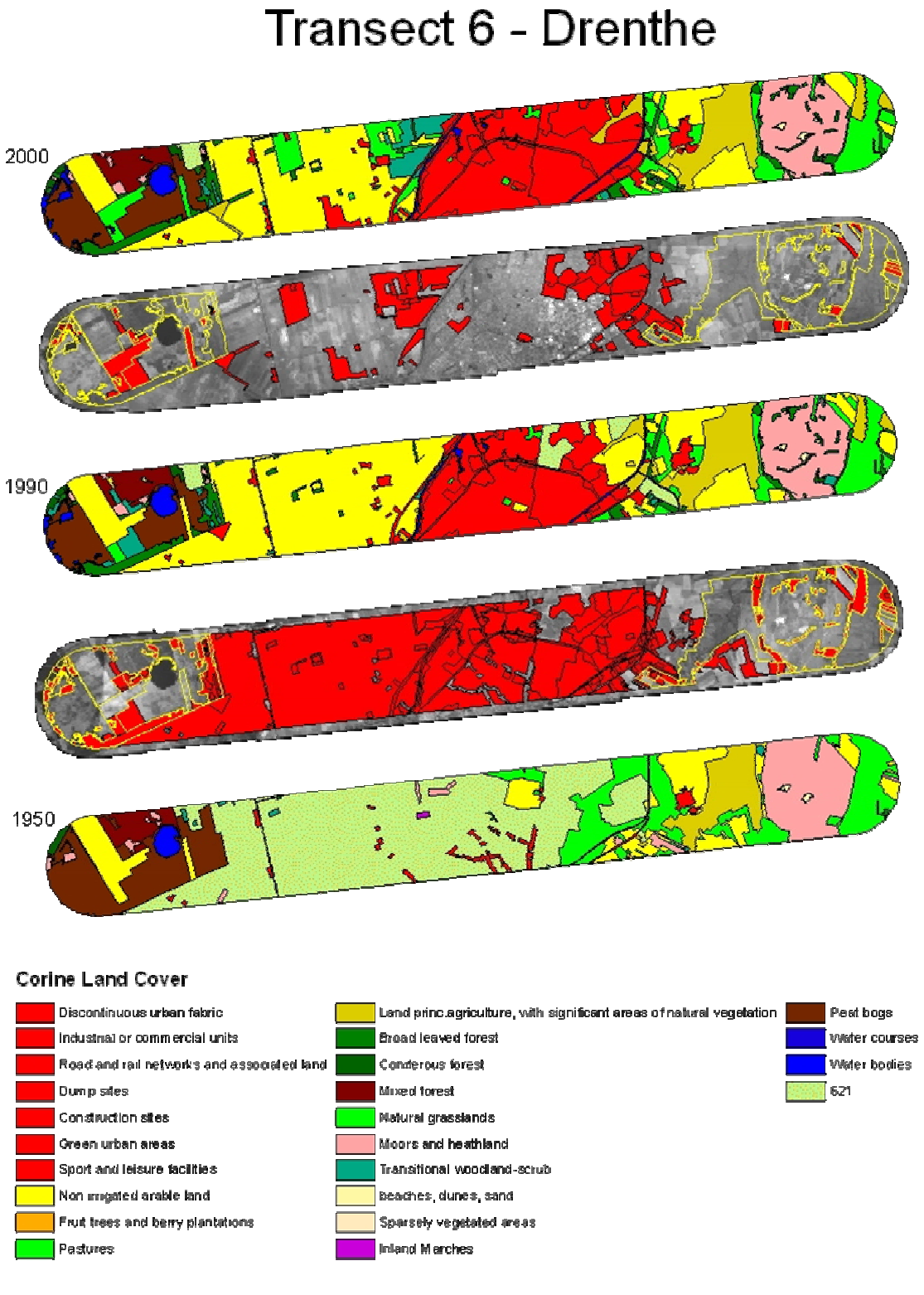

Transect 1 - Noord-Brabant
2000
1990
1950
Corine Land Cover
Discontinuous urban fabric
Industrial or commercial units
Road and rail networks and associated land
Construction sites
Green urban areas
Sport and leisure facilities
Non irrigated arable land
Fruit trees and berry plantations
Pastures
Broad leaved forest
Coniferous forest
Mixed forest
Moors and heathland
Transitional woodland-scrub
beaches, dunes, sand
Inland Marshes
Water courses
Water bodies
Sea and ocean
821


Corine Land Cover
Discontinuous urban fabric
Industrial or commercial units
Road and rail networks and associated land
Port areas
Mineral extraction sites
Construction sites
Green urban areas
Sport and leisure facilities
Non irrigated arable land
Pastures
Complex cultivation patterns
Land princ.agriculture, with signif.icant areas of natural vegetation
Broad leaved forest
Coniferous forest
Mixed forest
Natural grasslands
Transitional woodland-scrub
beaches, dunes, sand
Sparsely vegetated areas
Water courses
Water bodies
Transect 2 - Noord-Holland
1950
1990
2000

