

The changing Estate Landscape of Renkum

A comparison of the estates between past and present



A hand-drawn map of the Renkum landscape, showing the course of the Rijn river and various estates. The map is oriented with North at the top. At the top, the labels 'Gemencite' and 'Arnhem' are written in cursive. To the right, a circular stamp reads 'Gemeente Oosterbeek in 5 districten Sectie C in 1 Blad' and 'Versie'. On the left side, 'Loo-vijgen' is written vertically. On the right side, 'Smeent' and 'Arnhem' are written vertically. At the bottom right, 'Oosterbeek' is written. The map shows a winding river with several islands and branches. A scale bar is located at the bottom left, and a north arrow is at the bottom center.

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Preface

This report is about the estate landscape of Oosterbeek is written by students of the Geographic Information Science Master in Wageningen, for a project called Academic Consultancy Training (ACT). This project gives students the opportunity to practice their profession in real life. Their assignment was to provide the Estates Initiatives Group, a group set up to create awareness about the change in landscape and view of the beautiful nature at different estates close to Oosterbeek and also in the surroundings of Renkum.



Summary

The municipality of Renkum is famous for its estates, with its diverse scenery, and has attracted painters and other artists throughout the centuries. Over the course of time, views have been obstructed by the trees, and houses or other man-made structures. An attempt has been taken to analyse the current situation of the landscape, as well as the changes which have occurred since the 1800's. 11 viewpoints and 1 view line have been linked to paintings and pictures of the area. These have been used in a view shed analysis. This analysis shows the change in area that can be seen from the viewpoint, and thus the increase of view-obstruction between 2 time periods. The result indicates that the view is obstructed mainly due to the increase of trees and houses. This idea is supported by the statistical fragmentation analysis, which indicates that more and more buildings, deciduous forest and grass land appeared, in contrast to arable land, which has decreased. Estates boundaries have changed a lot since 1832, and in most of the cases they have been divided into smaller estates. The increase of buildings and roads, together with the increase of trees and forests, the estates of Renkum are losing their beautiful wide views. A proper planning of the developments can protect the natural beauty, as well as fulfil the increasing demand of more houses and infrastructures over time.

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1. Introduction

At the edge of the Veluwe, between the cities Wageningen and Dieren, a beautiful region also known as “the estate zone of the Veluwe” or “Gelders Arcadië” is located (Storm-Smeets, 2011). The natural features of this area, such as the large difference between the ice-pushed ridge (*stuwwal*) of the Veluwe contrasting with the river landscape of the Rhine, the soils, and the presence of clear spring water due to the hydrological system of the *stuwwal*, makes this region unique in the Netherlands.

The development of this region started in the middle ages with castles and mills. During the 17th to 19th century many estates were build and (re)developed, which gave the region its current characteristic appearance. The design and maintenance of the estates also resulted in rare vegetation and a high biodiversity.

The estate zone of the Veluwe features unique and rich ecological, landscape, cultural, and historical qualities. During the glory days of the estate zone of the Veluwe, from the mid to end of the 19th century, the region attracted many artists who lived in Oosterbeek (Romers, 1991). However, due to many developments over the last century, the unique and striking values of the estate zone of the Veluwe are degrading or even completely disappearing. Cuts in the budget of vegetation management, nature conservation and cultural history, lack of acknowledgement and protection of the estates, and their values in spatial planning impose a further threat to the landscape. The commissioner of this academic consultancy project, The Estate Initiatives

Group, is concerned about these issues. They aim to create knowledge and awareness about the estate zone of the Veluwe, and encourage preservation and positive development of the region, so that in the future the inhabitants of Renkum are again very proud and aware of the beautiful history, design and riches of their region.

This report gives an insight in the current state of the estates, and the process of change these have gone through. In a hope for the Estate Initiatives Group to make the public and municipality aware of the change in the estate landscape, and to convince them to about the importance of maintaining and restoring certain aspects within the estate landscape.

1.1. Objectives and research questions

Because the project aims to clarify about the change of the estate landscape, clear maps and graphs are needed. Especially the changes during the last 150 years are of interest. Hence, the following objectives have been identified:

- A. Visualize the present features of the estate zone in the municipality of Renkum (Gelderland).
- B. Visualize the changes of the estates over the past 150 years in the municipality of Renkum.

From these objectives, the following research questions have been derived:

- 1. What is the definition of an estate for this research?
- 2. Which estates belong to this definition?
- 3. Where are the original borders of these estates?
- 4. Which datasets and maps are available?
- 5. What is the current situation of the estate study area?
- 6. Which important view sheds have been lost?
- 7. Has the study area been fragmented over the years?
- 8. What is the best way to visualise this research?

1.2. Definition of an estate

The definition of an estate is important to define our study area. More or less estates could be taken into account following different definitions.

According to Gelders Arcadie, an estate is a spatial unit of minimum 5 acres large, which features a certain value (landscape, cultural or historical) or has an economical function and has a uniform management (p. 10, (Storms-Smeets, 2011)). An 'estate' thus includes the terrain (forest, park or garden) and all buildings and features inside it. Estate buildings can be separated into 'the main building', and the 'annexes', 'farms' and 'mills' on the estate. The most common landscape design styles in the estate zone of the Veluwe are 'the geometric style' and 'the landscape style' (Storms-Smeets, 2011), this should not be confused with the term 'estate landscape' which describes the overall design of the estate zone of the Veluwe.

Pieter van der Kuil uses the terms '*profit and pleasure*' to define the definition. An estate is a defined area, with a house on it. It has areas purely designated for pleasure, such as gardens, orangeries, and ponds. Besides this it has profit areas such as the forest for forestry and hunting, and farms with farmland that are rented out. The *pleasure* is maintained and only possible by the *profit* gotten from the estate.

Because only 5 estates in Renkum qualify according to this definition, it could be widened to: An estate landscape needs to have at least *profit and pleasure*, 'sier & opbrengsten' in Dutch. So an estate needs to have a garden purely for pleasure, and an area that makes profit, such as an orchard. But the profit does not have to maintain the pleasure.

We, the research team, agree with the second definition proposed by Pieter van der Kuil. An estate needs to consist of profit and pleasure, but the pleasure can be made possible by more than just the profit generated by the assets of the estate. But for the purpose of this research, which is to make the municipality aware of the change in the estate landscape, we

have chosen to use the definition of Gelders Arcadienootschap? as it entails the most ‘estates’ or area.

1.3. The study area

Three different definitions lead to widening list of estates, starting with a narrow list according to the strict definition, up to the longer list following the definition stated by Gelders Arcadie.¹

According to Pieter's definition	Added estates with Pieter's widened definition	Added estates according to Gelders Arcadie
- Mariendaal	- Dennekamp	- Johannahoeve
- Sonneberg	- Laag Wolfheze	- Reijerskamp
- Bilderberg	- Bato's wijk	- Dreijen
- Pietersberg/ Hemelseberg	- Hoog or Groot Oorsprong	- Overzicht
- Laag oorsprong	- Eekland	- Anneshof
- Bilderberg		

So the estates mentioned in the above table make up the estates for Oosterbeek and surroundings according to the definition of Gelders Arcadie, and are the initial list of estates and has been used in this research.

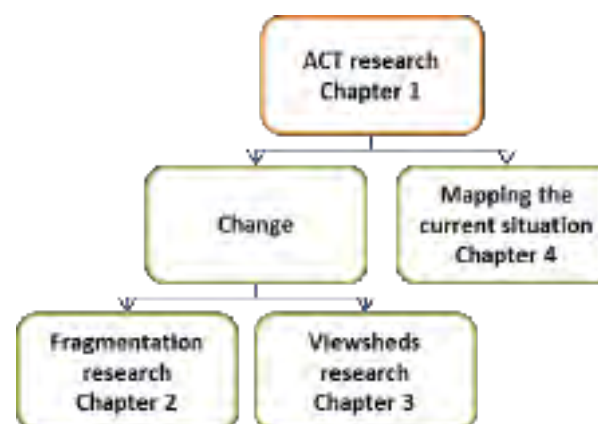
Because the estates started out with large plots of land, and have mostly been decreased over time, the earliest known boundaries of the estates

¹ Listed by Historical landscape expert Pieter van der Kuil

have been chosen to define the study area; and fragmentation research has been performed for that areas . The earliest known boundaries collected from the cadastral map of 1832.

Not all the estates listed existed at that moment. But because these estates were settled within the boundaries of the older estates, their areas have also been taken into account as well.

1.4. Layout of the research



The research has been split up in 2 major parts, namely the ‘Change research’ and ‘Mapping the current situation’. The change research has again been split up into 2 parts, namely the ‘ Fragmentation research’ and the ‘ Viewshed research’. The current situation consists of maps and statistics. These subjects will each be explained in their own following chapters.

2. The fragmentation research

This section comprises the investigation of the fragmentation of the estate landscape through time. Firstly, the background concerning this part will be discussed, after which the methodology is going to be explained and in the last section, the results of this research will be shown and interpreted.

2.2. Background

During the past centuries, the population in the Netherlands has increased rapidly. Due to this, the landscapes have changed, for example more buildings, roads, arable land and other aspects have been developed. Hence, the landscapes become more and more scattered and fragmented throughout time. This means that the size of land use areas decrease and thus land use density increases. One consequence is that the landscape becomes more disordered and that certain landscape values might disappear. Moreover, fragmentation also has negative effects on the biodiversity in many (nature) areas (Hanski, (2005).

2.3. Methodology

The goal of this analysis part is to show the fragmentation throughout time of the estates-landscape within the village of Oosterbeek. This has been done by defining the specific study area of the estates, and by

defining different time slices. After this, different land use maps have been created which were used to derive statistics from.

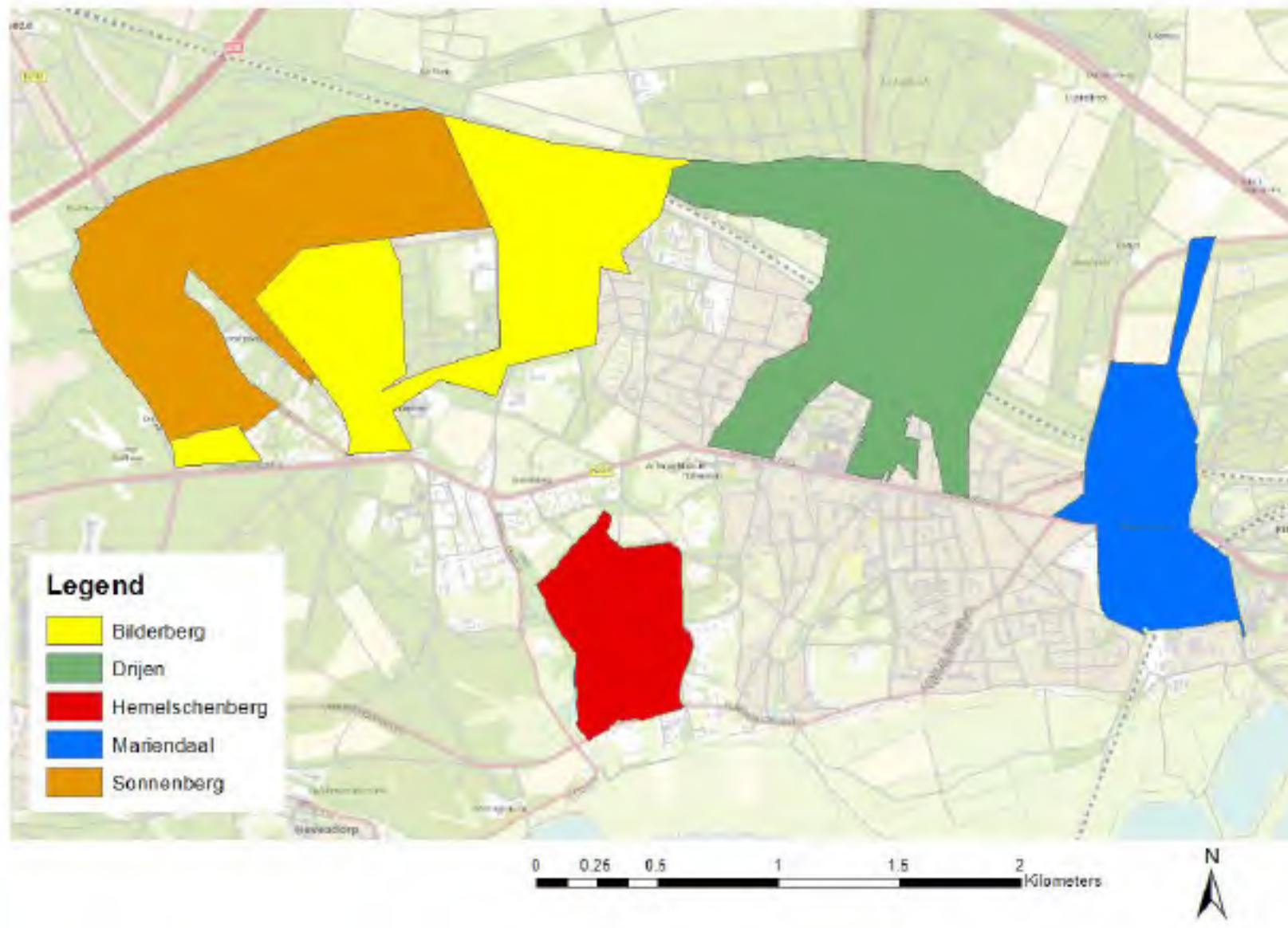
Defining the specific study area of the estates in Oosterbeek

The boundaries of the estates have been located based on the paper maps from the 'Kadastrale Atlas Gelderland' (werkgroep kadastrale atlas, 1985). These maps date from 1832. In this period, six estates were present in Oosterbeek: Bilderberg, Drijen, Hemelschenberg, Mariendaal, Sonenberg and Laag/Hoog Oorsprong. Although the study area for this research part is based only on these estates, a lot of changes took place after 1832; new estates appeared and existing estates became more fragmented.

The estate boundaries have been determined as follows. Firstly, the paper maps (see map 1 for a cut-out) have been scanned and geo-referenced, based on the RD (RijksDriehoekstelsel Nederland) coordinate system.

According to these geo-referenced maps, the estate boundaries have been digitized in ArcMap. See the following image for the result of this. The combined size of these estates is about 470 hectares.

The original estate borders (1832)



Map 1 Estate borders 1832

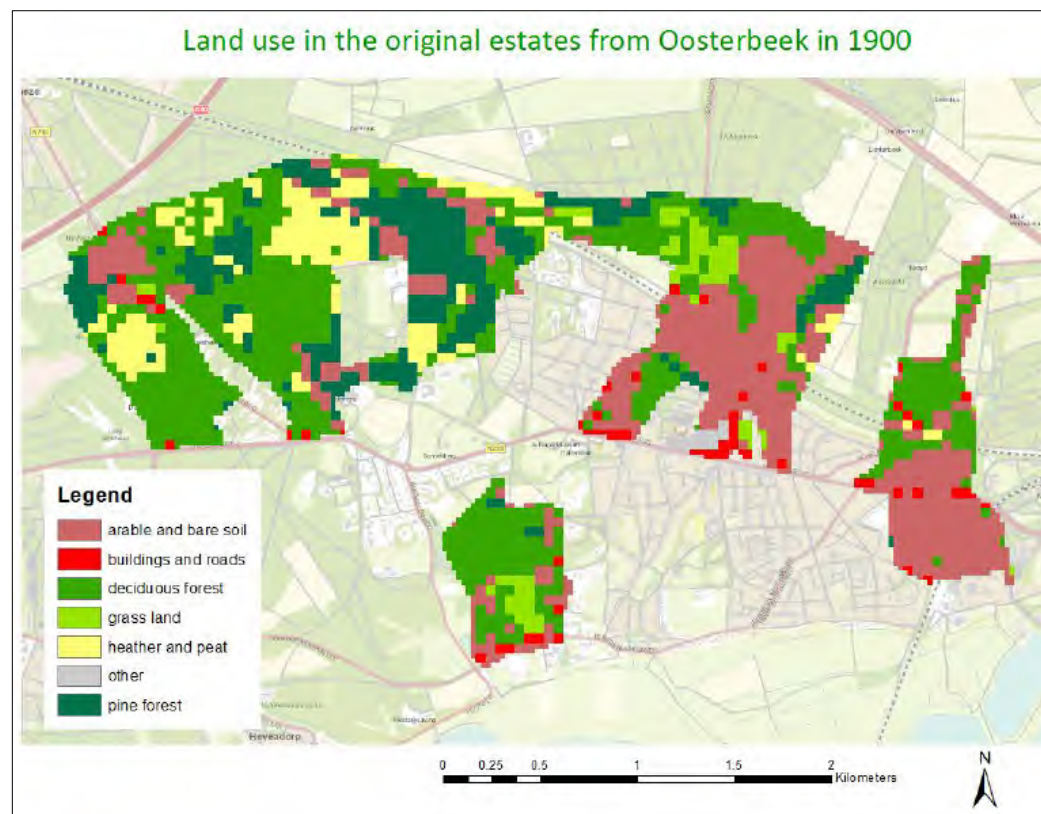
Choosing land use maps and different time slices

For the analysis of changes through time, it was decided to adopt the land use maps of the HGN (*Historisch Grondgebruiksbestand Nederland*), which are available at the GeoDesk of Wageningen University. Five maps were available, each comprising one time slice: HGN-1900, HGN-1960, HGN-1970, HGN-1980 and HGN-1990.