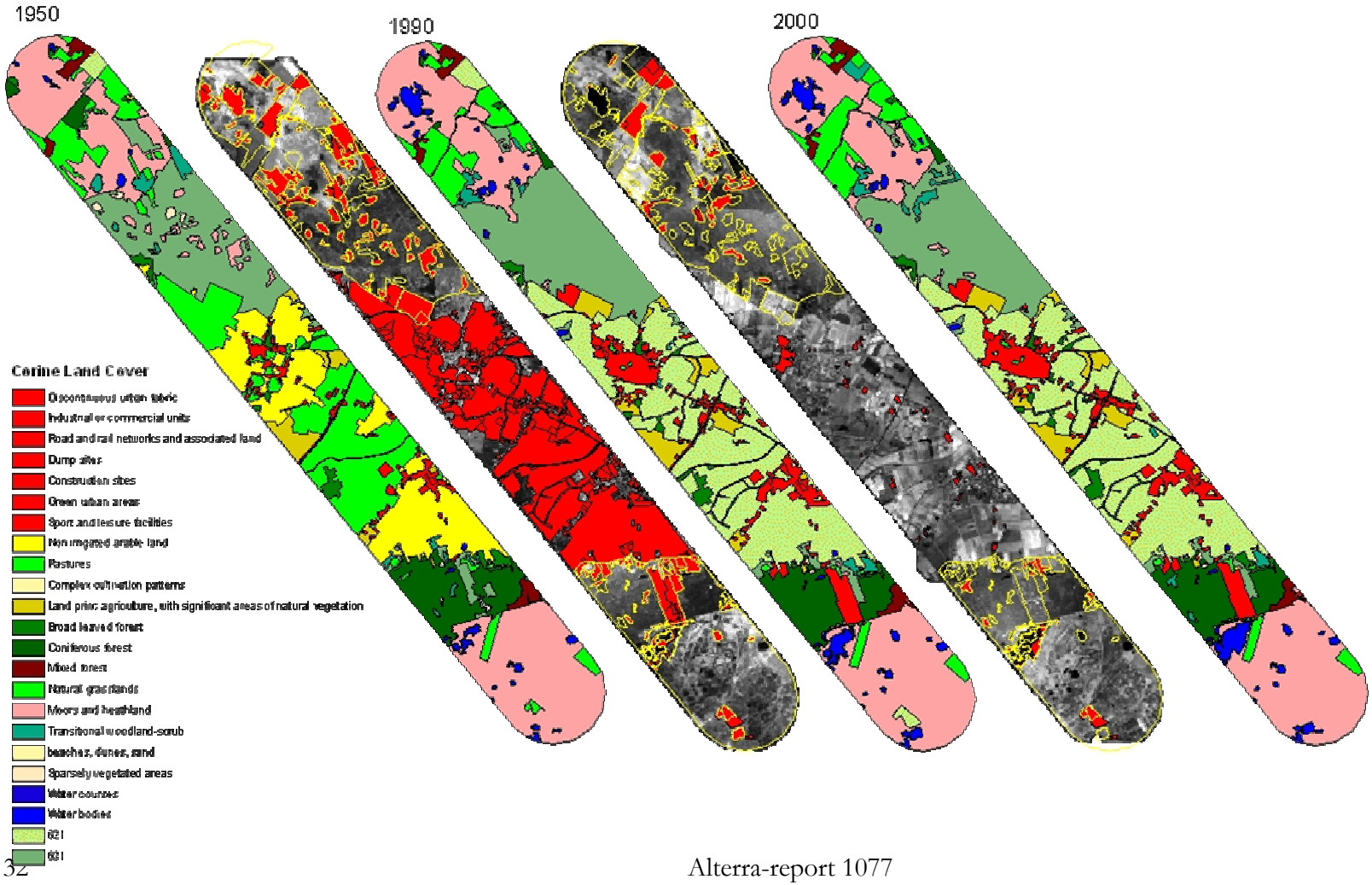

Corine Land Cover
Discontinuous urban fabric
Industrial or commercial units
Road and rail networks and associated land
Mineral extraction sites
Construction sites
Green urban areas
Sport and leisure facilities
Non irrigated arable land
Fruit trees and berry plantations
Pastures
Complex cultivation patterns
Land prin. agriculture, with significant areas of natural vegetation
Broad leaved forest
Mixed forest
Natural grasslands
Transitional woodland-scrub
beaches, dunes, sand
Water courses
Water bodies
Transect 3 - Limburg
1950
1990
2000

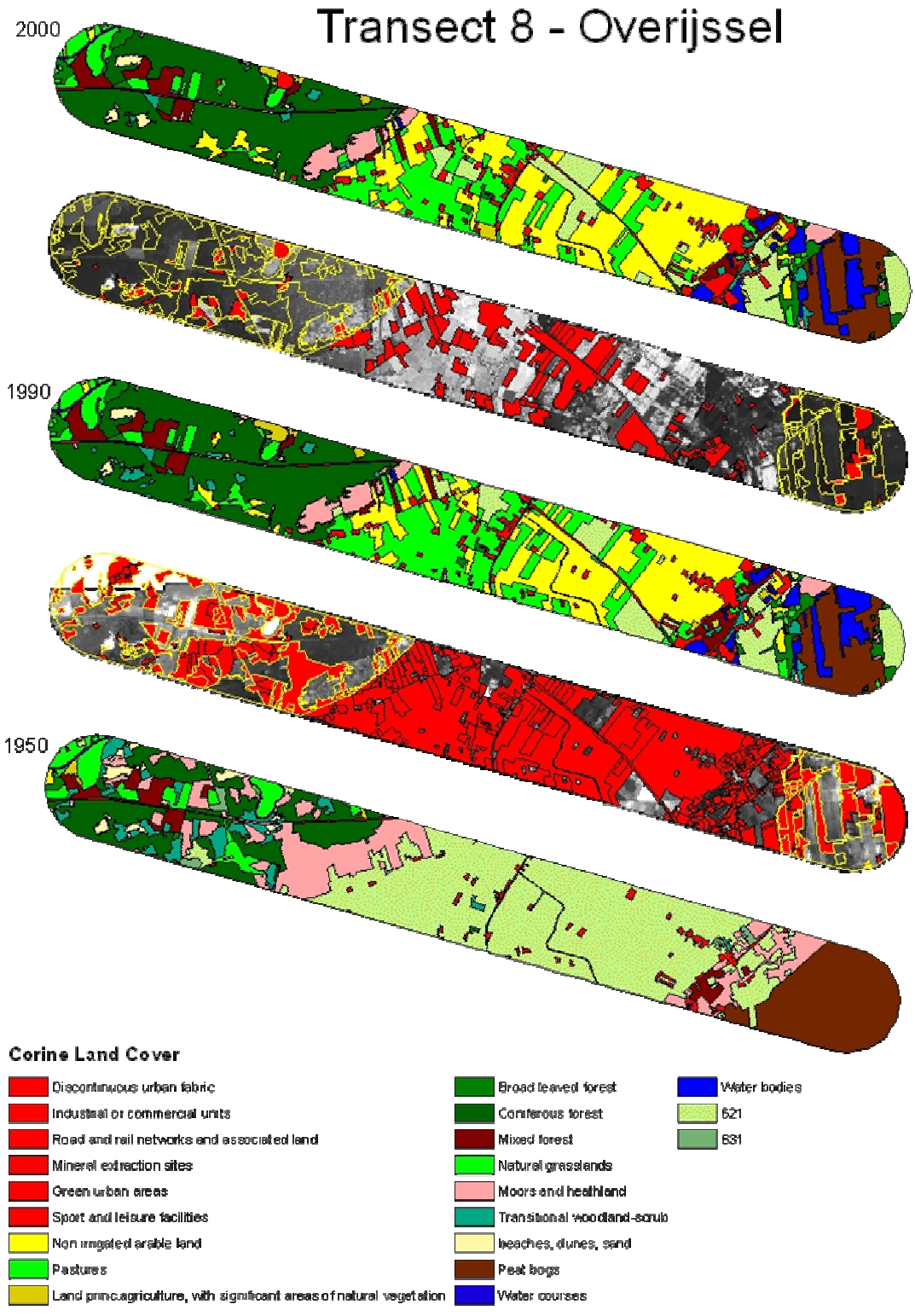

Transect 4 - Noord-Brabant
2000
1990
1950
Corine Land Cover
Discontinuous urban fabric
Industrial or commercial units
Road and rail networks and associated land
Dump sites
Construction sites
Green urban areas
Sport and leisure facilities
Non-irrigated arable land
Fruit trees and berry plantations
Pastures
Complex cultivation patterns
Land princ.agriculture, with significant areas of natural vegetation
Broad leaved forest
Coniferous forest
Mixed forest
Natural grasslands
Moors and heathland
Transitional woodland-scrub
beaches, dunes, sand
Inland Marches
Water courses
Water bodies
621

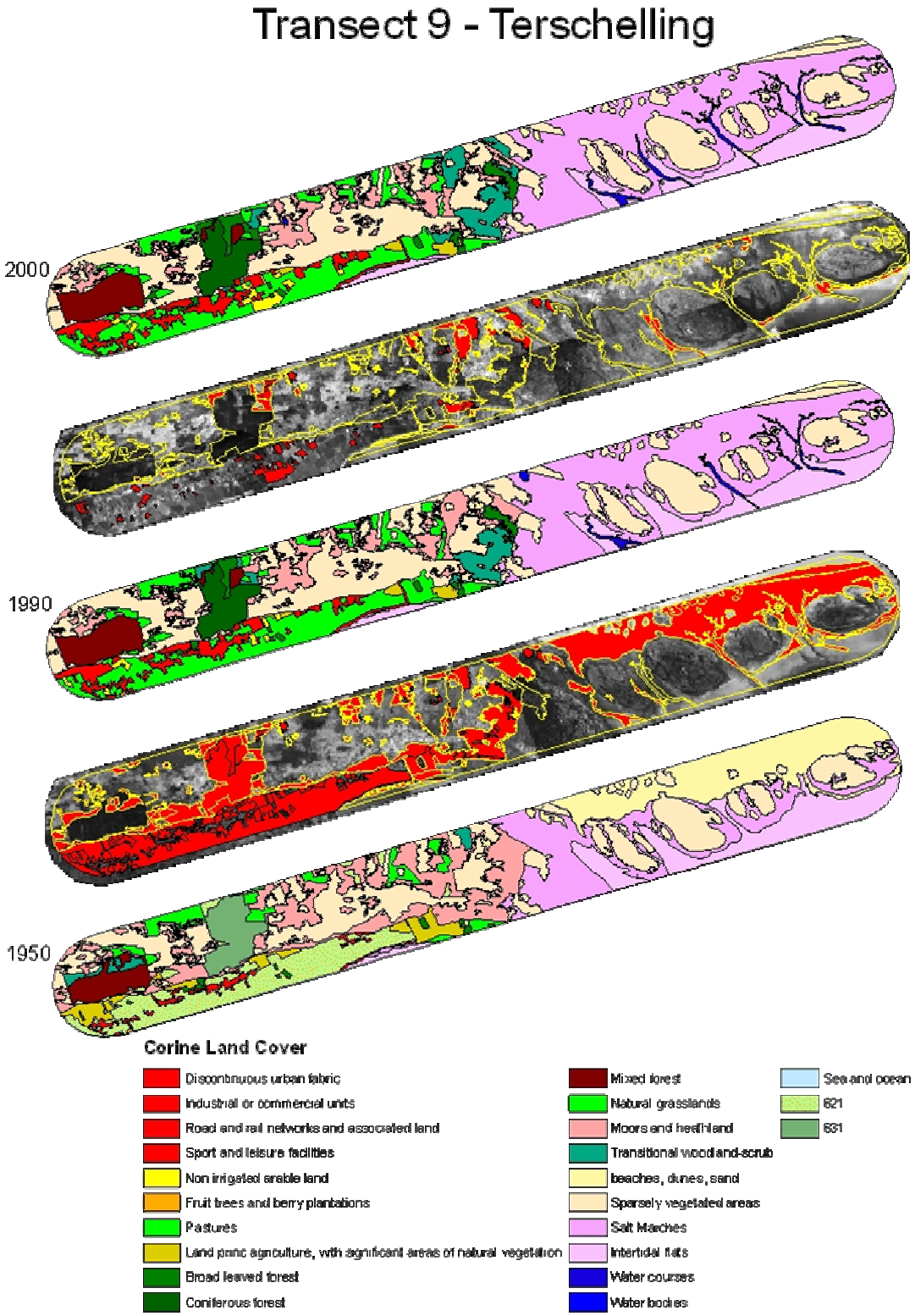

Transect 5 - Noord-Holland
1950
1990
2000
Corine Land Cover
Discontinuous urban fabric
Industrial or commercial units
Road and rail networks and associated land
Port areas
Dump sites
Construction sites
Green urban areas
Sport and leisure facilities
Non irrigated arable land
Pastures
Land principaly agriculture, with significant areas of natural vegetation
Broad leaved forest
Transitional woodland-shrub
Beaches, dunes, sand
Water courses
Water bodies
Agricultural land


Transect 6 - Drenthe
2000
1990
1950
Corine Land Cover
Discontinuous urban fabric
Industrial or commercial units
Road and rail networks and associated land
Dump sites
Construction sites
Green urban areas
Sport and leisure facilities
Non irrigated arable land
Fruit trees and berry plantations
Pastures
Land princ.agriculture, with significant areas of natural vegetation
Broad leaved forest
Coniferous forest
Mixed forest
Natural grasslands
Moors and heathland
Transitional woodland-scrub
Beaches, dunes, sand
Sparsely vegetated areas
Inland Marshes
Peat bogs
Water courses
Water bodies
621

Transect 7 - Drenthe




Transect 8 - Overijssel
2000
1990
1950
Corine Land Cover
Discontinuous urban fabric
Industrial or commercial units
Road and rail networks and associated land
Mineral extraction sites
Green urban areas
Sport and leisure facilities
Non irrigated arable land
Pastures
Land princ.agriculture, with significant areas of natural vegetation
Broad leaved forest
Coniferous forest
Mixed forest
Natural grasslands
Moors and heathland
Transitional woodland-scrub
beaches, dunes, sand
Peat bogs
Water courses
Water bodies
521
631


Transect 9 - Terschelling
2000
1990
1950
Corine Land Cover
Discontinuous urban fabric
Industrial or commercial units
Road and rail networks and associated land
Sport and leisure facilities
Non irrigated arable land
Fruit trees and berry plantations
Pastures
Land princ agriculture, with significant areas of natural vegetation
Broad leaved forest
Coniferous forest
Mixed forest
Natural grasslands
Moors and heathland
Transitional woodland-scrub
beaches, dunes, sand
Sparsely vegetated areas
Salt Marshes
Intertidal flats
Water courses
Water bodies
Sea and ocean
621
631

Appendix 8 DPSIR analyses for the various Dutch transects.

Transect 1 "Loonse & Drunense Duinen"

Driving forces	Demographic trends Transport network Cultural trends (more living space)	Agricultural policies, support system Transport network		Forestry
Pressures	**Urbanisation**	**Farming intensification**	**Land Abandonment**	**Afforestation**
State Land Cover Changes	Increase in artificial areas (112,121,141,142) at the expense of agriculture	Increase in field size Change from 242 into 231		* from 411 (inland marshes) and 621 (farmerd land) into 311 (broadleaved forest) * from 331 (sand dunes) to 322 (heathland)
Impact On Biodiversity	Loss of valuable habitats Possible gains due to increased environmental management	Fragmentation of valuable habitats Eutrophication Disappearance small landscape elements		* Loss of wetlands * Loss of inland dunes at the expense of heathland and forest * Loss of coniferous forest at the expense of broadleaved forest *Creation of forest habitats *Creation of moors and heathland habitat
Responses				Deforestation to give more opportunities to sandblown inland dunes

Other identified pressures	
Atmospheric deposition (eg. extension of Molinia caerulea in heatlands)	Forest fires
Ground water manipulation	
Recreation	

Transect 2 “Kennemer Duinen”

Driving forces	- Demographic trends - Transport network - Cultural trends (more living space)	- Agricultural policies, support system - Transport network		- Forestry
Pressures	**Urbanisation**	**Farming intensification**	**Land Abandonment**	**Afforestation**
State Land Cover Changes	- Increase in artificial areas. Conversion of pastures into artificial areas - Conversion of natural grasslands/dunes into artificial areas.	Increase in field size Change from natural grasslands into agricultural classes		Agricultural land into forest Internal Forest and semi-natural changes
Impact On Biodiversity	- Loss of valuable habitats - Possible degradation of coastal habitats (331, 321) - Possible gains due to increased environmental management - Disturbance due to recreation	Fragmentation of valuable habitats Loss of characteristic landscape elements		Creation of forest habitats
Responses	- Groundwater exploitation diminished or stopped (stopped in 2002 in Kennemerduinen). - Limited access to dunes. - Stimulate natural processes as sandblown dunes by removing top-layer / vegetation.			