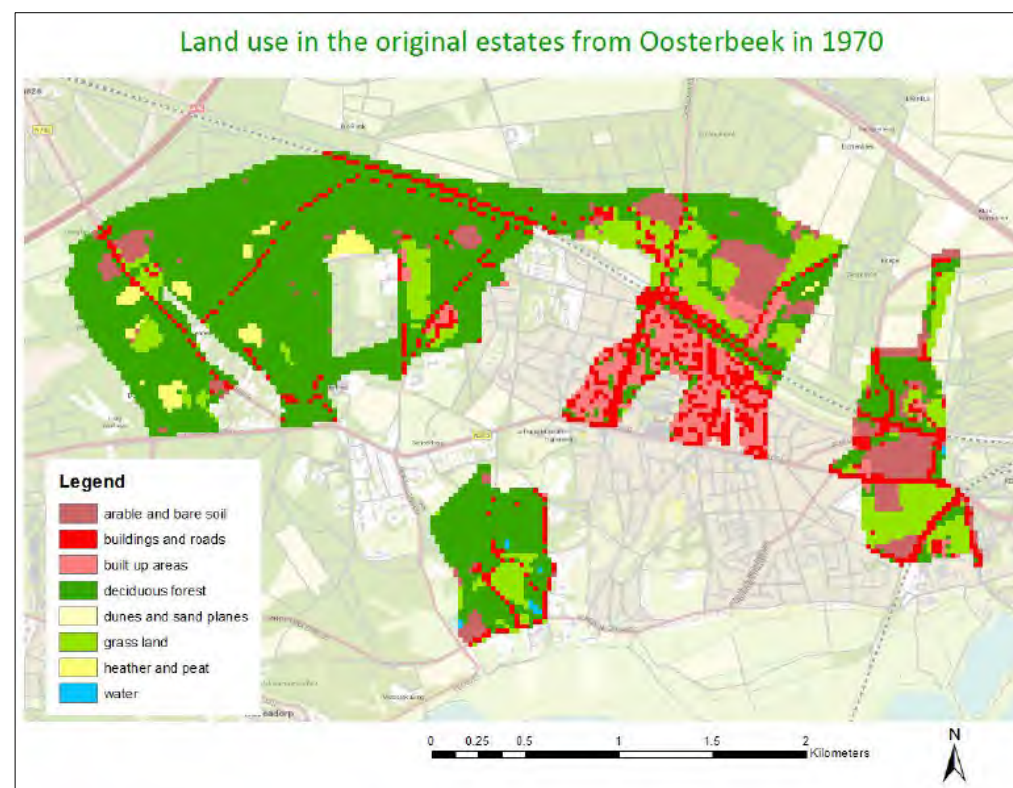
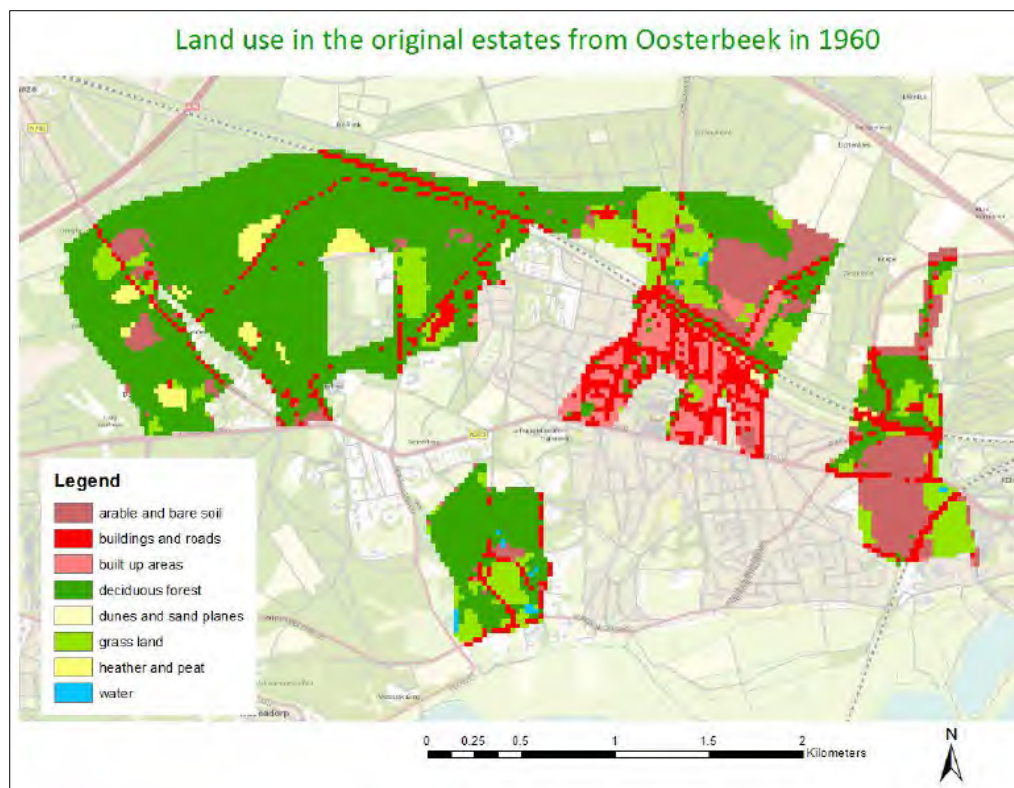
Creating land use maps based on the study area

In ArcGIS, the five mentioned maps from the HGN were used as input to be able to create maps based on the study area of the five estates. The land use maps each consist of a raster with pixel size 25x25 meters, except for HGN-1900 which has a pixel size of 50x50 meters. Therefore, this last one has been resampled to obtain the same pixel size as the other maps have.

After this, the five HGN maps have been clipped according to the boundaries in the 'estate borders' map (figure 2 – 6). The result is five new land use maps, as shown in the following figures.

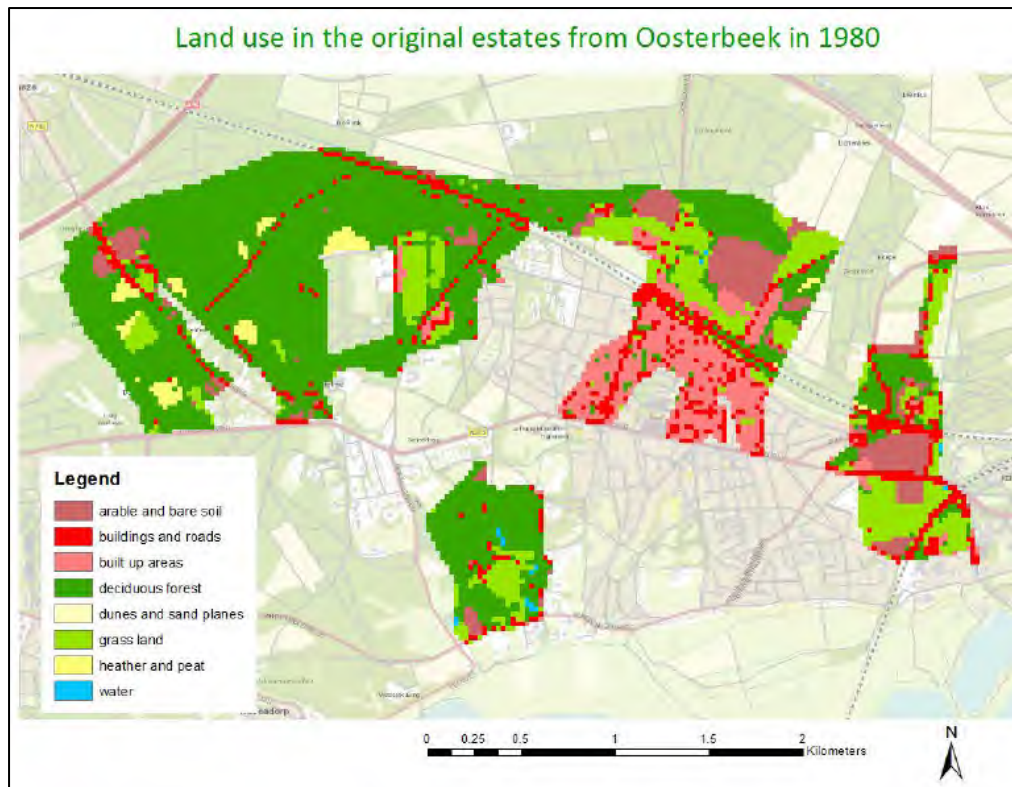


Map 2 Clipped HGN-1900

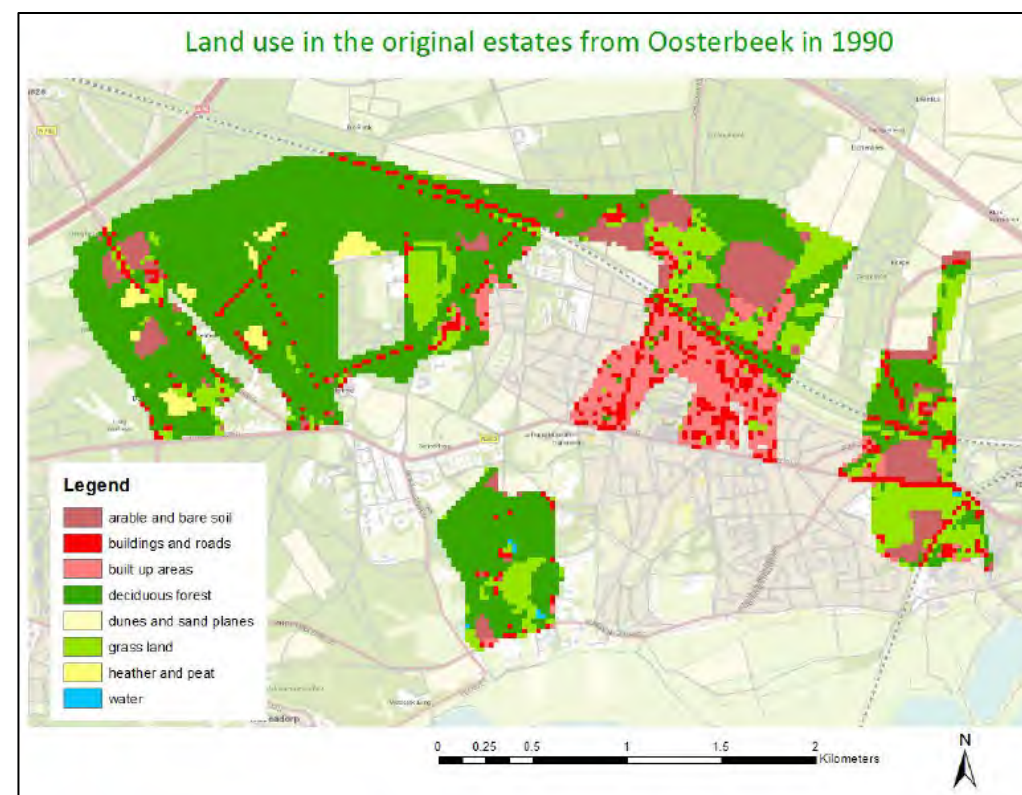


Map 4 Clipped HGN-1960

Map 3 Clipped HGN-1970



Map 5 Clipped HGN-1990



Map 6 Clipped HGN-1980

FragStats Analysis

The fragmentation research has been executed in the program Fragstats, version 4.0. This is a software package which has been developed to compute a large range of landscape statistics for map patterns in raster datasets².

The five compiled land use maps have been used as input in Fragstats to be able to derive the statistics from. The statistics are categorized in three kinds: patch metrics, class metrics and landscape metrics. Patch metrics tell something about statistics for each individual patch (a contiguous region), such as area, density and perimeter. Class metrics cover the statistics for all patches in one class, such as mean patch area and mean patch perimeter, but also the ratio between these two. And finally, landscape metrics calculate the total statistics for a map as a whole. Examples are total area and mean patch density for all classes in total.

2.4. Results

The output of the Fragstats analysis is a range of statistics, shown in tables and generated charts in MS Excel. They are categorized in both total results for the whole area, as well as results per land use class.

Results total area

As mentioned before, the study area is roughly 470 hectares. In the graph below is shown how the total number of patches has increased since 1900 in the same study area.

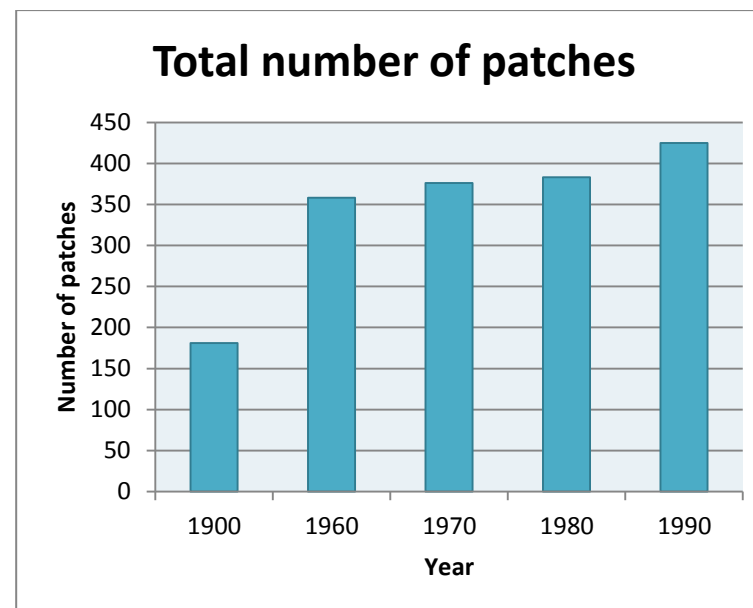


Figure 1 Total number of patches per time slice

The increasing amount of patches in the same study area has the consequence that the patch density increased, also the mean area of the patches has decreased. See the following two graphs for the results of this. Considering these trends, it can be concluded that the fragmentation of the landscape in the area has increased (almost doubled) between 1900 till 1990.

² <http://www.umass.edu/landeco/research/fragstats/fragstats.html>

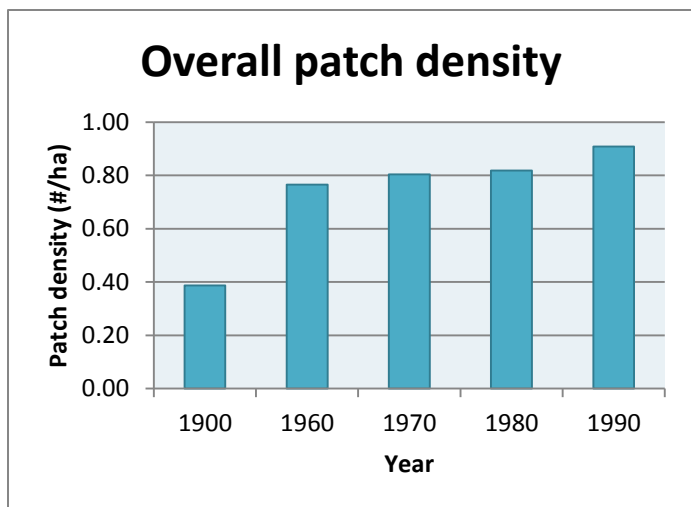


Figure 3 Overall patch density

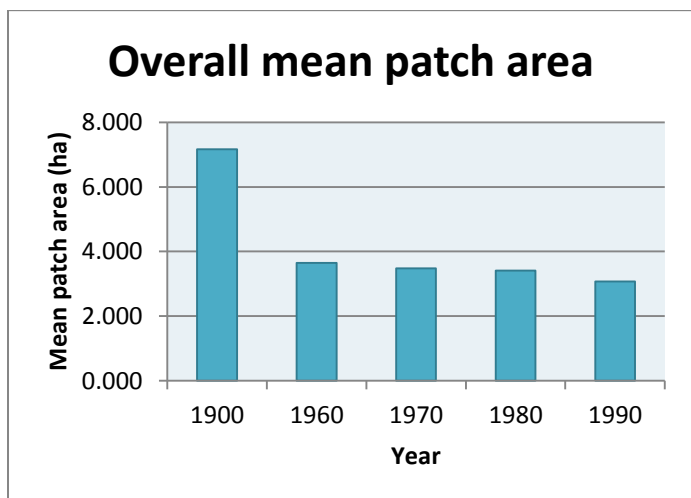


Figure 4 Overall mean patch area

Results per land use class

For showing the results of the land use classes, four classes are chosen: buildings & roads, arable & bare soil, deciduous forest and grass land. These classes show the most striking trends during the five periods.