Other identified pressures	
Atmospheric deposition	Recreation
Ground water level manipulation. Exploitation of ground water and infiltration of river water for drinking water. Desiccation.	

Transect 3 “Bemelerberg”

Driving forces	- Demographic trends - Transport network - Cultural trends (more living space)	- Agricultural policies, support system - Transport network		
Pressures	**Urbanisation**	**Farming intensification**	**Land Abandonment**	**Afforestation**
State Land Cover Changes	- Increase in artificial areas. - Conversion of pastures, arable land and orchards into artificial areas.	- Change from orchards into arable land		Change from agricultural land into broadleaf forest
Impact On Biodiversity	- Loss of valuable habitats	- Fragmentation of valuable habitats - Loss of characteristic landscape element		Creation of forest habitats
Responses	Increased nature management for remaining semi-natural areas	Subsidies for orchards (“hoogstambomen”)		

Other identified pressures	
Atmospheric deposition of nutrients	Water pollution and water level management
Recreation	Agricultural practises (fertiliser, intensification of soil use, removal of hedges etc.)
Disturbance	

Transect 4 “Kampina”

Driving forces	Demographic trends Transport network Cultural trends (leisure time)	Agricultural policies, support system Transport network		Subsidies for planting Ageing population Subsidies for nature development
Pressures	**Urbanisation**	**Farming intensification**	**Land Abandonment**	**Afforestation**
State Land Cover Changes	- Increase in artificial areas, despite of agricultural land	- Lost of complex cultivation patterns to pastures. - Increase in field size		- Internal changes within the forest and semi-natural class
Impact On Biodiversity	- Loss of valuable habitats - Disturbance - Pollution	- Loss of valuable grasslands & other semi-natural habitats		- Possible creation of more diverse habitats
Responses	- Increased environmental management (removal organic sediments fens)			

Other identified pressures	
Intensive agricultural activities in the surroundings	

Transect 5 “Jisperveld”

Driving forces	Demographic trends Transport network Cultural trends (leisure time)	Agricultural policies, support system Transport network		
Pressures	**Urbanisation**	**Farming intensification**	**Land Abandonment**	**Afforestation**
State Land Cover Changes	Enormous increase in artificial areas despite of pastures and a conversion of agricultural land into water courses (infrastructure)	Increase in field size and loss of grasslands to artificial areas.		
Impact On Biodiversity	Loss of “veenweide gebied”. Increased recreation Increased disturbance. Increased fragmentation Loss of openness landscape	Loss of valuable grasslands & other wetland related semi-natural habitats, also due to loss of traditional labour intensive faming practices (by boat)		
Responses	Increased environmental management. Agro-environmental schemes			

Other identified pressures	
Slightly brackish water disappears	

Transect 6 “Drentse Aa”

Driving forces	Demographic trends Transport network Cultural trends (leisure time)	Agricultural policies, support system Transport network		Loss of labour intensive farming practices
Pressures	**Urbanisation**	**Farming intensification**	**Land Abandonment**	**Afforestation**
State Land Cover Changes	Increased artificial areas concentrated around Assen despite of agricultural land	No large changes in terms of land cover, but number of farms drops		Conversion of moors, heathland, peatbogs and agricultural land into forest
Impact On Biodiversity	Increased recreation Increased disturbance.			
Responses	Increased environmental management. Agro-environmental schemes.	More sustainable farming practices		

Other identified pressures	
Lowering of water table, Drainage, diminishing of seepage and water pollution..	Disturbance by military training.
Atmospheric deposition	
Eutrophication	

Transect 7 “Dwingelerveld”

Driving forces	Demographic trends Transport network Cultural trends (leisure time)	Agricultural policies, support system Transport network	Traditional labour-intensive farming practices become too expensive	
Pressures	**Urbanisation**	**Farming intensification**	**Land Abandonment**	**Afforestation**
State Land Cover Changes	Loss of agricultural land into artificial areas and more specifically loss of arable land to discontinuous urban fabric		Sheep herds are more difficult to maintain on heathlands nowadays.	Change of moors and heathland into forest
Impact On Biodiversity	Increased recreation Increased disturbance Dessication		High quality heatlands turn gradually into grasslands	
Responses	Increased environmental management. Improved infrastructure for recreation. Restricted access to area (keep on tracks)		Agri-enviornmenta schemes (two subsidised herds)	Agri-enviornmenta schemes (two subsidised herds)

Other identified pressures	
Lowering of the water table.	
Atmospheric deposition.	
Agriculture	

Transect 8 “Overijsselse Vecht”

Driving forces	Demographic trends Transport network Cultural trends (leisure time)	Agricultural policies, support system Transport network		
Pressures	**Urbanisation**	**Farming intensification**	**Land Abandonment**	**Afforestation**
State Land Cover Changes	Loss of agricultural land to artificial areas	Change of pastures and semi-natural areas into arable land		Change of moors and heathland into forest
Impact On Biodiversity	Loss of habitats Increased recreation Increased disturbance Desiccation	Desiccation of valuable habitats		
Responses	Increased environmental management. Improved infrastructure for recreation.	Improved water management (raising groundwaterlevel in engbertsdijksvenen) to restore natural habitats		Special efforts to restore active raised bogs (engbertsdijksvenen). Recreation possibilities

Other identified pressures	
Atmospheric deposition	Lowering of the water table and water pollution
Acidification	
Eutrophication	

Transect 9 “Terschelling”

Driving forces	Demographic trends Transport network Cultural trends (leisure time)	Agricultural policies, support system Transport network	Ageing population Changes in agricultural subsidies Cultural changes (no farming on island)	
Pressures	**Urbanisation**	**Farming intensification**	**Land Abandonment**	**Afforestation**
State Land Cover Changes	Increase in sport and leisure facilities despite of agricultural land (243)	loss of natural grasslands to pastures in dune area (1950-1970)		Loss of some forests and semi-natural habitats to water (deforestation)
Impact On Biodiversity	Possible degradation of coastal habitats (331, 321, 333, 421) Increased recreaction Increased disturbance	Loss of valuable grasslands & other semi-natural habitats	Creation of new valuable habitats	
Responses	Possible gains due to increased environmental management (231 to 321). Limited access to terrains.			

Other identified pressures	
Recreation	
Water pollution	
Shipping	

Appendix 9 Land cover statistics and land cover change matrices at CORINE level 3 of 9 Dutch transects.

Appendix 9a. Land cover statistics at CORINE level 3 of 9 Dutch transects (1950, 1990 and 2000).

1950 land cover statistics of 9 Dutch transects.

1950	track1		track 2		track 3		track 4		track 5		track 6		track 7		track 8		track 9	
	km2	%	km2	%	km2	%	km2	%	km2	%	km2	%	km2	%	km2	%	km2	%
112	0,4	1,2	0,9	2,6	2,4	7,6	2,8	8,6	2,0	6,1	0,5	1,6	0,5	1,5	0,3	0,8	0,4	1,1
121	0,1	0,3	0,7	2,1	0,0	0,1	0,8	2,5	1,0	3,1			0,2	0,6	0,2	0,5	0,0	0,0
122	0,0	0,1	0,3	0,8			0,3	1,0	0,3	1,0	0,1	0,2	0,0	0,1	0,2	0,5	0,0	0,1
123			1,5	4,6					0,0	0,1								
131			0,0	0,0	0,1	0,4									0,1	0,2		
132													0,0	0,0				
133			2,0	6,0	0,1	0,2	0,0	0,1	0,3	0,8								
141	0,0	0,1	0,1	0,2			0,1	0,2	0,0	0,1			0,1	0,3	0,0	0,0		
142			0,2	0,6	0,1	0,4	0,0	0,1					0,0	0,1				
211			2,4	7,2	9,6	30,8			7,5	22,7	3,5	10,7	5,4	16,2	0,0	0,1		
222	0,0	0,1			12,2	38,9	0,0	0,1			0,0	0,0					0,0	0,0
231			1,2	3,6	3,9	12,4			16,0	48,2	4,4	13,3	7,4	22,4	1,5	4,6	0,7	2,0
242					0,1	0,3							0,0	0,0				
243			0,5	1,5			0,7	2,2			1,8	5,3	0,7	2,1	0,1	0,3	0,9	2,9
311	0,6	1,8	0,9	2,8	2,2	6,9	0,4	1,3	0,0	0,0	0,1	0,2	0,6	1,7	0,1	0,4	0,2	0,5
312	7,0	21,2	1,1	3,4			1,8	5,6			0,1	0,3	2,4	7,2	4,2	12,8	0,0	0,0
313	0,6	1,8	2,1	6,2			4,5	13,6			0,7	2,2	0,4	1,3	1,0	3,0	0,8	2,4
321			16,1	48,3	0,3	1,0							0,1	0,2	0,0	0,1	0,5	1,4
322	1,2	3,6					3,5	10,6			3,4	10,2	8,8	26,5	4,7	14,1	4,9	14,8
324	0,5	1,4	1,4	4,3			2,1	6,5			0,1	0,3	0,5	1,4	1,4	4,1	0,3	0,9
331	2,7	8,0	0,0	0,1	0,0	0,1	0,0	0,1			0,0	0,1	0,0	0,1	0,4	1,3	4,6	13,8
333											0,0	0,0	0,1	0,3			8,0	24,1
411	1,0	3,1					0,2	0,7			0,0	0,1						
412											3,2	9,7			4,2	12,8		
421																	4,4	13,4
423																	3,0	9,1
511	0,2	0,6	1,7	5,1	0,3	1,1	0,1	0,4	4,8	14,5	0,1	0,3	0,1	0,2	0,2	0,6		
512	0,1	0,2	0,2	0,5	0,0	0,0	1,5	4,7	0,1	0,2	0,3	0,8	0,3	0,9	0,0	0,0		
621	18,7	56,5					13,8	42,0	1,0	3,0	14,8	44,8	0,2	0,5	14,3	43,1	3,3	10,0
631													5,4	16,2	0,2	0,8	1,2	3,5

1990 land cover statistics of 9 Dutch transects.

1990	track1		track 2		track 3		track 4		track 5		track 6		track 7		track 8		track 9	
	km2	%	km2	%	km2	%	km2	%	km2	%	km2	%	km2	%	km2	%	km2	%
112	2,4	7,3	1,6	4,9	5,2	16,7	4,7	14,2	4,7	14,2	3,6	11,0	1,1	3,3	0,6	1,7	0,6	1,9
121	0,6	1,8	3,4	10,2	0,4	1,2	1,6	4,8	1,6	5,0	1,5	4,6	0,4	1,3	0,5	1,6	0,0	0,1
122	0,3	1,0	0,8	2,5	0,1	0,4	0,5	1,6	0,8	2,4	0,3	1,1	0,1	0,4	0,4	1,1	0,1	0,3
123			2,4	7,1					1,1	3,5					0,0	0,0		
131					0,2	0,7			0,0						0,1	0,4		
132									0,0	0,1			0,0	0,1				
133	0,1	0,2	0,3	1,0	0,1	0,3	0,1	0,3	3,0	9,0	0,7	2,2	0,1	0,3				
141	0,3	0,9	0,2	0,6	0,0	0,0	0,2	0,6	0,3	1,0	0,6	2,0	0,1	0,4	0,0	0,1		
142	0,4	1,2	0,6	1,9	0,3	1,0	0,8	2,3	0,4	1,3	0,2	0,7	0,6	2,0	0,1	0,4	0,4	1,3
211			1,0	3,0	8,1	25,8	4,5	13,7	0,2	0,7	12,2	37,1			6,5	19,8	0,1	0,4
222	0,2	0,5			4,4	14,0	0,0	0,1									0,0	0,0
231			0,3	0,9	8,1	25,8	6,1	18,6	11,1	33,7	2,1	6,3	1,8	5,5	6,5	19,7	3,8	11,3
242			0,0	0,1			0,1	0,3										
243			0,3	1,0	0,0	0,2	0,5	1,5	0,7	2,2	2,4	7,3	1,2	3,7	0,4	1,1	0,2	0,6
311	1,5	4,4	1,0	3,1	3,3	10,5	0,9	2,6	0,1	0,4	1,4	4,3	0,7	2,0	1,0	3,0	0,5	1,5
312	7,6	23,1	0,8	2,4			2,3	6,9			0,2	0,5	1,9	5,9	7,5	22,8	0,9	2,8
313	0,6	1,9	2,2	6,6	0,1	0,3	5,7	17,3			0,7	2,1	0,4	1,2	1,5	4,4	1,1	3,4
321			14,5	43,4	0,3	1,0	0,1	0,3									0,4	1,3
322	1,0	3,1					3,0	9,1			2,7	8,2	8,2	24,6	1,0	3,0	2,7	8,1
324	0,3	0,9	1,5	4,4	0,0	0,1	0,5	1,5	1,4	4,3	0,6	1,7	0,4	1,1	0,7	2,0	0,8	2,4
331	2,2	6,6	0,1	0,3			0,0	0,0			0,0	0,1	0,0	0,1	0,2	0,7	0,1	0,4
333																	10,1	30,4
411	0,2	0,6																
412											2,0	6,0			2,0	6,0		
421																	8,3	25,0
423																	2,6	7,7
511	0,1	0,4	1,8	5,5	0,6	1,9	0,2	0,6	6,4	19,3	0,3	0,8	0,1	0,3	0,2	0,5	0,3	1,0
512	0,1	0,2	0,4	1,1	0,0	0,0	1,3	3,8	0,1	0,4	0,4	1,2	0,8	2,4	1,2	3,6	0,0	0,1
621	15,1	45,8							0,9	2,7	1,0	3,0	9,4	28,2	2,6	8,0		
631													5,7	17,3				

2000 land cover statistics of 9 Dutch transects.