The graph below shows how the total area of the patches per class changed; in total more deciduous forest has been developed, and also buildings/roads and grass land have increased, in contrast to arable land, which decreased quite some hectares.

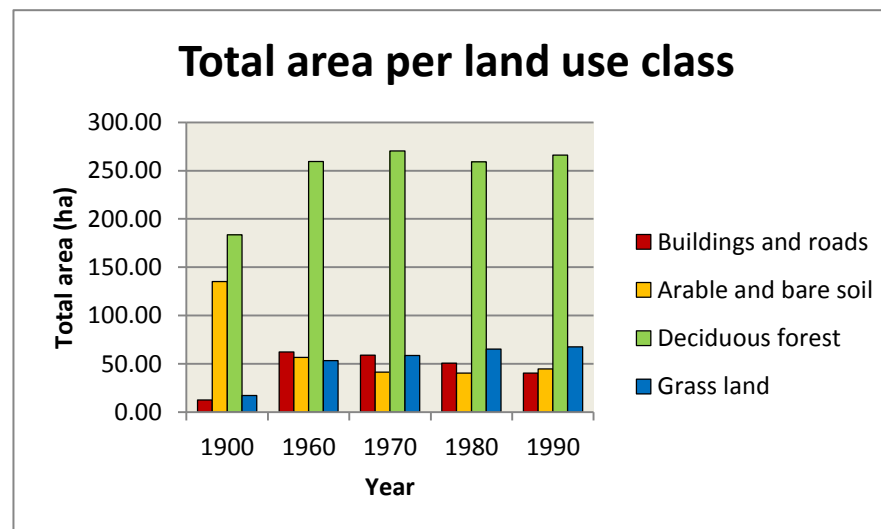


Figure 2 Total area per land use class

Number of patches per land use class

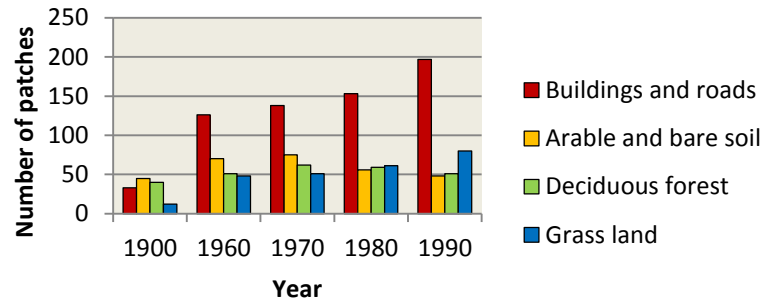


Figure 5 Number of patches per land use class

Patch density per land use class

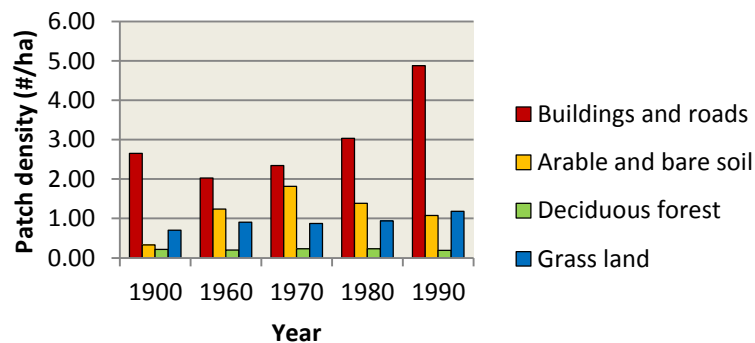


Figure 6 Patch density per land use class

Figure 6 shows that the number of patches for buildings and roads increased, as well as the number for grass land. The number of patches

for arable land and deciduous forest remained almost equal during the five periods.

Figure 7 explains the patch density in number of patches per hectare for the four chosen classes. In 1960, the density for buildings and roads is lower than in 1990 for example. Reason for this could be that the total area in that period was larger than in 1990 while the number of patches was lower. For arable land, the density was highest in 1970, due to a smaller total area and higher number of patches. Deciduous forest and grass land show almost an equal trend during the five periods.

Figure 8 shows the mean patch area per land use. Buildings and roads and grass land show almost an equal trend, while arable land and deciduous forest decrease in mean area.

Mean patch area per land use class

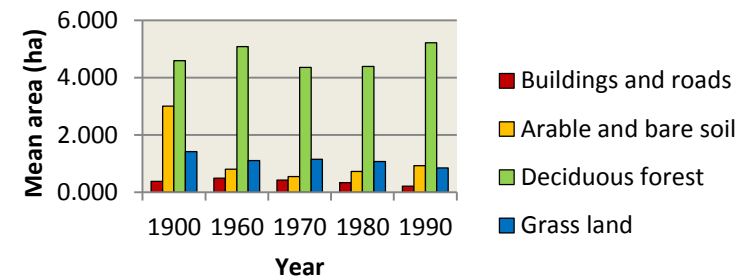


Figure 7 Mean patch area per land use class

3. The viewsheds research

3.1. Viewshed analysis

Hills and other high elevation terrains in the Netherlands were frequently used by painters and other artists for their works (Romers, 1991). It is no surprise that Oosterbeek, with its distinct view on the Rhine river, has been the venue for many painters in the 19th century. These paintings have usually been made on points with a broad view of the area. These are called 'viewpoints'.

These viewpoints, today have changed completely in comparison with the 19th century when open maintained landscapes were more dominantly present rather than today's replanted forests and strips of built up area.

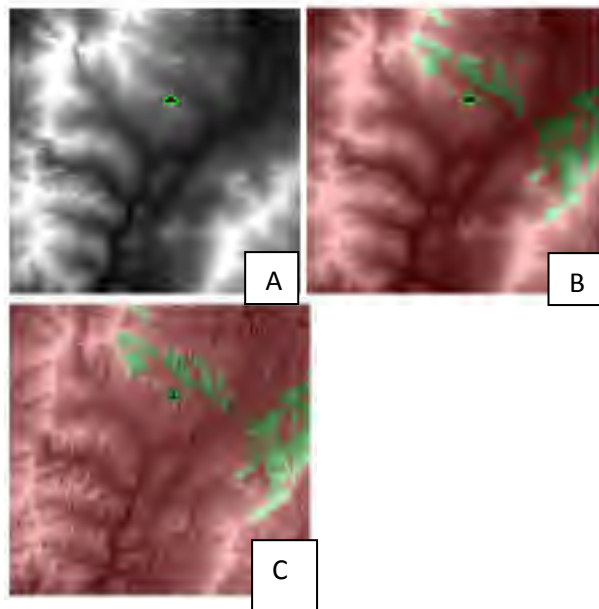
Today's technology allow scholars to calculate the visibility of a selected viewpoint. This is done in the viewshed analysis, and gives a good indication of the physical features of a landscape, such as hills, valleys, and ridges. A Digital Elevation Model (DEM) is used as an input. The viewshed resulting from the analysis shows only the visibility of the area when the land surface is not covered with any objects. For a better representation of the 'actual' surface landscape with objects, a Digital Terrain Model (DTM) is used. This model contains scanned objects that are present in the terrain, objects such as trees, houses and other buildings. With this extra layer the visibility changes depending on the quantity of present objects. Given this information one can calculate, using this extra layer, the visibility of the total surface area that can be observed from that specific point.

3.2. Technical explanation of the viewshed analysis

A view shed identifies the cells in an input raster that can be seen from one or more observation locations. Each cell in the output raster receives a value that indicates how many observer points can be seen from each location. If there is only one observer point, each cell that can see that observer point is given a value of 1. All cells that cannot see this point are given a value of 0. The observer point feature class can contain points or lines(ESRI, 2008).

The view shed analysis tools are useful when the objective is to know how visible objects might be - for example, identifying the locations on the landscape from where the water towers are visible, or the view be from a road.

An example of a view shed is given in figure 1, in which the view shed from an observation tower is identified. The height of the observation tower could also be specified in the analysis. The elevation raster displays in Figure A with the position of observation tower. In Figure B the cells in green are visible from the observation tower. Using layer transparency, a hill shade raster underneath the elevation raster and incorporate the output from view shed analysis can easily be displayed for visualization and better understanding.



Map 7 The elevation raster displays the height of the land (lighter shades represent higher elevations), and the observation tower is marked as a green triangle. B. Cells in green are visible from the observation tower, while cells in red are not. C. Displaying hillshaded with viewshed

3.3. Viewshed analysis for Oosterbeek area

The Oosterbeek area was visited several times to observe and verify the locations from where the historical photographs were captured and the paintings were drawn. A GPS Garmin device was used to get the actual coordinates of those points. Some of them were used later as observation points for the viewshed analysis. For some points, comparison of the historical photographs and paintings were also made with the current situations. In most of the cases, a huge difference in the view have been noticed.

Viewsheds of 1 road and 11 observation points have been calculated in this research in the following way. An airborne LiDAR³ generated DEM of 0.5m resolution was used as the base of the analysis. The photographs and paintings of the area indicate that only a few trees and buildings were present in the historical time period around hundred or two hundred years back, compared to the current situation. Hardly any house or tree could create an obstacle to the view. The current situation gathered from DTM includes all the buildings, trees and other manmade structures. These objects obstruct the view. Based on historical paintings and photographs it is assumed that the entire view for that time was open. Considering these scenarios, a DEM was used to represent the historical landscape, and a DTM as the current landscape for the viewshed analysis.

A viewshed analysis was performed for the 11 chosen viewpoints and the 1 road (Utrechtseweg). Considering the average human height, an observation height of 1.75 m was used.

³ LiDAR, also known as *Light Detection and Ranging*, “is an active remote sensing technique. This technology involves transmitting pulses of laser light toward the ground and measuring the time of pulse return.” LILLESAND, T. K., RALPH. W CHIPMAN, JONATHAN 2008. *Remote sensing and image interpretation* Wiley



3.4. Viewpoints

In the next pages the results of the viewshed analysis are shown. Comparing the results of the current and the historical scenarios major changes on the view can be noticed.

For each viewshed a description is given which describes what can be currently observed at each viewpoint in relation to the old situation.

The results indicate that the view is obstructed in most of the areas by either trees, or buildings and other man-made structures.

Table 1 Viewpoint overview of the GPS points measured in the field

Point	Location / Address	Viewpoint Orientation	X coordinate	Y coordinate	Description
1	Van Eeghenweg & Pietersbergseweg	South-East	185,880.89	443,958.97	Viewpoint from the corner at Van Eeghenweg & Pietersbergseweg
2	Sandersweg	South-East	185,798.87	444,017.84	Viewpoint is at the bench at the end of Sandersweg
3	Forest path connecting Sandersweg with Sandersweg behind the Pietersberg Estate	South	185,753.23	443,960.30	This was an important viewpoint for many people that used this path to walk between the two estate houses 'Pietersberg' and 'Hemelse berg'. The view in 2012 has almost completely been blocked by trees and two new villas.
4	Hemelseberg	South	185,297.48	443,724.82	The Hemelse Berg- viewpoint is now surrounded by trees and two villas that block the view towards the river Rhine.
5	Bato's Wijk	South	186,320.76	443,816.76	Viewpoint that is currently blocked by trees
6	Junction of Weverstraat and Jagerskamp	South East	186,078.00	443,894.15	This view used to be open but is now blocked by houses
7	Overzicht	South	185,959.60	444,142.20	Provided a great lookout on the river rhine during the 1800's and early 1900's. A senior apartment flat blocks the view since the 1950's.
8	Junction Van Wassenaerweg & Rosandeweg	North West	187,262.55	443,711.32	View on the old water tower and meadows. This water tower area is now an urban area.

9	Junction Jonkheer Nedermeijer van Rosenthalweg & Stenenkruis		186,937.90	443,936.75	View on the railway bridge towards Nijmegen crossing the river Rhine. In the 1800's Rosande was predominantly open consisting only of arable land.
10	Junction Emmastraat & Vogelweg	South	186,780.74	444,040.73	View from the Vogelweg towards the railroad bridge.
		South-West			View on the sheepfold with in the background a church and the river Rhine.
11	Junction Benedorpseweg & Acacialaan	South	186,907.74	443,554.16	This displays the Benedendorpseweg around 1890 with farmhouses, and was a stretched road from the church in the west to the Rosande polder in the east.
Viewline of road	Utrechtseweg	South			This was the place where many painters positioned themselves to get a good overview of the Oosterbeek village. This was the main road in Oosterbeek, connecting Arnhem & Utrecht.



Image 1 View from the 'Van Eeghenweg' bench, date of photograph around 1955 (source: P. van der Kuil)



Image 2 Van Eegehenweg' viewpoint in 2012 (Photo: A.Patwary)

Viewpoint 1: Van Eeghenweg

Viewpoint around 1955

Image 1 shows the original view from the 'Van Eeghen' bench. The photograph was taken in 1955. What is visible is the relative open landscape with tree lines and built up features such as a church tower, the factory's chimney, and the railway-bridge. One was able to see places across the river such as Driel, and even the city of Nijmegen (image 3).

Viewpoint 2012

For the same viewpoint, a photograph of today (image 2) has been taken. The once open landscape has made way for mostly treelines. Distinct built up features such as the rail road bridge and the river are blocked by trees (image 4). The house visible in the front of the historic photo is still present in the current photograph.

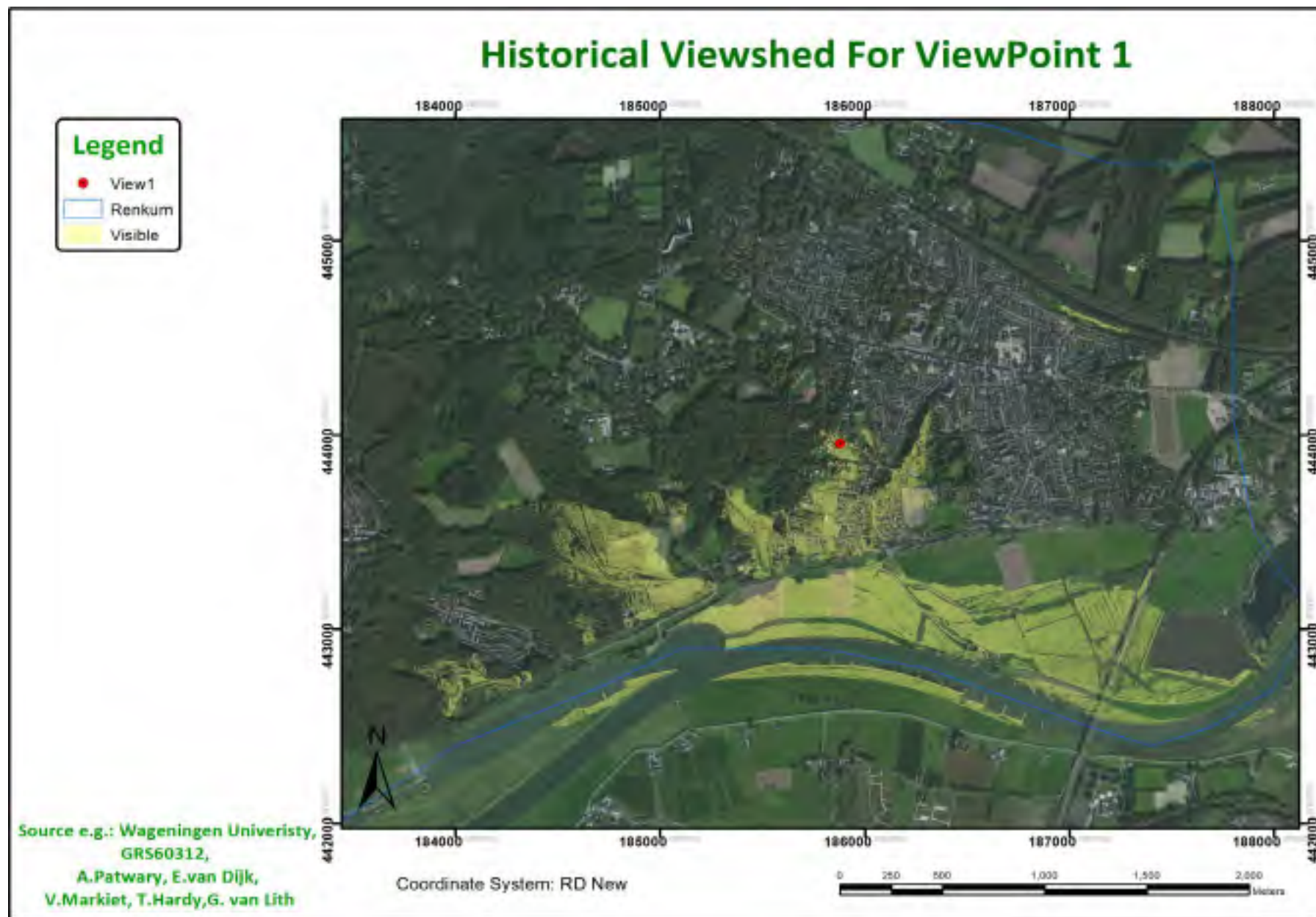


Image 3 Historical viewshed Van Eeghenweg around the 19th century.

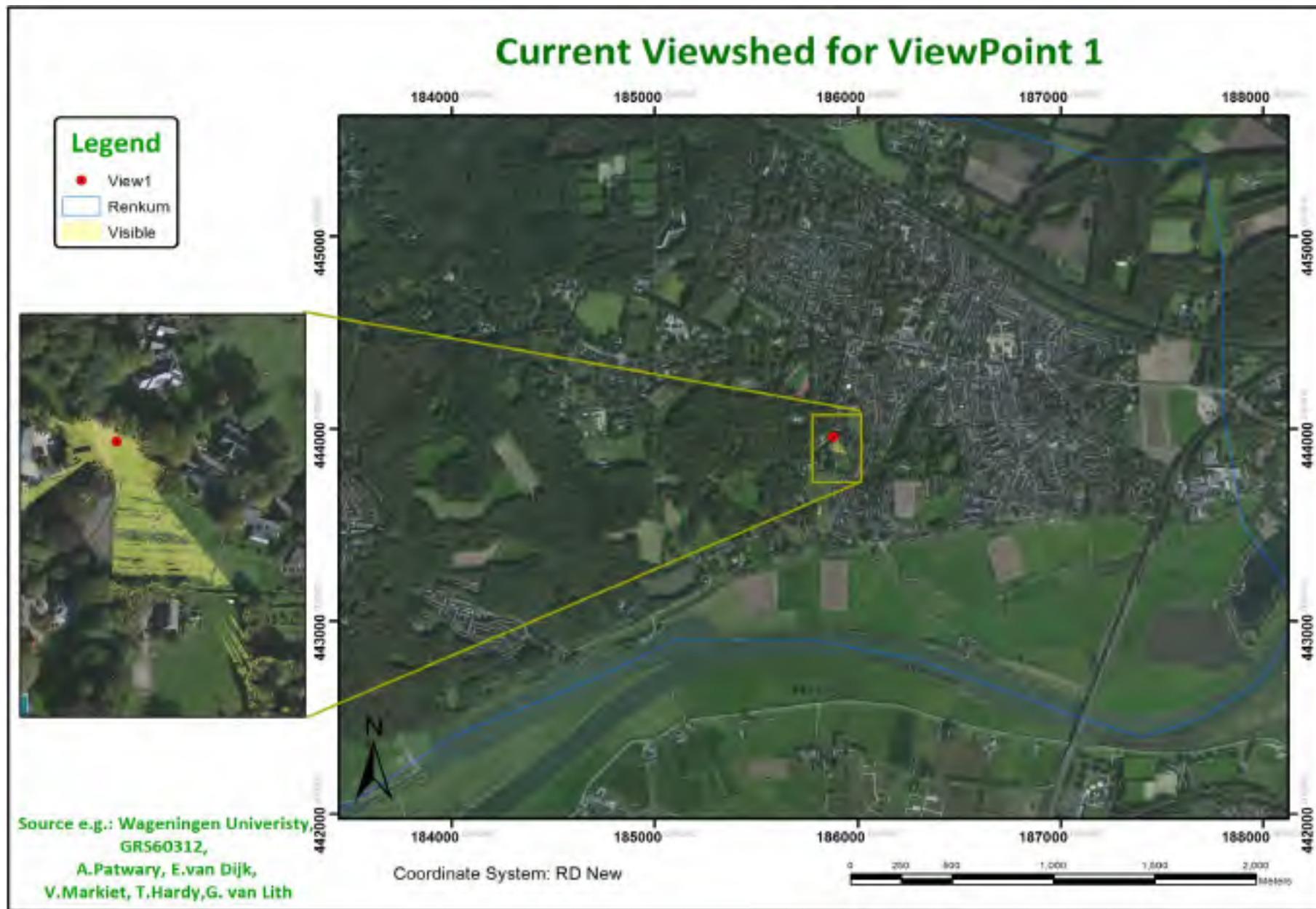


Image 4 Van Eeghenweg viewpoint visibility in 2012

Viewpoint 3: Forest path behind the Pietersberg estate

This path (image 5) used to be an important connection between two estate houses; 'The Pietersberg' and the 'Hemelse Berg'. This location was used as an observation point for the people that walked from the one estate to the other, allowing them to quickly obtain a view of the arable fields and old centre (image 7). On the painting the old church on the 'kerkpad' which is surrounded by a few houses is clearly visible. It shows the initial buildings that formed the village of Oosterbeek. Image 6 & 8 show what the current situation looks like. Dense treelines and two villas built in the 2000's block the view line.



Image 6 Photograph of the current situation of the forest path viewpoint (2012). One of the new villas, visible in the centre of the image, blocks the current view between the trees. (photo: A. Patwary)



Image 5 View on the old city centre from the Sandersweg. Painter: Pelgron, 1891 (source: P van der Kuil)

Historical Viewshed For ViewPoint 3

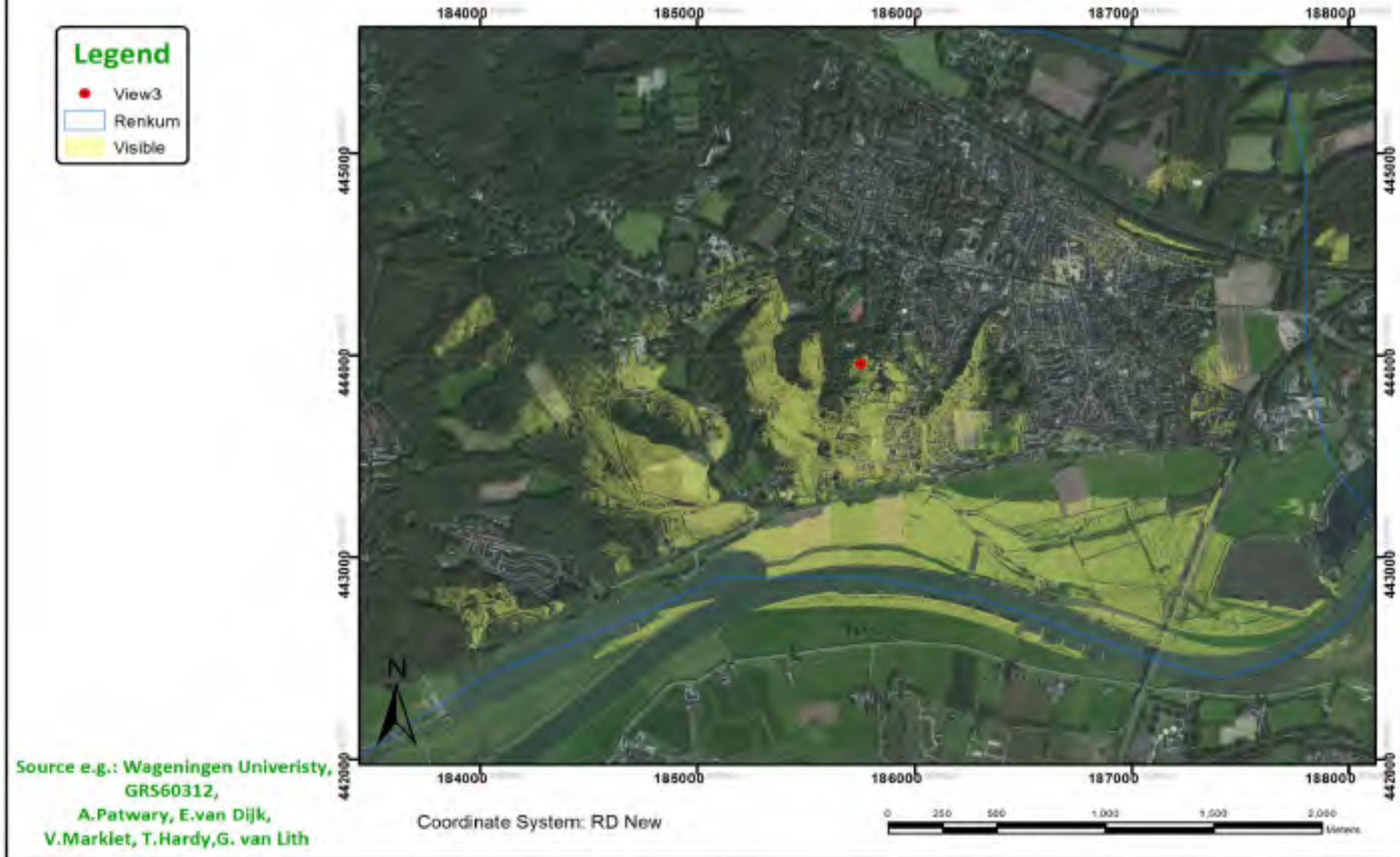


Image 7 Historical viewshed analysis of the old forest path connecting estate houses 'Pietersberg' and 'Hemelse berg'.

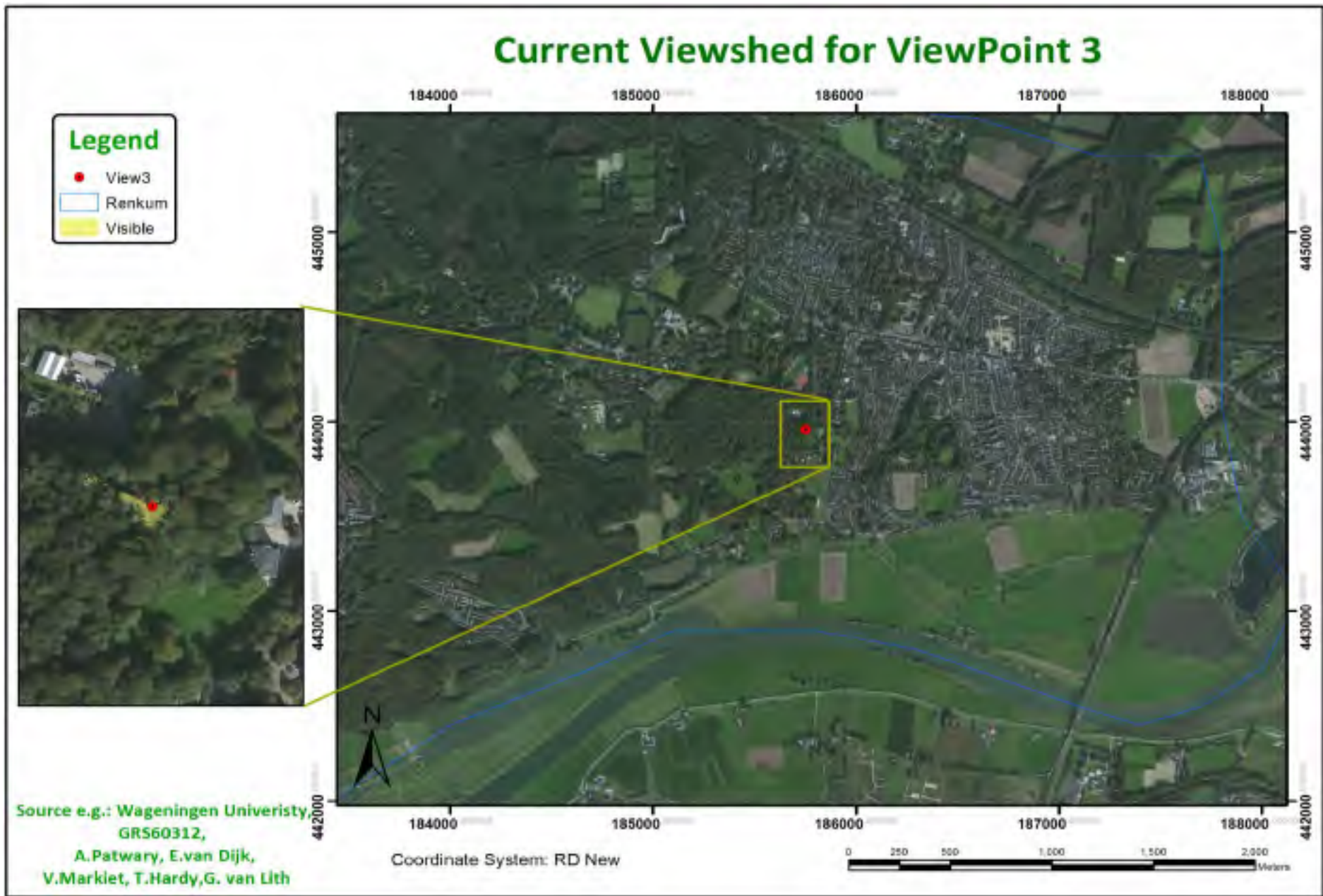


Image 8 Current visibility from the exact location anno 2012.

Viewpoint 5: Bato's Wijk

The current viewpoint of Bato's Wijk is blocked by a treeline and a rock feature. The viewpoint changed significantly over the past 80 years and used to provide the observer a more open view of the area (images 9, 10 & 12). The trees were left free to grow, so together with an increase in ornaments, they slowly decreased the visibility (images 11 & 13).



Image 9 View from Bato's Wijk, orientation South-West towards the old city centre, photograph was taken around 1935 (source: P. van der Kuil).



Image 11 Bato's wijk viewpoint in 2012 with an orientation towards the South/South-West (photo: A.Patwary).



Image 10 Bato's wijk viewpoint with distinct openness in the background ('Rosande Polder'). Orientation is towards the east (date photograph: around 1930,source: P. van der Kuil).

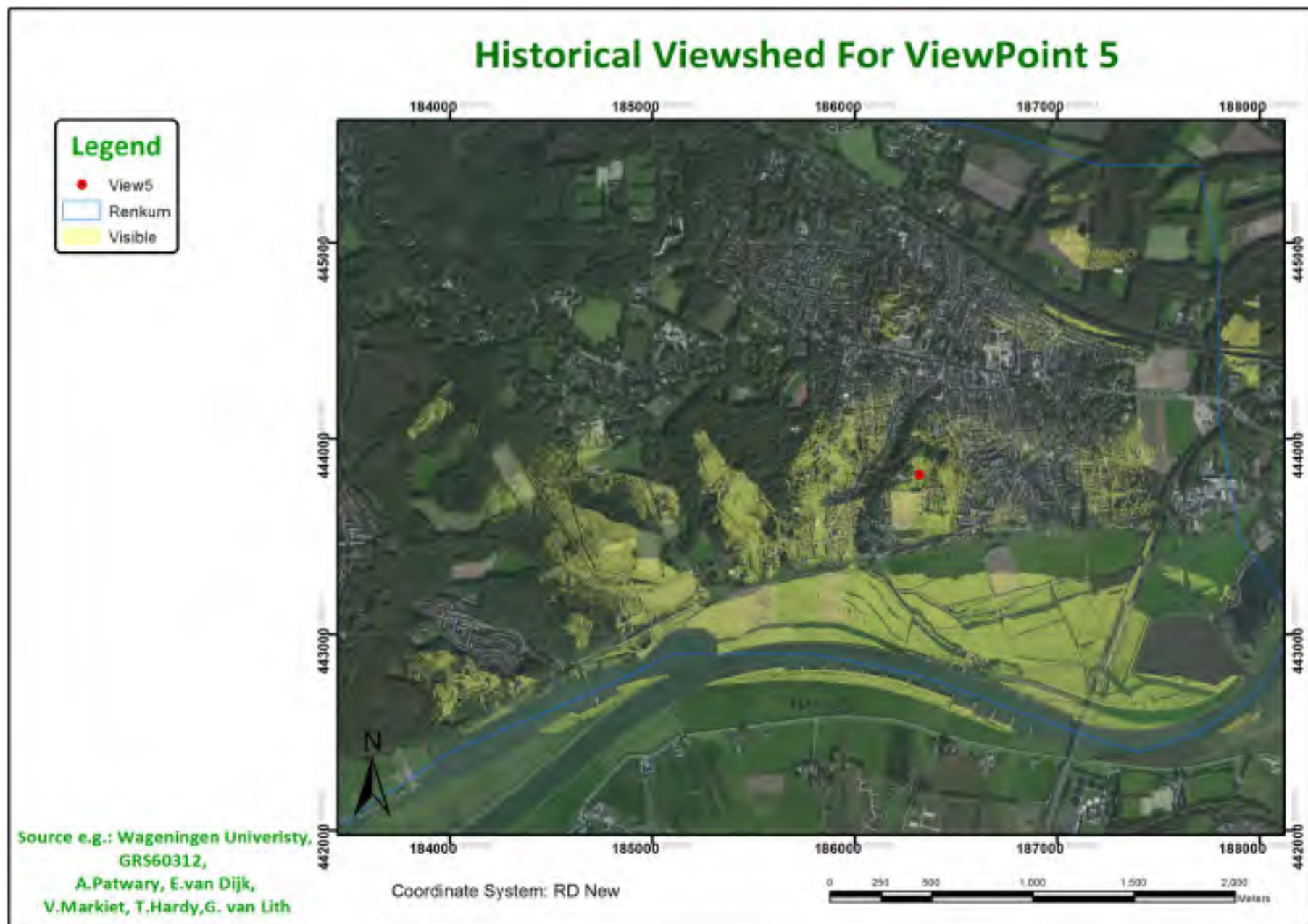


Image 12 Historical viewshed analysis of observation point 'Bato's wijk' for the 19th century