2000	track1		track 2		track 3		track 4		track 5		track 6		track 7		track 8		track 9	
	km2	%	km2	%	km2	%	km2	%	km2	%	km2	%	km2	%	km2	%	km2	%
112	2,7	8,1	1,6	4,9	5,6	17,8	4,8	14,6	5,5	16,5	4,6	13,9	1,3	3,8	0,6	1,9	0,7	2,1
121	0,7	2,0	3,5	10,5	0,5	1,5	1,8	5,4	3,9	11,9	2,2	6,6	0,5	1,4	0,6	1,9	0,1	0,2
122	0,3	1,0	0,9	2,6	0,1	0,4	0,6	1,9	1,1	3,3	0,3	1,1	0,1	0,4	0,4	1,1	0,1	0,3
123			2,5	7,4					1,0	2,9								
131					0,1	0,4				0,0					0,1	0,3		
132							0,0	0,1	0,0	0,1	0,0	0,0						
133	0,0	0,1	0,4	1,3	0,2	0,7	0,1	0,4	2,1	6,4	0,4	1,2						
141	0,3	1,0	0,2	0,6	0,2	0,7	0,2	0,6	0,5	1,4	0,7	2,1	0,2	0,5	0,0	0,1		
142	0,4	1,3	0,7	2,1	0,4	1,1	0,8	2,3	0,5	1,4	0,4	1,3	0,6	2,0	0,4	1,1	0,5	1,5
211			0,8	2,3	9,1	29,2	4,1	12,3	0,4	1,2	9,0	27,1			7,3	22,1	0,3	0,9
222	0,2	0,7			4,7	14,9	0,3	0,8		0,0							0,0	0,0
231			0,5	1,6	5,8	18,7	5,6	17,1	10,4	31,5	3,2	9,7	2,1	6,3	5,3	16,1	3,4	10,4
242			0,0	0,1			0,2	0,7		0,0								
243			0,3	0,8	0,0	0,2	0,5	1,6	0,5	1,4	2,5	7,5	1,2	3,7	0,4	1,1	0,2	0,7
311	1,8	5,4	1,0	3,1	3,4	11,0	0,9	2,6	0,1	0,4	1,6	4,7	0,8	2,3	1,0	3,1	0,7	2,0
312	7,3	22,2	0,8	2,4			2,3	6,9			0,2	0,5	1,9	5,7	7,7	23,3	0,9	2,7
313	0,6	1,9	2,2	6,7	0,1	0,3	5,9	17,8			0,8	2,4	0,4	1,2	1,3	4,1	1,1	3,4
321			13,3	40,0	0,3	1,0	0,3	0,8			0,4	1,4					0,4	1,2
322	1,3	4,0					3,2	9,8			2,7	8,3	8,2	24,8	1,0	3,1	2,4	7,3
324	0,2	0,6	1,4	4,3			0,4	1,3	0,3	0,9	0,9	2,6	0,6	1,9	0,5	1,4	1,2	3,8
331	2,1	6,4	0,2	0,7			0,0	0,0			0,0	0,1	0,0	0,1	0,2	0,7	0,3	1,0
333			0,6	1,9													9,8	29,6
411	0,2	0,6																
412											2,2	6,6			2,0	6,1		
421																	8,2	24,8
423																	2,3	7,0
511	0,1	0,4	1,8	5,4	0,7	2,1	0,2	0,6	6,3	19,2	0,3	0,8	0,1	0,3	0,2	0,5	0,4	1,3
512	0,1	0,2	0,5	1,6	0,0	0,0	0,8	2,4	0,2	0,5	0,5	1,4	0,9	2,7	1,2	3,7	0,0	0,0
621	14,6	44,1							0,3	1,0	0,2	0,6	8,8	26,6	2,8	8,4		
631													5,4	16,3				

Appendix 9b. Land cover change matrices of 9 Dutch transects for the period 1950 – 2000.

Transect 1 “Loonse & Drunense Duinen”

Area (m2)	lc98																	
lc53	112	121	122	133	141	142	222	311	312	313	322	324	331	411	511	512	621	Sum
112	392048				4078													396126
121		114419																114419
122			27395															27395
141					22843													22843
222	12934						8745											21679
311					44513			468336						28943			39622	581414
312	6023		9113	5935		71695		26292	6306431		398331	107673					77585	7009077
313	3570		10885						4348	505938							64744	589485
322	5841	24974	2880				2798	20326	576313	5896	522706		15084				21792	1198609
324						29168		32460	250201	77592		59003					9953	458377
331									146636		410104		2103285					2660024
411		27387				43930		800689						155625				1027631
511			44498												143766			188263
512																81966		81966
621	2253555	498464	242908	36009	255600	275997	225788	426341	48971	40891		24046		2766			14349016	18680349
Sum	2673971	665244	337677	41943	327033	420789	237331	1774444	7332899	630317	1331141	190722	2118368	187334	143766	81966	14562712	33057658

Transect 2 “Kennemer Duinen”

Area (m2)	lc00																				
lc50	112	121	122	123	133	141	142	211	231	242	243	311	312	313	321	324	331	333	511	512	Sum
112	871815																				871815
121		658374		18210													24871		2915		704370
122			206793									10569			36450						253813
123				1538028																	1538028
131																7207					7207
133	270326	652362	60089	709079		52868	88173							28799					146294		2007989
141						56154															56154
142							199393								5179						204573
211	70458	986747	147733		94309		12860	519970	195458		139630	163146		55190	13902	7318					2406720
231	6775	328676	64127		100945		27485	211118	161724		51102	154045		5481		75470	7548		10103	6158	1210757
243		10189					38318		14283	7028	68369	99629			152532	27622				72949	490920
311		342438	10821		4252				5125			341899			213115						917649
312		3756	18238									1876	698806	18861	286690	67761	16662	26475			1139125
313											2637			1979515	88389			10087			2080627
321	404356	448633	320768	97884	198734	87005	318109	30284	149040	10446		65168	66351	21078	12444610	396176	165458	579085	10032	297542	16110759
324		65807	44566		39681			1213	2733			171415	20721	120808	83384	848185	5727	25448			1429688
331							16906														16906
511				90983															1622264		1713247
512			460									9247								164939	174646
Sum	1623729	3496984	873595	2454182	437921	196027	701244	762584	528362	17474	261738	1016995	785878	2229731	13324250	1429738	220267	641094	1791608	541589	33334991

Transect 3 “Bemelerberg”

Area (m2)	LC00																
LC50	112	121	122	131	133	141	142	211	222	231	243	311	313	321	511	512	Sum
112	2216467	95539		13478							35887	3691					2365062
121		30445															30445
131										2536		115104					117640
133	43152						21497										64649
142						23491	92463										115954
211	760911	205857	85738	26053	197147	53868	25012	4651270	1400406	1831069		242218			159022		9638571
222	2277478	132455	50165	93510	6786	138207	106868	3168925	2861203	2954977	13390	246669	6331	121189			12178153
231	215484				18377		104297	1328534	410403	1038497		671905	86643		15930		3890070
242	59715									20739							80454
311												2153330					2153330
321														172759	143407		316166
331														7107	12384		19491
511														12552	324630		337182
512																8364	8364
Sum	5573207	464296	135903	133041	222310	215566	350137	9148729	4672012	5847818	49277	3432917	92974	313607	655373	8364	31315531