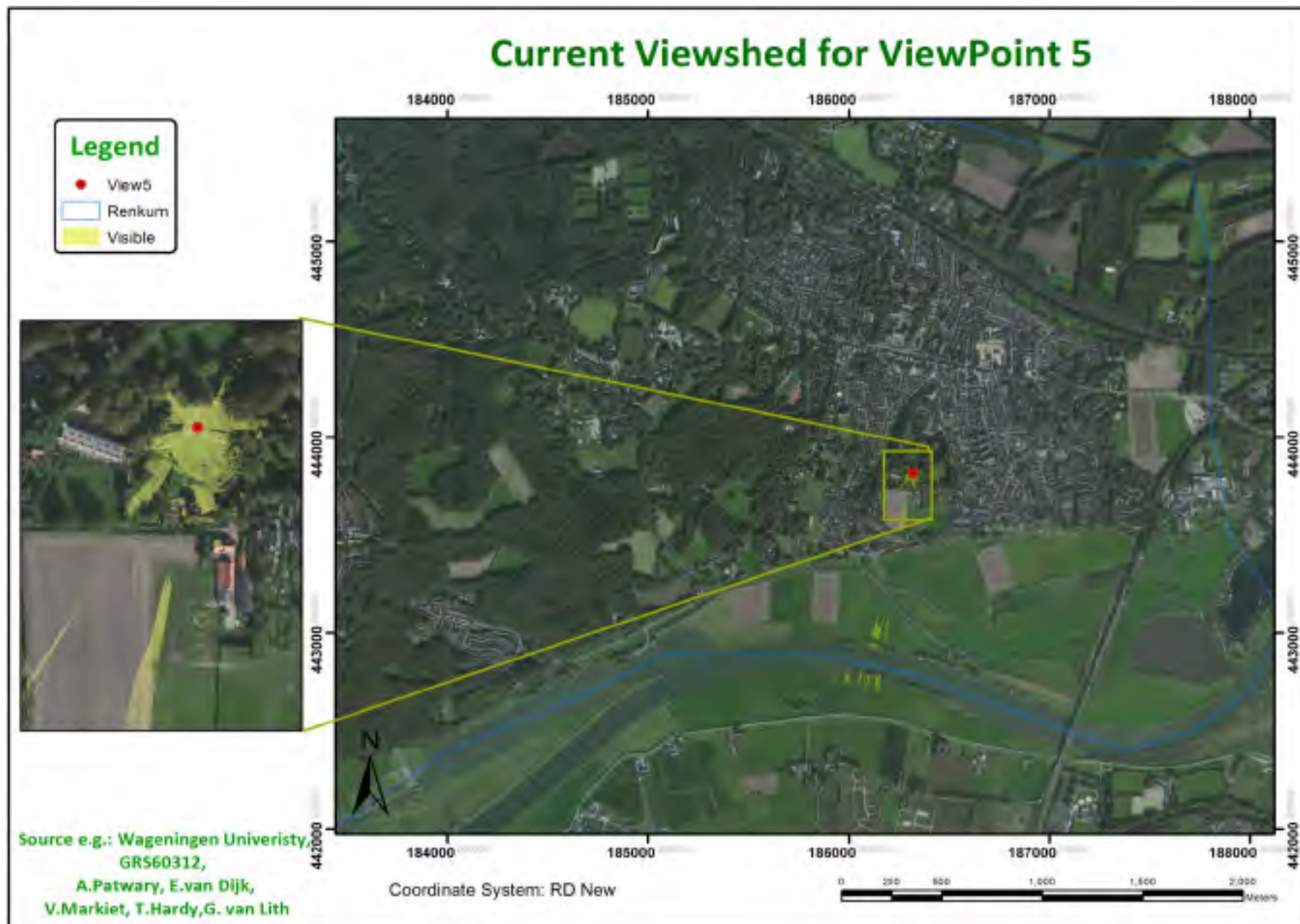


Image 13 Current visibility of the view point 'Bato's Wijk'. Trees and ornaments block the view causing the visibility to decrease significantly.



Image 14 view from 'Rosandeweg' towards the old water tower that has been demolished. Orientation: North-West (Source: Google maps,2010).



Image 15 Photo looking at the water tower taken from Rosandeweg & van Wassenaweg street view, date photo: around 1930 (source: P. van der Kuil).

Viewpoint 8: Rosandeweg

Rosande weg is situated in the South-eastern part of Oosterbeek and in the 1800's was mainly surrounded by arable land used for agriculture, and meadows used as grassland. Image 15 shows the water tower (location: between the Molenweg and Beukenlaan) that was used for water storage . Since the 1900's, especially after the second world war this area has been transformed from open arable land into built up area. The typical open landscape from the 1800's and early 1900's completely disappeared. This is displayed in the viewshed analysis (Image 17).

Historical Viewshed For ViewPoint 8

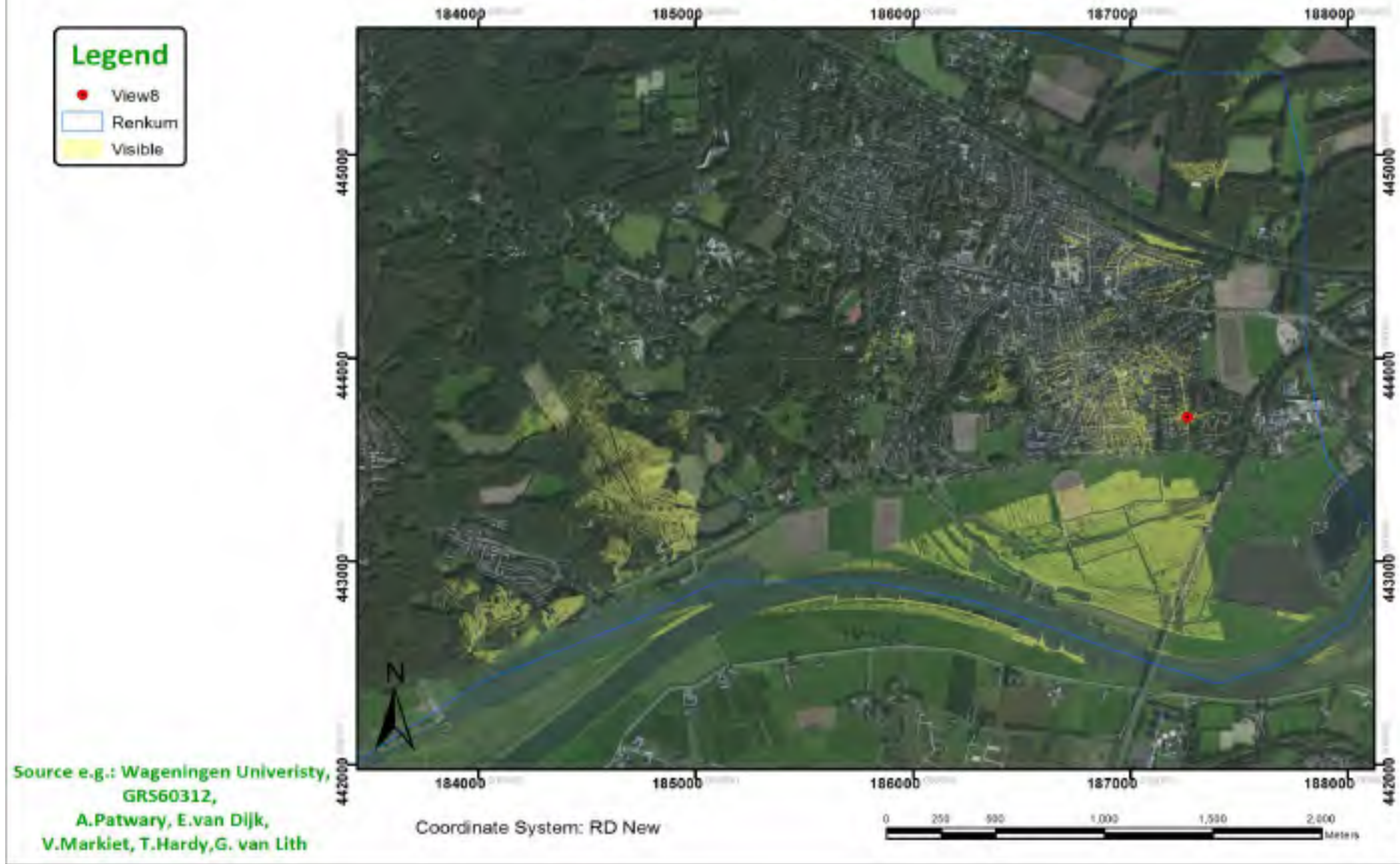


Image 16 Historical Viewpoint 'Rosandeweg' for the 19th century.

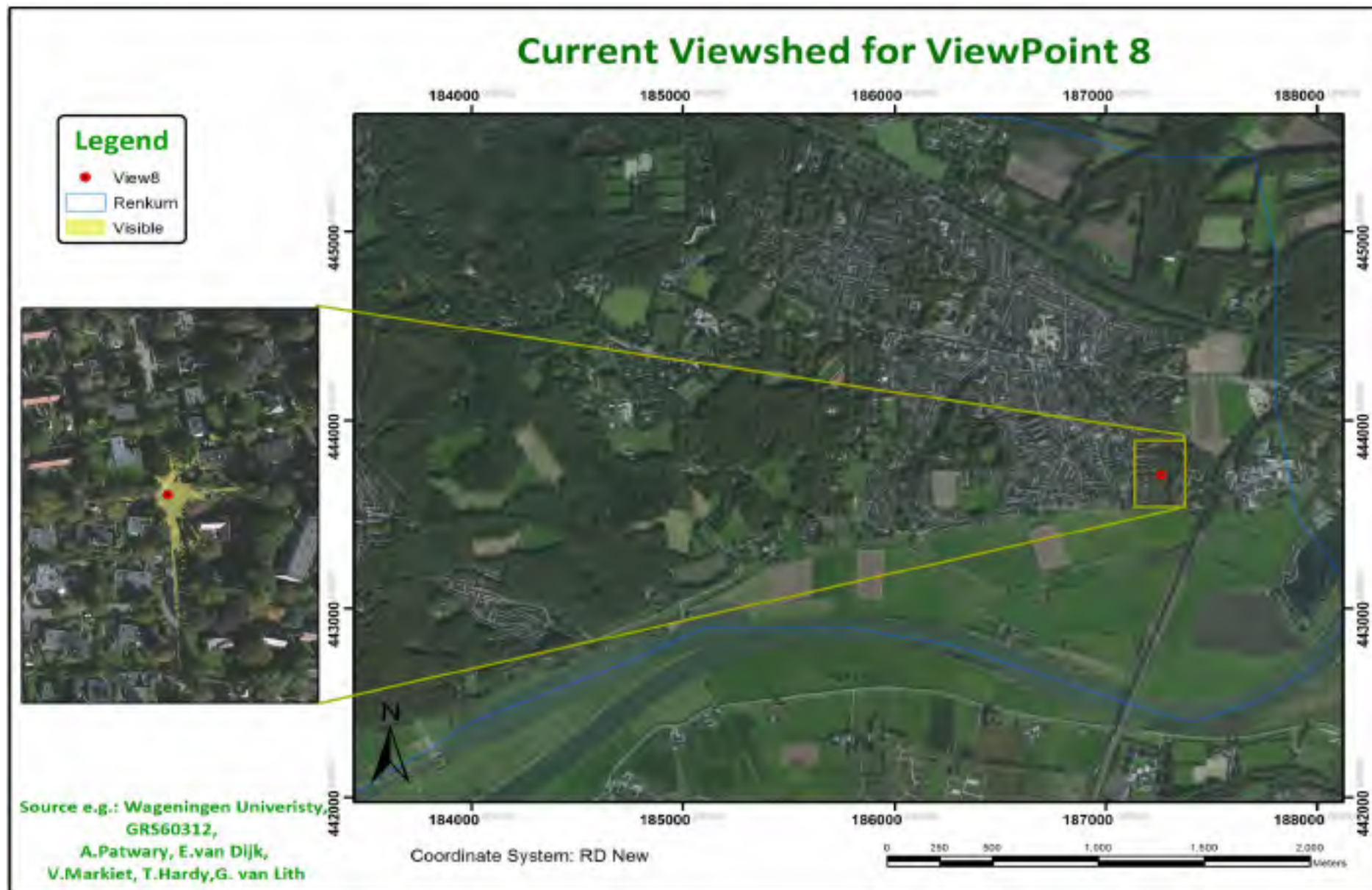


Image 17 Current visibility for 'Rosandeweg' in 2012



Image 20 Junction of 'Vogelweg' and 'Emmastraat' (source: Google streetview)



Image 19 The 'Vogelweg' to the south orientated towards the rhine and railroad bridge, photo is from around 1930 (source: P. van der Kuil).



Image 18 The sheepfold painted by J. Pelgrom overlooking the Rhine around 1840 (source: P. van der Kuil)

Viewpoint 10: Sheepfold at the Junction at Emmastraat and Vogelweg

The sheepfold, as painted by Jacobus Pelgrom (image 20), was on the location where now the junction of Emmastraat and Vogelweg is situated. Pelgrom considered this viewpoint as an important location for the village of Oosterbeek. In the 19th century one could see the arable lands in the 'Rosande polder' and the rail road bridge over the Rhine. As this observation point was situated on a lower altitude than the northern part of Oosterbeek, the view did not reach much further than just across the river.

In the 20th century the area slowly started to fill up with houses for people working on the lands (Image 19). In 2012 the location doesn't give the opportunity to see far anymore, as houses have blocked the view entirely (image 18 & 22).

Historical Viewshed For ViewPoint 10

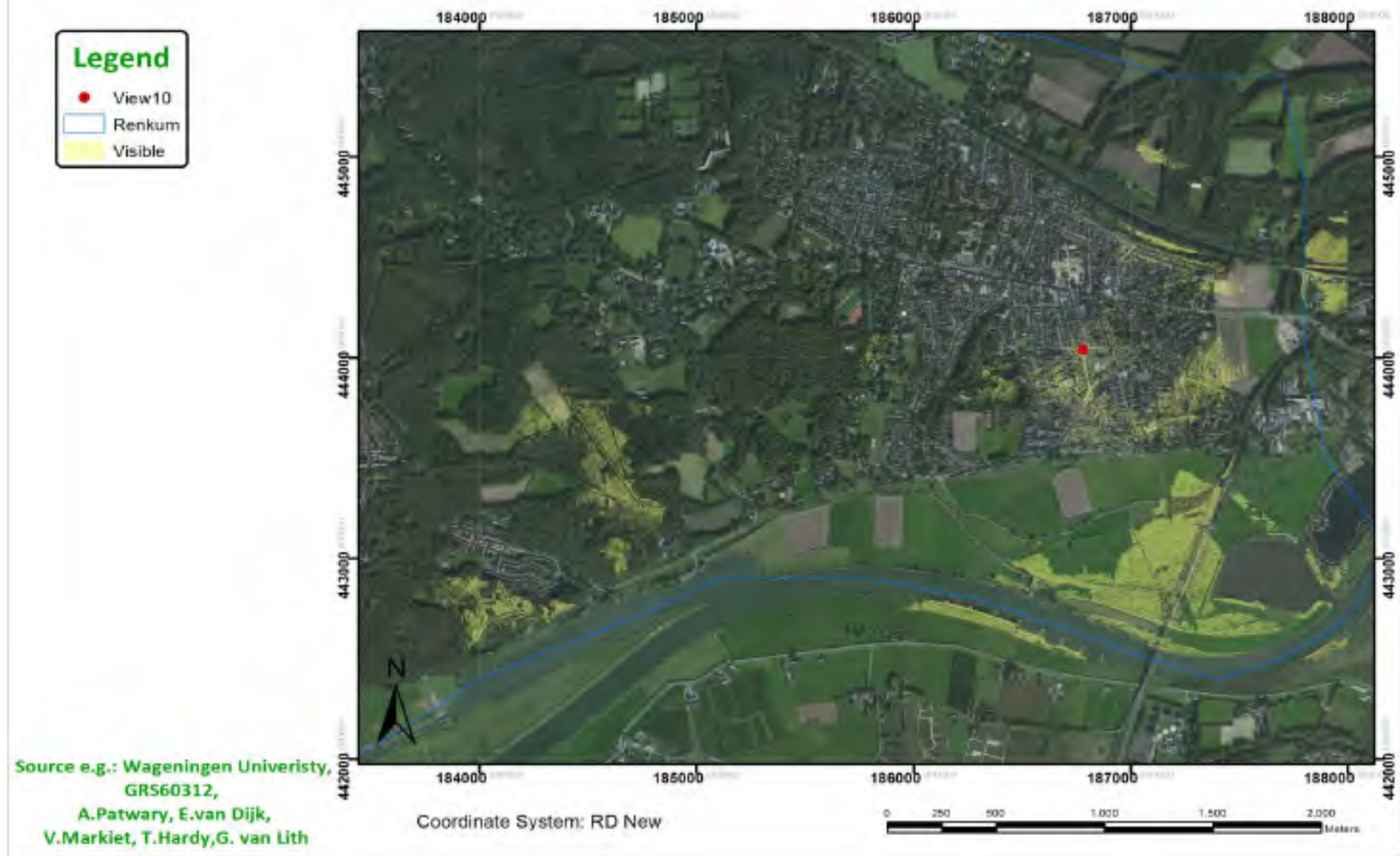


Image 21 Historical viewshed around the 19th century

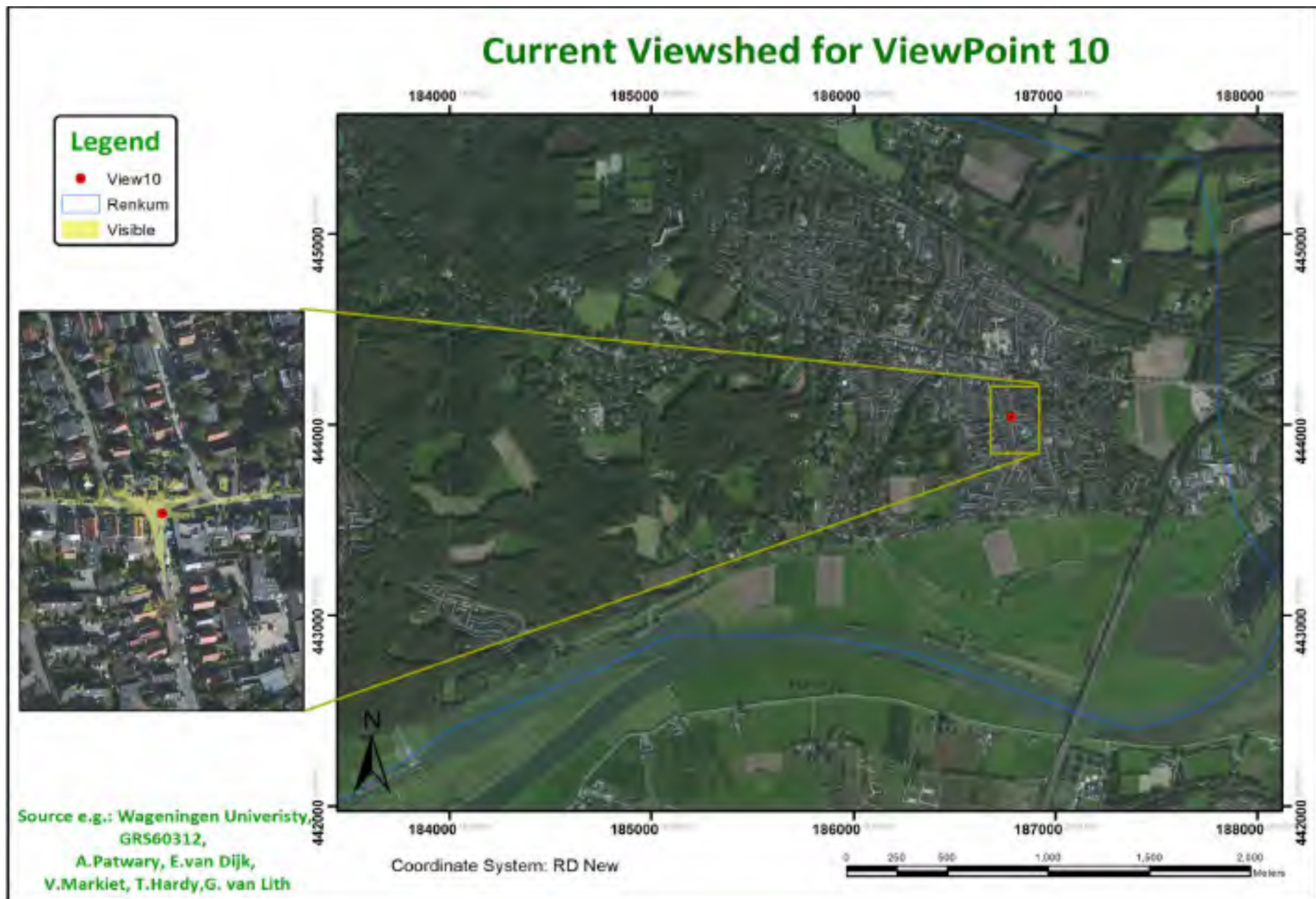
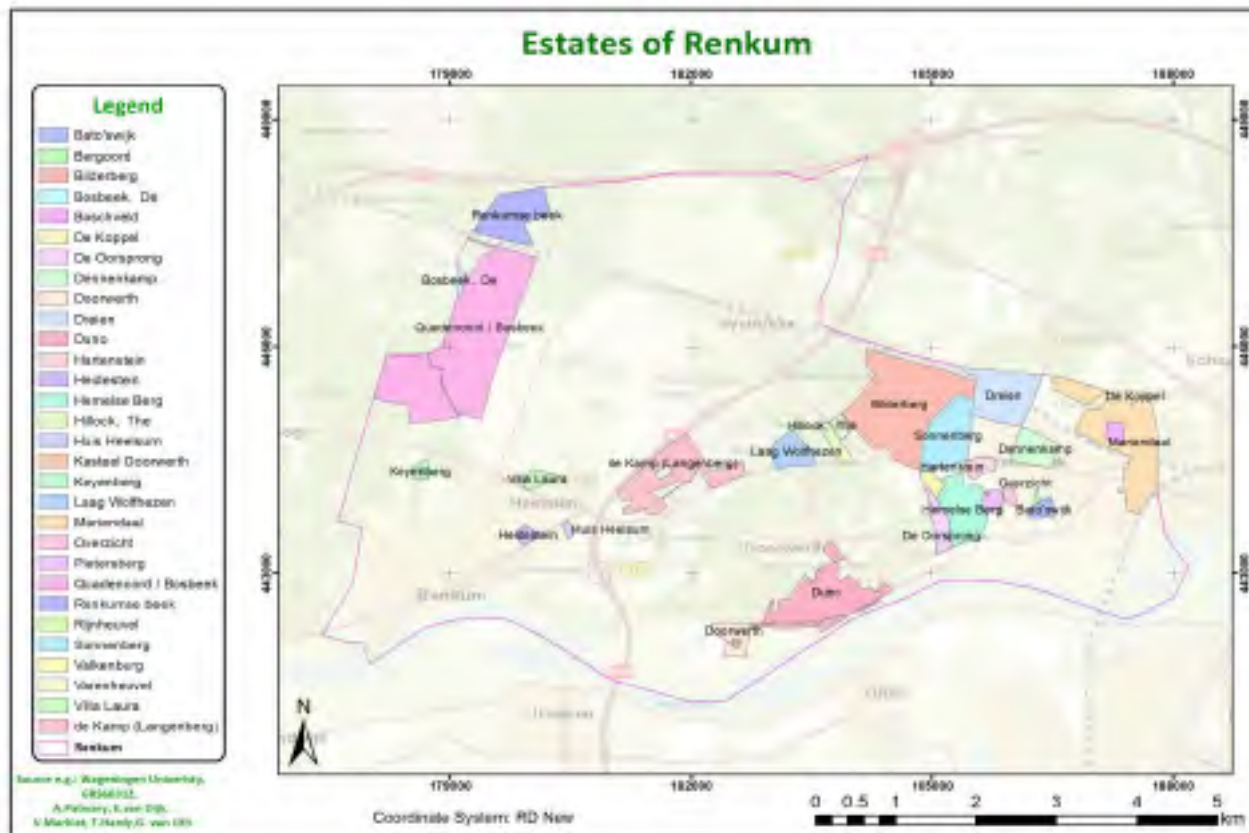


Image 22 Visibility of the observation point as of 2012.

4. Mapping the current situation

This section describes conclusions regarding the current situation of the estate landscape within Renkum. First of all the estate borders how they

are today are located based on the estates map from the municipality.



The landscape how it looks today, has been visualized by showing which features are still present today and where they are located.

This has been done by creating several output maps, from datasets containing landscape features (such as soil types, DEM, archaeological features), in combination with the estate boundaries maps.

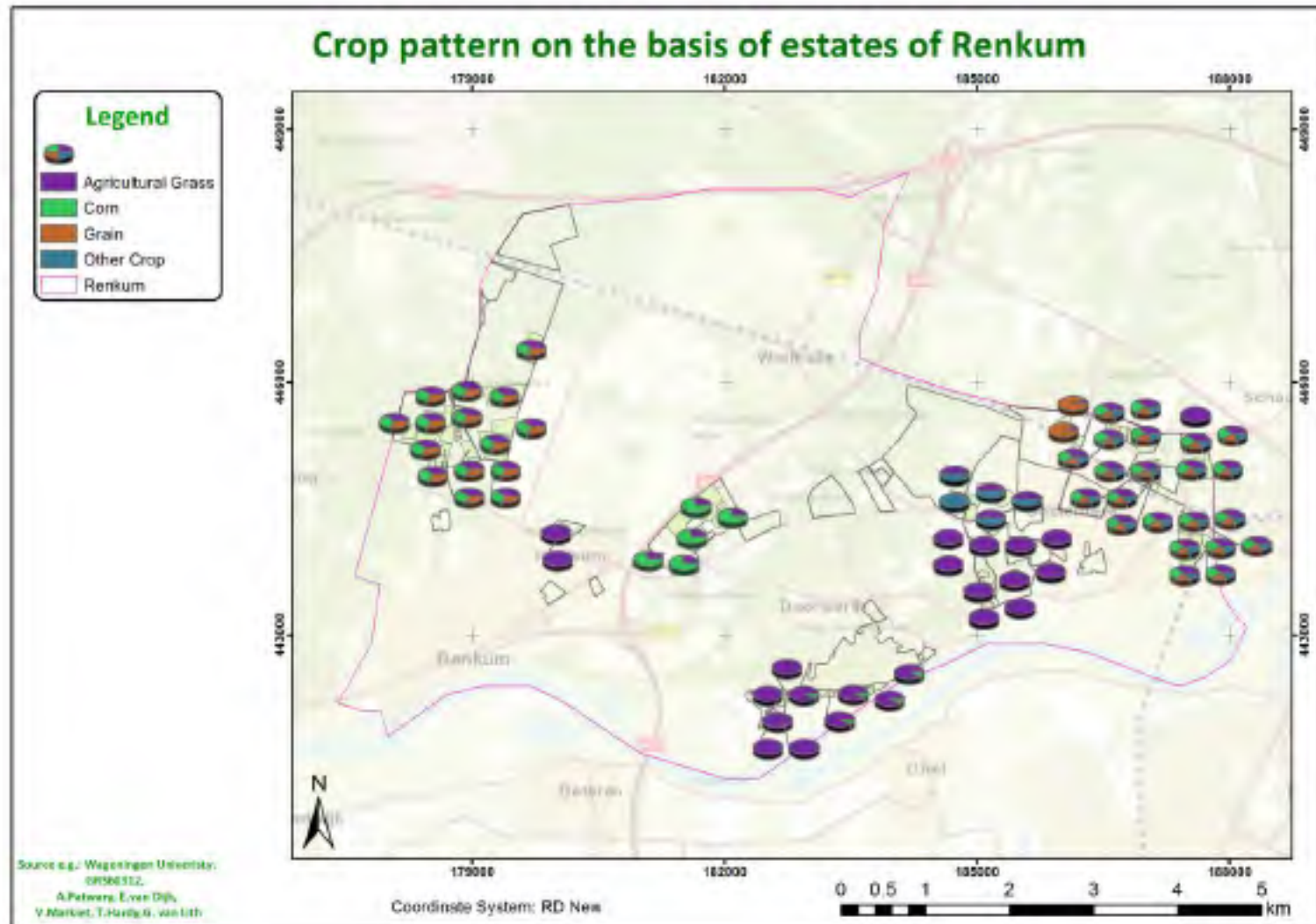
The following 4 maps have been created:

- Crop pattern on the basis of Renkum
- Forest and vegetation distribution
- Soil properties
- Archaeological terrain

Map 8 The different estates the Renkum municipality.

Crop patterns

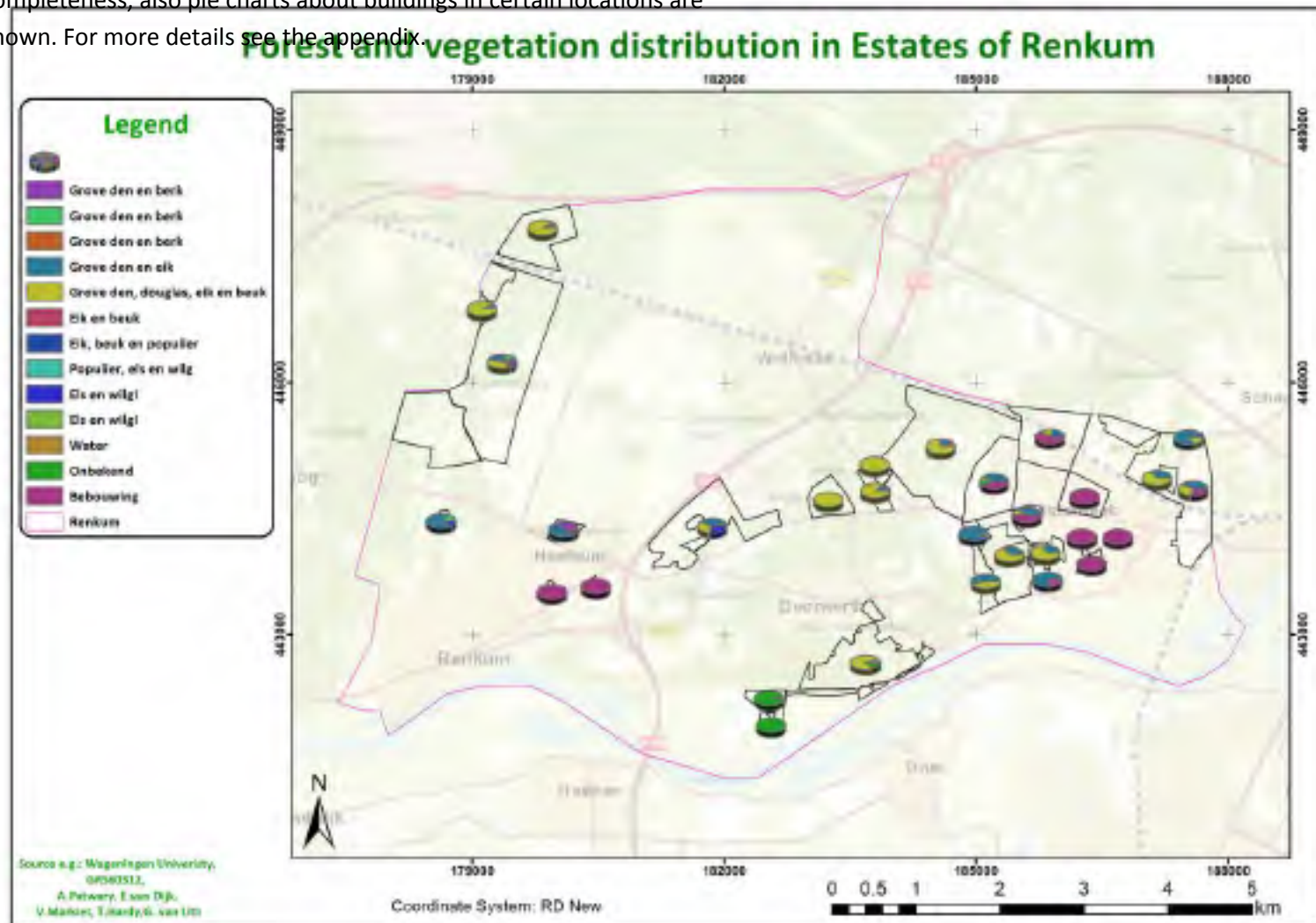
In the number 9 the crop pattern within the estates of Renkum are shown. In the east of the area, agricultural grass, corn and grain are dominant, while in the west all of the four crops are present. In the south, basically agricultural grass is more dominant. For more details see the appendix.