Transect 4 “Kampina”

Area (m2)	lc00																					
lc50	112	121	122	132	133	141	142	211	222	231	242	243	311	312	313	321	322	324	331	511	512	Sum
112	2766968	25516				27491				699	2515											2823189
121		772160					42283			6334			4942					5801				831520
122			344476																			344476
133		23070																				23070
141						52339																52339
142							19380															19380
222	9176		105					5874		9386												24541
243	201631		27122					110841		257600		88204	20533							3849		709780
311	37553		15446			18354		4677		87527			218068					44492		987		427104
312	5556													1799364			12198	11498				1828616
313	89785	5556					72377			2378			79991		4158850		32935	35090		8002		4484964
322								14975		77557			30300	36048	509119	30244	2670547	133645				3502435
324	9596						164242			6566			227701	392773	1157948		14309	154788				2127923
331														19552					8757			28309
411			21282							93705		29805	82293				10167				2620	239872
511																				123454		123454
512							14186								8654	236830	473076	30414			771360	1534520
621	1693722	965289	209923	34384	117713	100312	442799	3917079	272025	5083944	232831	409074	201427	28917	25472		18315	7601		48373	12743	13821943
Sum	4813987	1791591	618354	34384	117713	198496	755267	4053446	272025	5625696	235346	527083	865255	2276654	5860043	267074	3231547	423329	8757	184665	786723	32947435

Transect 5 “Jisperveld”

Area (m2)	lc00																
lc58	112	121	122	123	132	133	141	142	211	231	243	311	324	511	512	621	Sum
112	1964457	52387	9267				713							1826			2028649
121	171817	725960	17957	23528		11595		21570	7689	3199				42231			1025545
122		3206	324990							3998				269			332462
123				27886													27886
133	205142	21736						31430						4283			262591
141							41691										41691
211	54951	1878260	224805	877967		1754017		142030	107297	236850	60967	71334	293540	1787140	11267		7500426
231	2901404	881204	312463	8229	27882	322360	390186	228697		10132769	390738	52564	3627	235032	64426		15951582
311												11989					11989
511	136860	226528	77810	1524		25332	36677	26907		38020	19826	1784		4210698			4801967
512	7050														74677		81727
621	26448	158243	133533	17542		8093			278956					55203		325826	1003845
Sum	5468128	3947525	1100825	956676	27882	2121398	469267	450634	393942	10414837	471531	137671	297167	6336681	150370	325826	33070360

Transect 6 “Drentse Aa”

Area (m2)	lc00																					
lc50	112	121	122	132	133	141	142	211	231	243	311	312	313	321	322	324	331	412	511	512	621	Sum
112	520998	12790	4385		3963														1548			543685
122			38162					19653														57815
211	307891	55061	18116		5076	130972	41101	1929201	443052	59687	65234			448040		26719			3484	10701		3544335
222	6418								77													6495
231	378732	813766	42196		57932	24689	21668	460431	1793901	532812	194802				3267				57190			4381387
243						21327				1742370												1763697
311	5775						9108				36608											51490
312											24874	53145			5389							83407
313													720842									720842
322		13739					26889	33563	28697	1845	384971	57449	69782		2588804	58994	5173		2139	75294	7952	3355289
324								2444			64386	20281									8279	95390
331																	36077					36077
411																26385						26385
412											666093	5440	6862		131196	80870		2164277		103248	42872	3200857
511	777	398			12366		4211		3192	6401									74625			101971
512															1109			14949		238530		254588
621	3388519	1277486	245486	10245	304284	520889	340969	6511796	950841	149361	119902	31252				668803			111791	36142	149119	14816884
Sum	4609111	2173240	348345	10245	383620	697878	443946	8957086	3219761	2492476	1556869	167567	797486	448040	2729765	861772	41249	2179226	250778	463914	208222	33040595

Transect 7 “Dwingelerveld”

Area (m2)	lc00																	
lc50	112	121	122	141	142	231	243	311	312	313	322	324	331	511	512	621	631	Sum
112	505969																	505969
121		203322																203322
122			26787															26787
132	9005																	9005
141				96027														96027
142					26766													26766
211	600086	43546	8348	23722	12246	19130	153038	55006				8961				4452550	8399	5385033
231	148849	183322	107499	33061	49497	1438700	441294	172506	24107	2554	252759	46607		29295	21732	4369450	91807	7413041
243		29087					619009	43975										692071
311								471547			29568	63669				2050		566834
312		5365			233573	182478	6312		1776109		67397	47361	13157	596			65668	2398016
313		9563								365698	69838							445100
321						11614					34349			9587				55549
322						350942		11444		15187	7362371	86650		6154	568708		382975	8784431
324		3128				12548		7274	80494	9450	72301	61898			15325		205748	468166
331													7277				21791	29068
333					15053				5343		21051						73529	114975
511								5644						68701		6820		81166
512											7893				300116			308009
621						53364						106951						160315
631	11993				312656	21404					286161	199359					4540684	5372256
Sum	1275902	477333	142634	152810	649791	2090179	1219653	767396	1886053	392890	8203689	621456	20435	114333	905882	8830870	5390600	33141907

Transect 8 “Overijsselse Vecht”

Area (m2)	lc00																			
lc50	112	121	122	131	141	142	211	231	243	311	312	313	322	324	331	412	511	512	621	Sum
112	272817							2914												275731
121		164481																		164481
122			164049																	164049
131				19780						5099								34791		59670
141					14892															14892
211								15210		19764	12071									47045
231	10019					85906	173609	980477	97782	68884	73305	29941								1519925
243									3356		17753	66835								87944
311								14825		111050	14540									140414
312											4177233			54460						4231694
313			2512	111		116181				2266	38480	799378	16798					21971		997696
321											29655									29655
322	17749	34377	34882	55559	14062	93775	250081	199228	58730	197337	1939537	360206	941668	171120	6381			224758	61722	4661173
324	26289	4137					13085	5304		137196	1051633	36054	8947	45987	23699				4604	1356933
331						2499					199069		16601	16216	193977			9494		437857
412				7254			64736	58461	11712	387431			29081	131172		2023959		849360	668877	4232044
511		1722					6746										178997			187466
512																		6948		6948
621	270296	424565	162599	8956	15142	74712	6802841	4045733	196408	94515		20335		50579	3968			67595	2035647	14273891
631	22633					4874					159883	35375						26466		249233
Sum	619804	629282	364042	91661	44096	377947	7311098	5322152	367989	1023542	7713160	1348123	1013094	469535	228026	2023959	178997	1241384	2770850	33138740

Transect 9 “Terschelling”

Area (m2)	lc00																				
lc49	112	121	122	142	211	222	231	243	311	312	313	321	322	324	331	333	421	423	511	512	Sum
112	357167																				357167
121		9786																			9786
122			37207														5404	1800			44411
222						6814															6814
231							589883		72560							11262					673704
243	11141		4493	373134	9679		314685	204543	24302									7299			949275
311	10657			7150					140004												157810
312																13081					13081
313											793788										793788
321												400526	27886				27224	19537			475172
322			8743	8137			75342		241884		8538		2248149	987766		1314483				11933	4904976
324											203765			96465							300229
331															169625	509859	3753975	10457	114768		4558684
333			10164	7501						1703			134708	74067		7754910	11431		2404		7996888
421			3271										9240	90408		184548	4081254	40276	20997		4429995
423															147479		342971	2228846	291628		3010925
621	311877	50113	35878	78371	274263		2462477	12799	56991	13048						18804	472				3315094
631				14901					139365	884782	113763										1152811
Sum	690843	59899	99757	489195	283941	6814	3442387	217342	675105	899534	1119853	400526	2419984	1248706	317104	9806947	8222731	2308216	429797	11933	33150610

Appendix 9c. Land cover changes of nine Dutch transects for the period 1950 – 1990 (as % of 1950 land cover).

		Transect 1	Transect2	Transect3	Transect 4	Transect5	Transect 6	Transect 7	Transect8	Transect9
CORINE land cover class name	Code	Change(%)	Change(%)	Change(%)	Change(%)	Change(%)	Change(%)	Change(%)	Change(%)	Change(%)
continuous urban fabric	111									
discontinuous urban fabric	112	509,2	85,6	121,7	65,4	131,6	712,3	115,2	109,5	77,7
industrial and commercial units	121	431,0	383,8	1145,9	89,6	60,7	1349,0	106,0	225,1	321,2
road and rail networks and associated land	122	1132,6	232,5		50,7	133,8	878,1	432,5	121,9	124,6
port areas	123		54,4			4001,6				
airports	124									
mineral extraction sites	131		-100,0	85,0					145,9	
dump sites	132							272,3		
construction sites	133		-82,6	57,4	297,4	1038,8				
green urban areas	141	1170,0	249,1		263,8	658,3		21,7	196,1	
port and leisure facilities	142		216,2	165,5	3891,0			2327,6		
non-irrigated arable land	211		-58,6	-16,2		-96,9	244,9	-100,0	13818,5	
permanently irrigated land	212									
rice fields	213									
vineyards	221									
fruit trees and berry plantation	222	610,0		-64,0	10,9		-100,0			
olive groves	223									
pastures	231		-75,2	107,5		-30,2	-52,6	-75,6	328,5	456,8
annual cops associated with permanent crops	241									
complex cultivation patterns	242			-100,0						
land principally occupied by agriculture with signific	243		-35,2		-32,3		36,3	76,7	299,5	-78,5
agro-forestry areas	244									
broad-leaved forest	311	152,7	14,0	52,7	102,9	919,7	2653,7	16,8	615,1	205,7
coniferous forest	312	8,8	-29,7		24,5		109,8	-18,8	78,3	6876,7
mixed forest	313	7,2	6,2		26,9		-4,0	-7,8	47,2	41,1
natural grasslands	321		-10,3	-0,8				-100,0	-100,0	-10,0
moors and heath lands	322	-13,3			-14,5		-28,7	-7,1	-78,5	-45,3
sclerophyllous vegetation	323									
transitional woodland-scrub	324	-38,4	1,8		-76,3		499,4	-24,6	-50,6	166,0
beaches, sand, dunes	331	-18,2	589,7	-100,0	-69,1		14,3	-29,7	-47,3	-97,0
bare rocks	332									
sparsely vegetated areas	333							-100,0		25,9
burnt areas	334									
glaciers and perpetual snow	335									
inland marshes	411	-79,9			-100,0		-100,0			
peat bogs	412								-53,0	
salt marshes	421									87,0
salines	422									
intertidal flats	423				49,6					-15,0
water courses	511	-23,6	6,3	76,0	-17,8	32,7	145,9	40,9	-4,5	
water bodies	512	0,0	108,7	0,0		65,4	56,5	160,2	17084,1	
coastal lagoons	521									
estuaries	522									
sea and ocean	523									
Farmed land	621	-19,0			-100,0	-12,1	-93,4	5734,6	-81,5	-100,0
Forest	631							7,0	-100,0	-100,0

Appendix 10 Land Cover Changes between 1950 and 2000 subdivided into Inside and Outside Natura2000 sites for 9 transects (% and m2).

N2000	Type of change		Transect 1 Area	%	Transect 2 Area	%	Transect 3 Area	%	Transect 4 Area	%	Transect 5 Area	%	Transect 6 Area	%	Transect 7 Area	%	Transect 8 Area	%	Transect 9 Area	%
outside	no change	0	9469119	67,9	5977506	45,1	11365247	40,7	5739774	28,2	8686963	37,2	2491852	12,1	2688328	19,6	2775815	16,1	582283	13,5
	to artificial area	1	3716167	26,7	4087849	30,8	4497924	16,1	4119676	20,3	10855947	46,5	8075756	39,2	1341619	9,8	1379843	8,0	918123	21,3
	to agricultural area	2	132361	0,9	194379	1,5	35887	0,1	241351	1,2	39335	0,2	54394	0,3	10255	0,1	1155430	6,7		
	to forest and semi-natural area	3	398967	2,9	430271	3,2	749564	2,7	327854	1,6	417202	1,8	1040692	5,1	449696	3,3	187428	1,1	16668	0,4
	to wetlands	4																	3	0,0
	to water bodies	5			198332	1,5	330742	1,2	76575	0,4	2136998	9,1	210871	1,0	44101	0,3	295589	1,7		
	internal change at level 1 (without ambiguous classes)	6	48248	0,3	2372207	17,9	10922489	39,1	715096	3,5	940920	4,0	1135949	5,5	417218	3,0	555706	3,2	161984	3,8
	internal change between agricultural classes and 621	7	178315	1,3					9112152	44,8	278956	1,2	7576708	36,8	8746952	63,9	10814601	62,9	2548161	59,2
	internal change between forest classes and 631	8															35375	0,2	76176	1,8
inside	no change	10	15792403	82,8	16403332	81,7	2184184	64,0	8208943	65,1	9261278	95,3	9594807	77,0	15182656	78,1	9361380	58,7	18536683	64,3
	to artificial area	11	189709	1,0	314170	1,6	60000	1,8	136433	1,1	31057	0,3	10329	0,1	488975	2,5	108472	0,7	17410	0,1
	to agricultural area	12	84134	0,4	7098	0,0	2536	0,1	85385	0,7	33397	0,3	100503	0,8	583912	3,0	265596	1,7	75342	0,3
	to forest and semi-natural area	13	941971	4,9	453934	2,3	756737	22,2	826588	6,6	5647	0,1	1435283	11,5	377475	1,9	823305	5,2	611975	2,1
	to wetlands	14	31709	0,2									14949	0,1					3837596	13,3
	to water bodies	15			347662	1,7					64678	0,7	190666	1,5	607297	3,1	938847	5,9	441730	1,5
	internal change at level 1 (without ambiguous classes)	16	2027084	10,6	2548250	12,7	410212	12,0	2554810	20,3	317982	3,3	1072545	8,6	2009344	10,3	4051090	25,4	4063367	14,1
	internal change between agricultural classes and 621	17	47472	0,2					802799	6,4			35290	0,3	128412	0,7	230380	1,4	201378	0,7
	internal change between forest classes and 631	18													65668	0,3	159883	1,0	1061733	3,7
		Total	33057659		33334990		31315522		32947436		33070360		33040594		33141909		33138740		33150612	