Map 9 Crop patterns

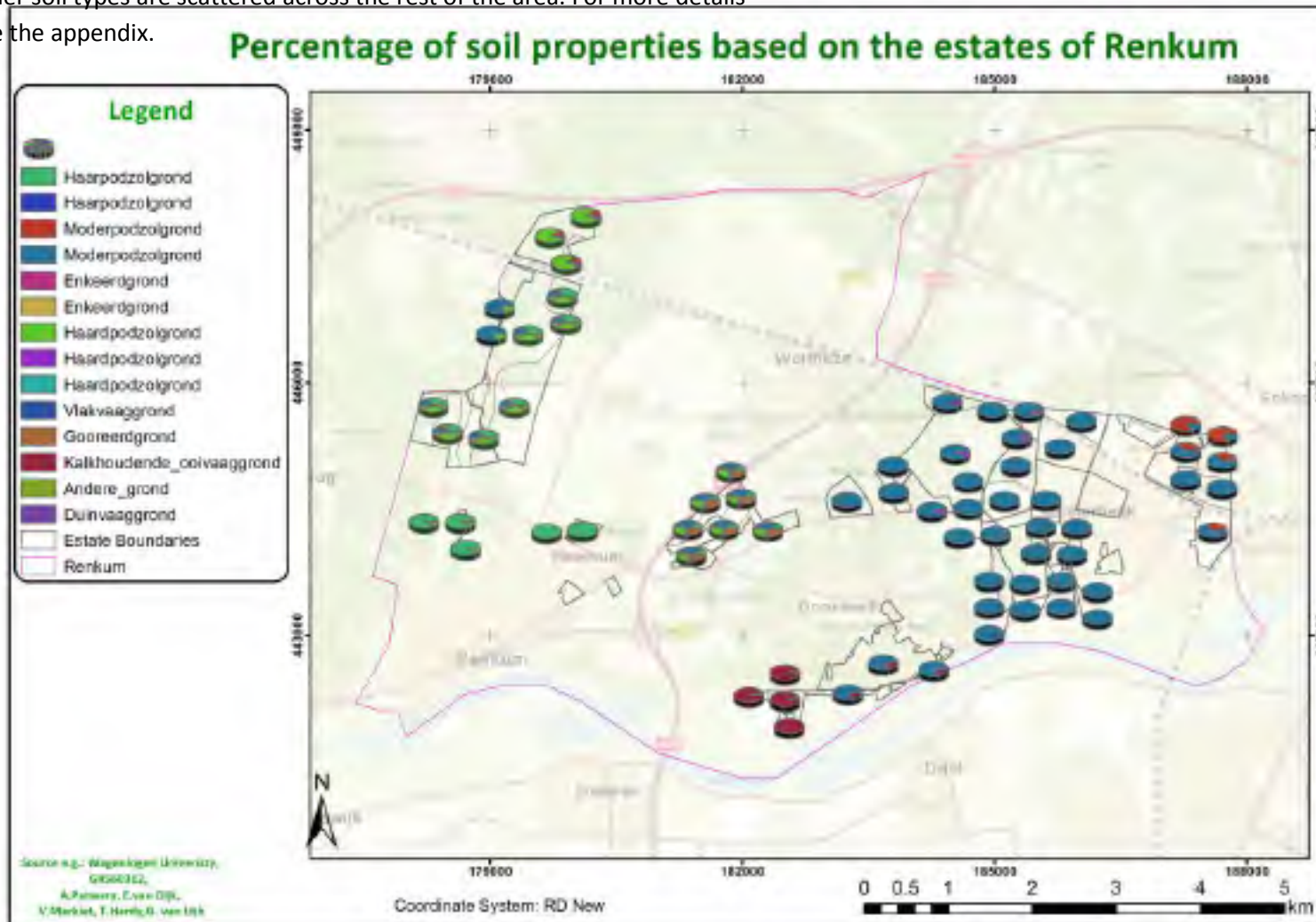
Forest and vegetation distribution

In the map number 10 the patterns are shown concerning vegetation and forest. In the west, basically pines and oaks are dominant. For the completeness, also pie charts about buildings in certain locations are shown. For more details see the appendix.



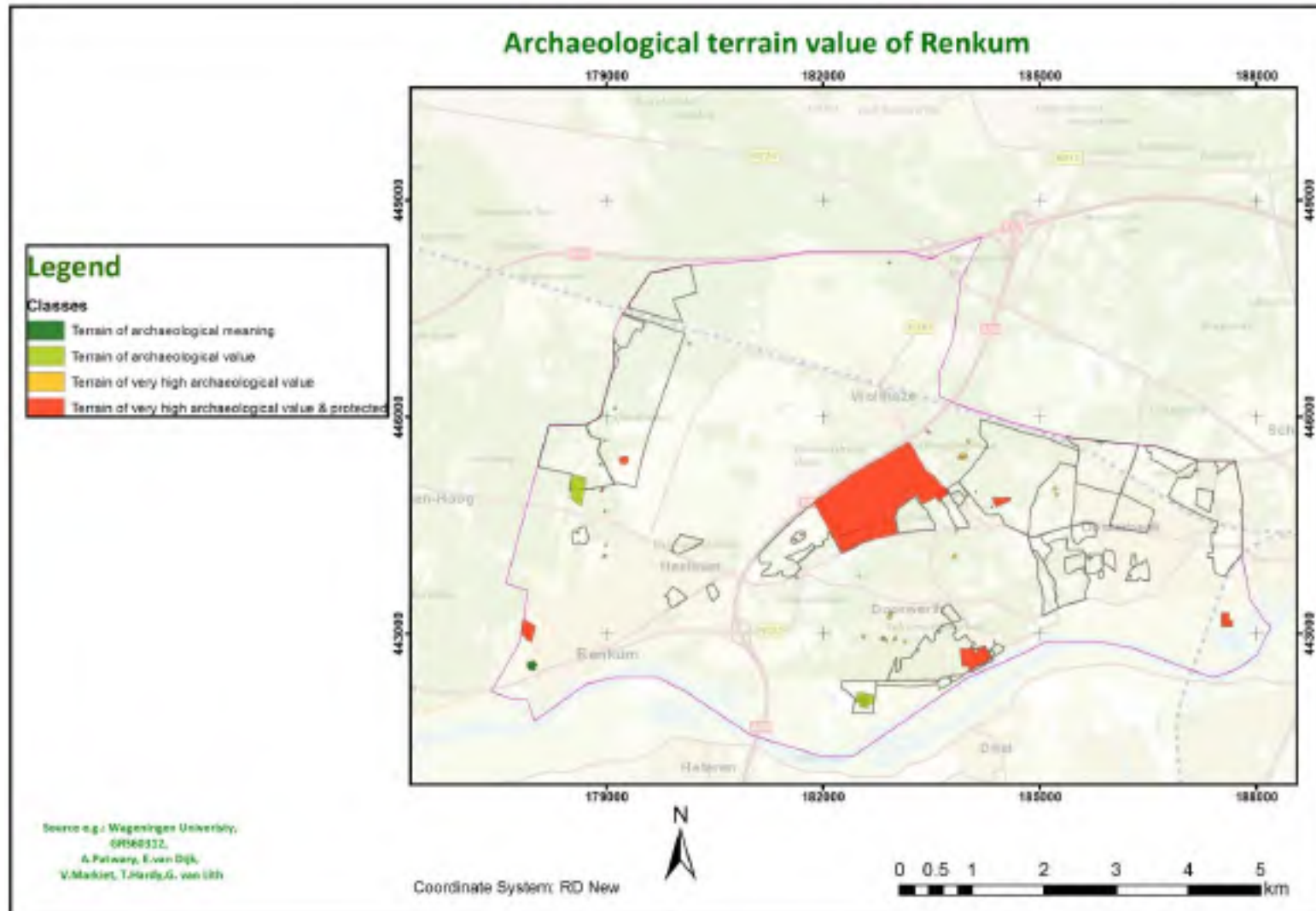
Soil properties

In map number 11 the statistics of different soil types are shown. Almost in the west, modderpodzol soil is dominant, while in the east haarpodzol soil is most present. In the south, also chalk ooivaag soil is present. The other soil types are scattered across the rest of the area. For more details see the appendix.



Map 11 Percentage soil properties

Archaeological terrain



Map 12 Archaeological terrain values

The Archaeological terrain map shows important areas that are designated by the KICH (Kennis Infrastructuur Cultuur Historie) as archaeological terrains. Especially the estate of 'lagerkamp' is located in a terrain of very high archaeological value and is as well protected. Estate 'Oude Noord/ Bosbeek' which is situated on the left side in the Renkum municipality also has some archaeological value but is however not protected.

5. Conclusion

Many stakeholders within the municipality of Renkum are concerned about the degradation of the estate landscapes. This includes its inhabitants, and the commission called Estate Initiatives Group. Therefore, the purposes of this research project were to analyse the current situation of the landscape, as well as the changes within the landscape between certain periods in the past.

This chapter covers the conclusions which can be drawn from these project purposes.

5.1. Analysis of the changes in time

The viewshed research

For the viewshed research, 11 viewpoints have been chosen as observation points. From these points, both old and new pictures have been chosen to visually check the changes within the area of these points. Next to this, viewshed analysis have been executed in ArcGIS to be able to determine the view area on those points.

It can be concluded that mainly trees and buildings block the viewsheds. When progressing in time, more buildings and more trees appeared, so the view lines and the viewshed areas decreased significantly.

The fragmentation research

For the fragmentation research, five input raster maps have been used for statistical analysis of the five different time slices. It can be concluded that for all the patches (land use regions) the mean area decreased and the patch density increased, which signifies the fragmentation of the area. For the different land use classes, it can be concluded that more build up areas, deciduous forest and grass lands appeared, in contrast of arable land which decreased quite some hectares. So also per land use class, fragmentation is visible.

5.2. Mapping the current situation

The position of the estate borders how they are today, were located based on the estates map from the municipality.

The present-day landscape, has been visualized by showing which features are present today and where they are located. This has been done by creating several output maps, using datasets containing landscape features (such as soil types, DEM, archaeological features) in combination with the estate boundaries map.

6. Discussion

The identification and definition of estate borders and parcels

Defining the borders of an estate has happened in a systematic way that involved cross-checking the parcel owners in the '*kadastrale atlas Gelderland*' from 1832 with the estates owners mentioned in the book from 'Stichting Geldersch Arcadië'. In this way, the parcels belonging to the owner could be identified, but if for instance an estate land parcel has been leased by someone else, the rightfully parcel owner might not be in the cadaster list. In this scenario parcels were perhaps not included in the estate inventory.

When geo-referencing the cadaster atlas scanned images were used. A basemap of 1930 was used to identify and to trace the current borders. The scanned maps from the cadaster are drawings from 1832 and thus still had to be geo-referenced. Such an overlay means small distortions compared to reality.

The current analysis

The dataset of the current estate borders, presented by the municipality of Renkum, was only a first draft. At the time (June,2012), these borders were not yet verified by their cartography department. In that respect borders indicated in the map might not exactly represent the real borders.

Viewshed analysis

The viewshed analysis is a great tool to calculate the visibility of an observation point , and thus very suitable for the purpose of our research. However, it has some limitations.

In the DEM there are no trees or buildings. However, in the historical time a few buildings and trees existed which could have blocked the view. These trees and buildings are not included in the DEM. Again the DEM used in the historical viewshed analysis included some "no data" values. These 'no data' values are trees and houses that were removed after processing the airborne LiDAR image. For the viewshed analysis these 'no data' areas are not included in the computation of the viewshed. Hence, the calculated viewshed area represents a different fraction of the historical viewshed area. For that reason the result does not fully represent the actual historical situation.

Whilst analysing the viewshed using the DTM, one tree or house created a 'non-visible' zone (Figure 11) and assigned all the pixels behind the object a ' non-visible' value. However, when one is positioned on a hill looking downward, the areas that are not visible for the computer such as below the leafs and in between houses, are in reality visible for the observer.

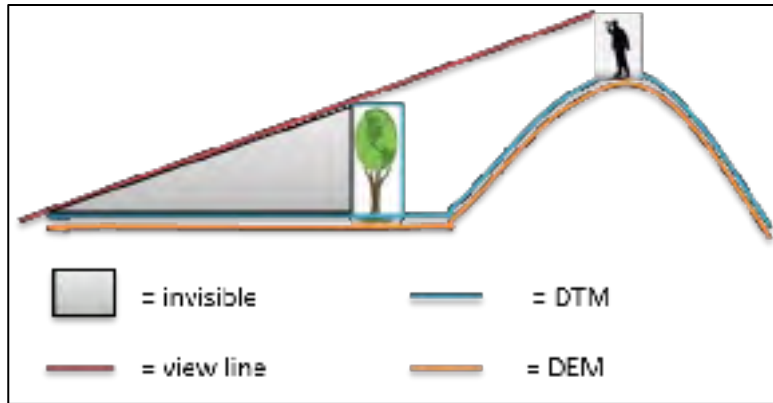


Figure 9 The Orange line represents the DEM, and the blue the DTM. When calculating with the DTM, the tree will block the view behind it. But in real life, a person would be able to look underneath past the canopy, revealing at least a small portion of the area behind the tree.

Land use change over time

During the fragmentation research, we had to deal with some constraints; only land use maps of 1900, 1960, 1970, 1980 and 1990 have been used for the fragmentation analysis. Unfortunately, land use maps from other time periods were not available. This means irregular time intervals, and

no data before 1900. Next to this, the resolution of the 1900 map is 50x50 meters, while the other four have a pixel size of 25x25 meters. Converting the 50x50 map to 25 by 25 meant creating artefacts in the data. Converting the 25x25 into 50x50 meant loss of data. In this research the 50x50 has been converted to a 25x25, which will have caused slight artefacts in the data. The research would also be more complete if all the estates within the municipality of Renkum could have been digitized and analysed. However, due to a lack of available data and time, we were only able to digitize the estates within the village of Oosterbeek. They were derived from the Gelderse Atlas Oosterbeek, Renkum and Doorwerth. Moreover, only five of the six estates have been digitized. We have located the sixth estate (Laag/Hoog Oorsprong) too late, and due to time constraints it was not possible anymore to restore this mistake. Therefore, the study area consists of only five estates.

7. Acknowledgements

We have very much enjoyed working on this project. It gave us the opportunity to dive into the realm of historical maps and paintings. The process of searching the optimum method of calculating and visualising change through time enriched our GIS skills.

We would like to thank *Ron van Lammeren* for his enthusiasm and knowledge about visualising historical landscapes, *Arend Ligtenberg* for his guidance in the project, and leading us to the fragmentation software Fragstats.

We also would like to thank *Flip Witte* and his colleagues for inspiring us time to time to complete the entire project. We would like to especially thank *Pieter van der Kuil* for his inexhaustible source of knowledge of the area, his compelling way of telling us the history of the area, and his willingness to guide us through the area to position the needed GNSS points.

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Appendix I

The results of the fragmentation research

Table 2 Results of the total fragstats research

Total results									
	Total area		Total number of	Percentage	Patch density	Patch area (ha)		Fractal dimension index (-)	
Time slice	(ha)		patches (#)	of total (%)	(#/ha)	Mean	SD	Mean	SD
1900		467.88	181	100	0.39	7.160	59.287	1.049	0.054
1960		467.88	358	100	0.77	3.649	43.391	1.054	0.067
1970		467.88	376	100	0.80	3.476	42.385	1.054	0.070
1980		467.88	383	100	0.82	3.413	41.634	1.049	0.064
1990		467.88	425	100	0.91	3.078	39.857	1.045	0.064

The fragstats results of time slice 1900

RESULTS	Time slice: 1900								
	Total area per class	Number of patches	Percentage	Patch density	Patch area (ha)		Fractal dimension index (-)		
LU Class	(ha)	(#)	of total (%)	(#/ha)	Mean	SD	Mean	SD	
arable and bare soil	135.25	45	24.86	0.33	3.006	9.627	1.051	0.056	
buildings and roads	12.44	33	18.23	2.65	0.377	0.409	1.023	0.039	
built up areas	0.00	0	0.00	0.00	0.000	0.000	1.000	0.000	
deciduous forest	183.50	40	22.10	0.22	4.588	10.785	1.059	0.064	
dunes and sand planes	0.00	0	0.00	0.00	0.000	0.000	1.000	0.000	
grass land	17.06	12	6.63	0.70	1.422	2.207	1.041	0.040	
greenhouses	0.00	0	0.00	0.00	0.000	0.000	1.000	0.000	
heather and peat	45.25	23	12.71	0.51	1.967	3.491	1.060	0.046	
pine forest	72.44	27	14.92	0.37	2.683	5.299	1.050	0.051	
reed swamp	0.00	0	0.00	0.00	0.000	0.000	1.000	0.000	
water	0.00	0	0.00	0.00	0.000	0.000	1.000	0.000	
other	1.94	1	0.55	0.52	1.938	0.000	1.046	0.000	
Total	467.88	181	100	0.39	7.160	59.287	1.049	0.054	

Table 3 The fragstats results of time slice 1960

RESULTS	Time slice: 1960								
	Total area per class	Number of patches	Percentage	Patch density	Patch area (ha)		Fractal dimension index (-)		
LU Class	(ha)	(#)	of total (%)	(#/ha)	Mean	SD	Mean	SD	
arable and bare soil	56.50	70	19.55	1.24	0.807	2.812	1.031	0.043	
buildings and roads	62.25	126	35.20	2.02	0.494	2.288	1.062	0.079	
built up areas	23.75	33	9.22	1.39	0.720	0.957	1.079	0.072	
deciduous forest	259.38	51	14.25	0.20	5.086	26.847	1.057	0.074	
dunes and sand planes	0.56	2	0.56	3.56	0.281	0.031	1.065	0.008	
grass land	53.13	48	13.41	0.90	1.107	2.481	1.052	0.050	
greenhouses	0.00	0	0.00	0.00	0.000	0.000	1.000	0.000	
heather and peat	10.88	19	5.31	1.75	0.572	0.803	1.039	0.045	
pine forest	0.00	0	0.00	0.00	0.000	0.000	1.000	0.000	
reed swamp	0.00	0	0.00	0.00	0.000	0.000	1.000	0.000	
water	1.44	9	2.51	6.26	0.160	0.098	1.032	0.034	
other	0.00	0	0.00	0.00	0.000	0.000	1.000	0.000	
Total	467.88	358	100	0.77	3.649	43.391	1.054	0.067	

Table 4 The fragstats results of time slice 1970

RESULTS	Time slice: 1970								
	Total area per class	Number of patches	Percentage	Patch density	Patch area (ha)		Fractal dimension index (-)		
LU Class	(ha)	(#)	of total (%)	(#/ha)	Mean	SD	Mean	SD	
arable and bare soil	41.25	75	19.95	1.82	0.550	1.324	1.033	0.046	
buildings and roads	59.00	138	36.70	2.34	0.428	1.126	1.066	0.081	
built up areas	30.00	35	9.31	1.17	0.857	2.079	1.061	0.075	
deciduous forest	270.31	62	16.49	0.23	4.360	24.974	1.050	0.071	
dunes and sand planes	0.00	0	0.00	0.00	0.000	0.000	1.000	0.000	
grass land	58.44	51	13.56	0.87	1.146	2.452	1.050	0.058	
greenhouses	0.00	0	0.00	0.00	0.000	0.000	0.000	0.000	
heather and peat	8.13	10	2.66	1.23	0.813	0.640	1.062	0.044	
pine forest	0.00	0	0.00	0.00	0.000	0.000	1.000	0.000	
reed swamp	0.00	0	0.00	0.00	0.000	0.000	1.000	0.000	
water	0.75	5	1.33	6.67	0.150	0.085	1.025	0.025	
other	0.00	0	0.00	0.00	0.000	0.000	1.000	0.000	
Total	467.88	376	100	0.80	3.476	42.385	1.054	0.070	

Table 5 The fragstats results of time slice 1980

RESULTS	Time slice: 1980								
	Total area per class	Number of patches	Percentage	Patch density	Patch area (ha)		Fractal dimension index (-)		
LU Class	(ha)	(#)	of total (%)	(#/ha)	Mean	SD	Mean	SD	
arable and bare soil	40.44	56	14.62	1.38	0.722	1.644	1.037	0.047	
buildings and roads	50.50	153	39.95	3.03	0.330	1.102	1.051	0.072	
built up areas	42.31	33	8.62	0.78	1.282	5.290	1.040	0.064	
deciduous forest	259.06	59	15.40	0.23	4.391	20.957	1.046	0.064	
dunes and sand planes	0.00	0	0.00	0.00	0.000	0.000	1.000	0.000	
grass land	65.25	61	15.93	0.93	1.070	2.560	1.058	0.055	
greenhouses	0.00	0	0.00	0.00	0.000	0.000	1.000	0.000	
heather and peat	9.19	13	3.39	1.41	0.707	0.660	1.058	0.041	
pine forest	0.00	0	0.00	0.00	0.000	0.000	1.000	0.000	
reed swamp	0.00	0	0.00	0.00	0.000	0.000	1.000	0.000	
water	1.13	8	2.09	7.11	0.141	0.087	1.038	0.042	
other	0.00	0	0.00	0.00	0.000	0.000	1.000	0.000	
Total	467.88	383	100	0.82	3.413	41.634	1.049	0.064	

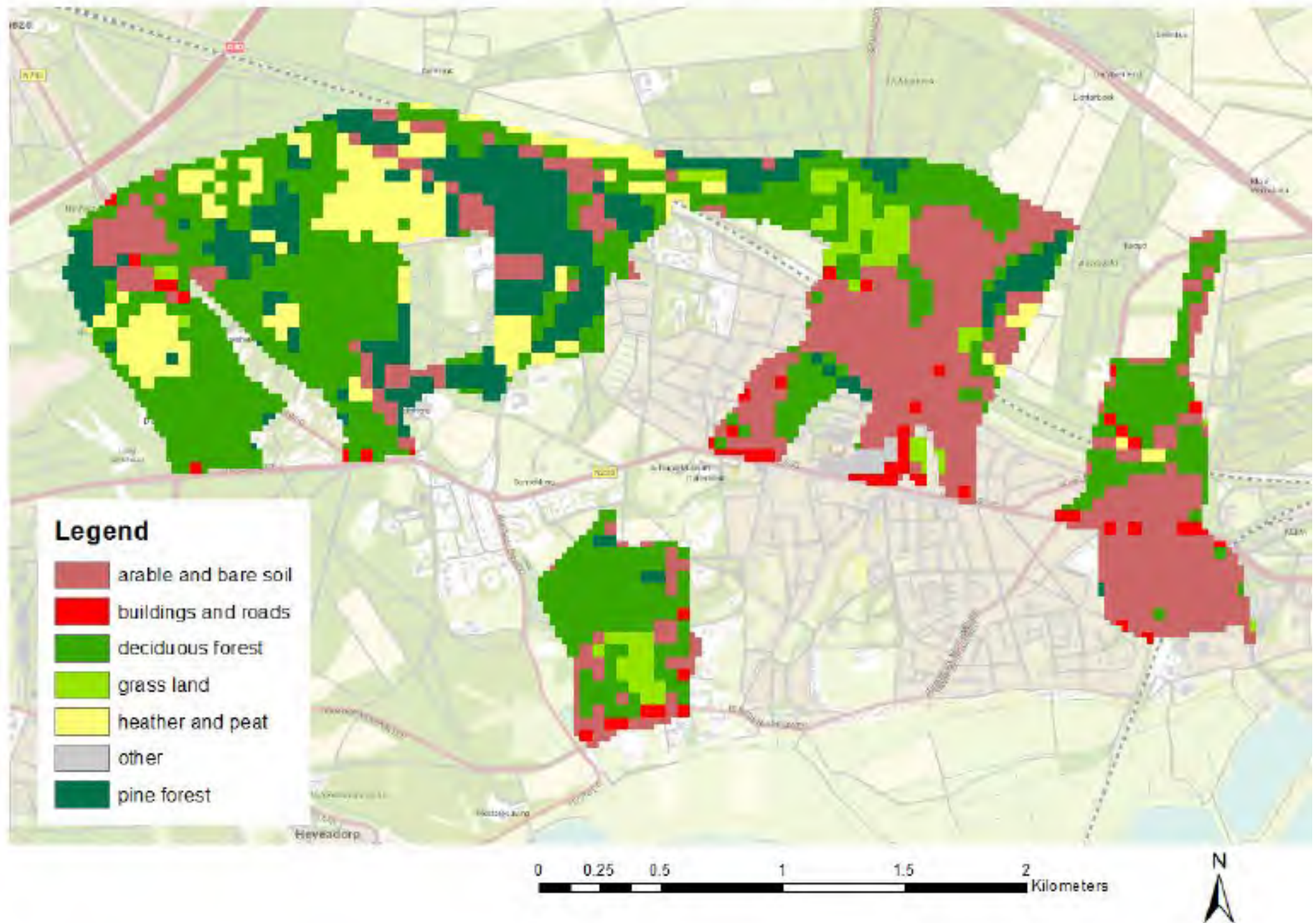
Table 6 The fragstats results of time slice 1990

RESULTS	Time slice: 1990								
	Total area per class	Number of patches	Percentage	Patch density	Patch area (ha)		Fractal dimension index (-)		
LU Class	(ha)	(#)	of total (%)	(#/ha)	Mean	SD	Mean	SD	
arable and bare soil	44.63	48	11.29	1.08	0.930	1.951	1.031	0.037	
buildings and roads	40.38	197	46.35	4.88	0.205	0.324	1.042	0.067	
built up areas	39.63	32	7.53	0.81	1.238	5.039	1.051	0.074	
deciduous forest	266.06	51	12.00	0.19	5.217	26.693	1.053	0.073	
dunes and sand planes	0.00	0	0.00	0.00	0.000	0.000	1.000	0.000	
grass land	67.63	80	18.82	1.18	0.845	2.112	1.051	0.058	
greenhouses	0.13	1	0.24	8.00	0.125	0.000	1.017	0.000	
heather and peat	8.81	11	2.59	1.25	0.801	0.658	1.059	0.042	
pine forest	0.00	0	0.00	0.00	0.000	0.000	1.000	0.000	
reed swamp	0.00	0	0.00	0.00	0.000	0.000	1.000	0.000	
water	0.63	5	1.18	8.00	0.125	0.056	1.030	0.036	
other	0.00	0	0.00	0.00	0.000	0.000	1.000	0.000	
Total	467.88	425	100	0.91	3.078	39.857	1.045	0.064	

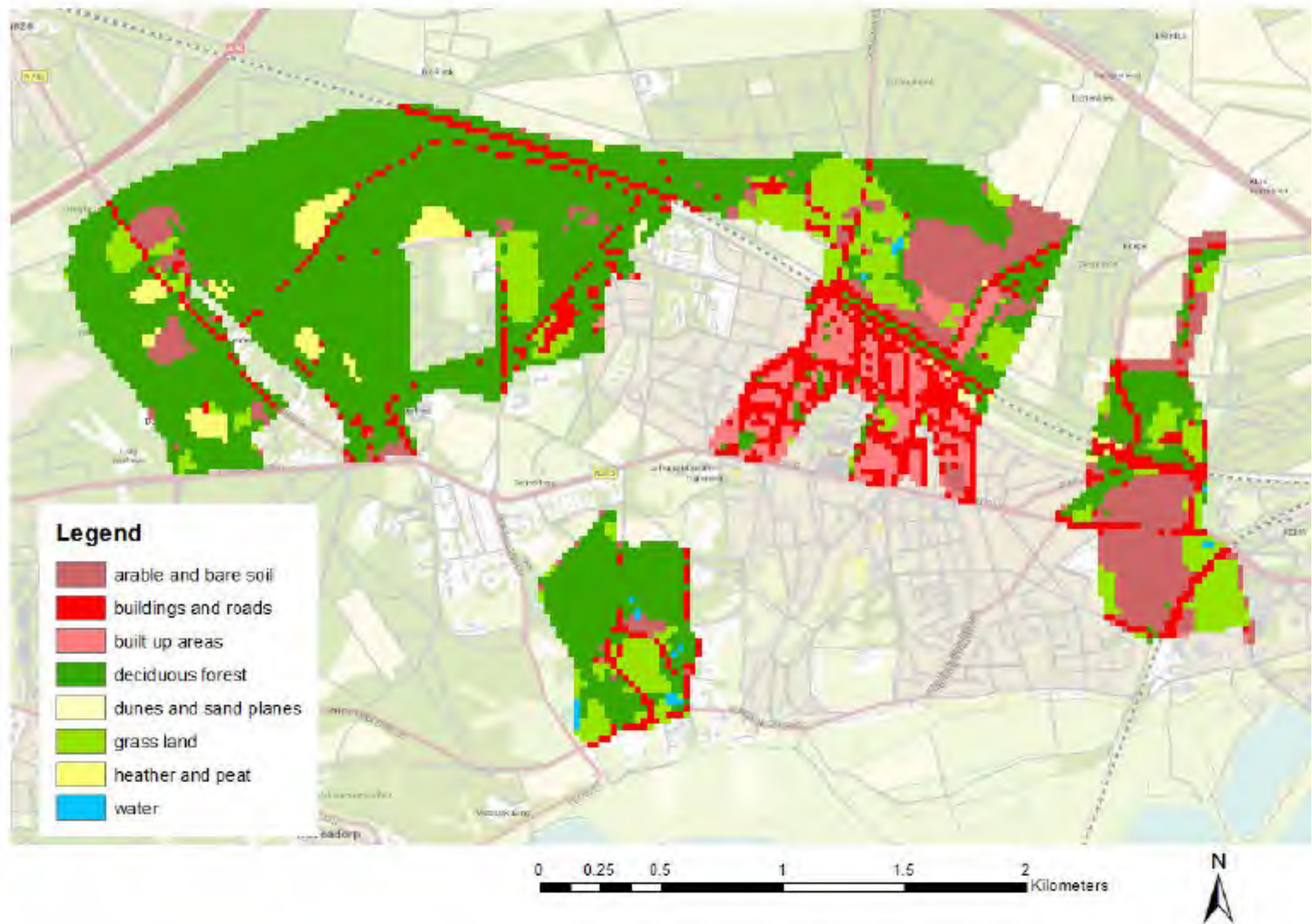
Appendix II

The fragmentation research Land use maps

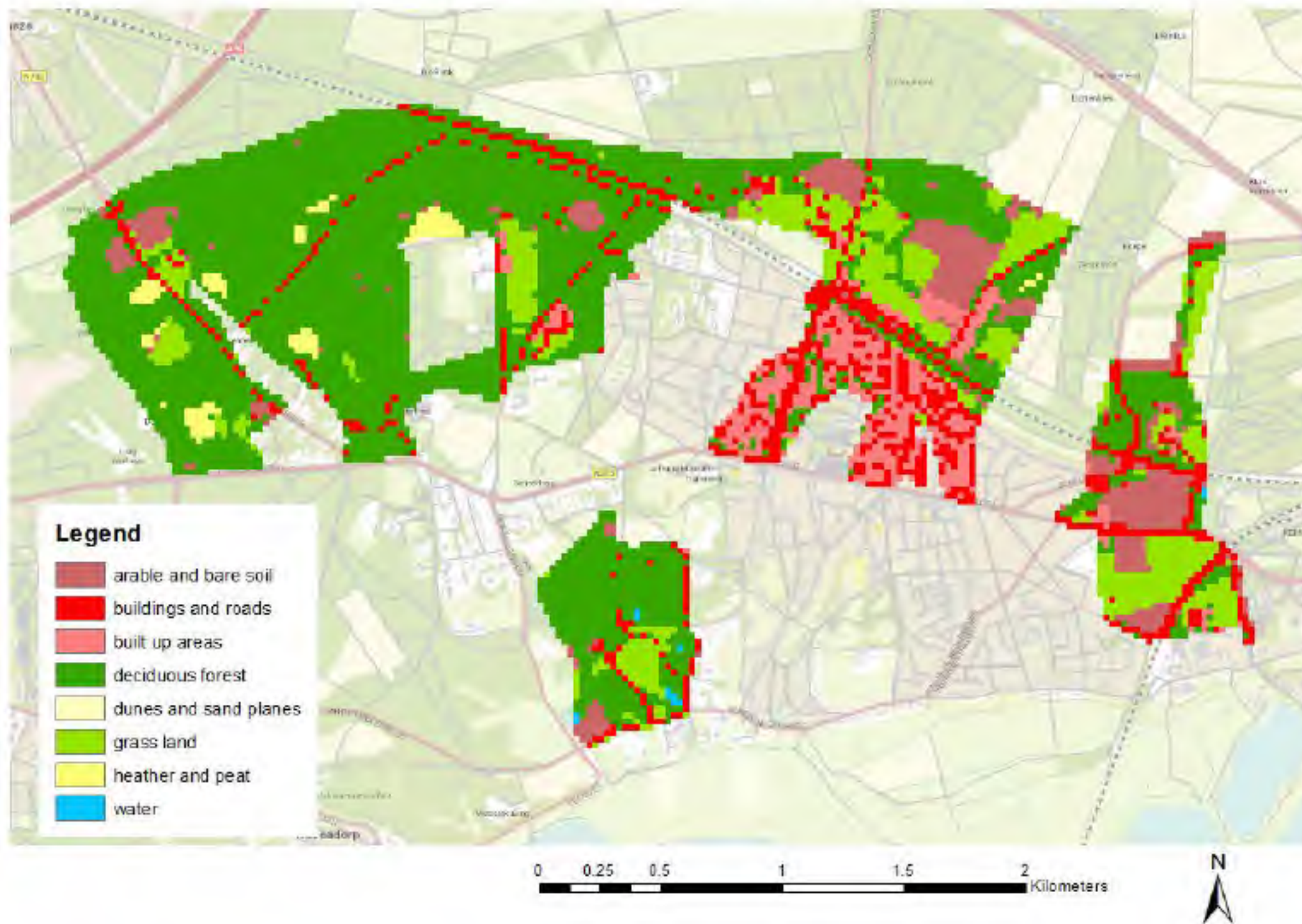
Land use in the original estates from Oosterbeek in 1900



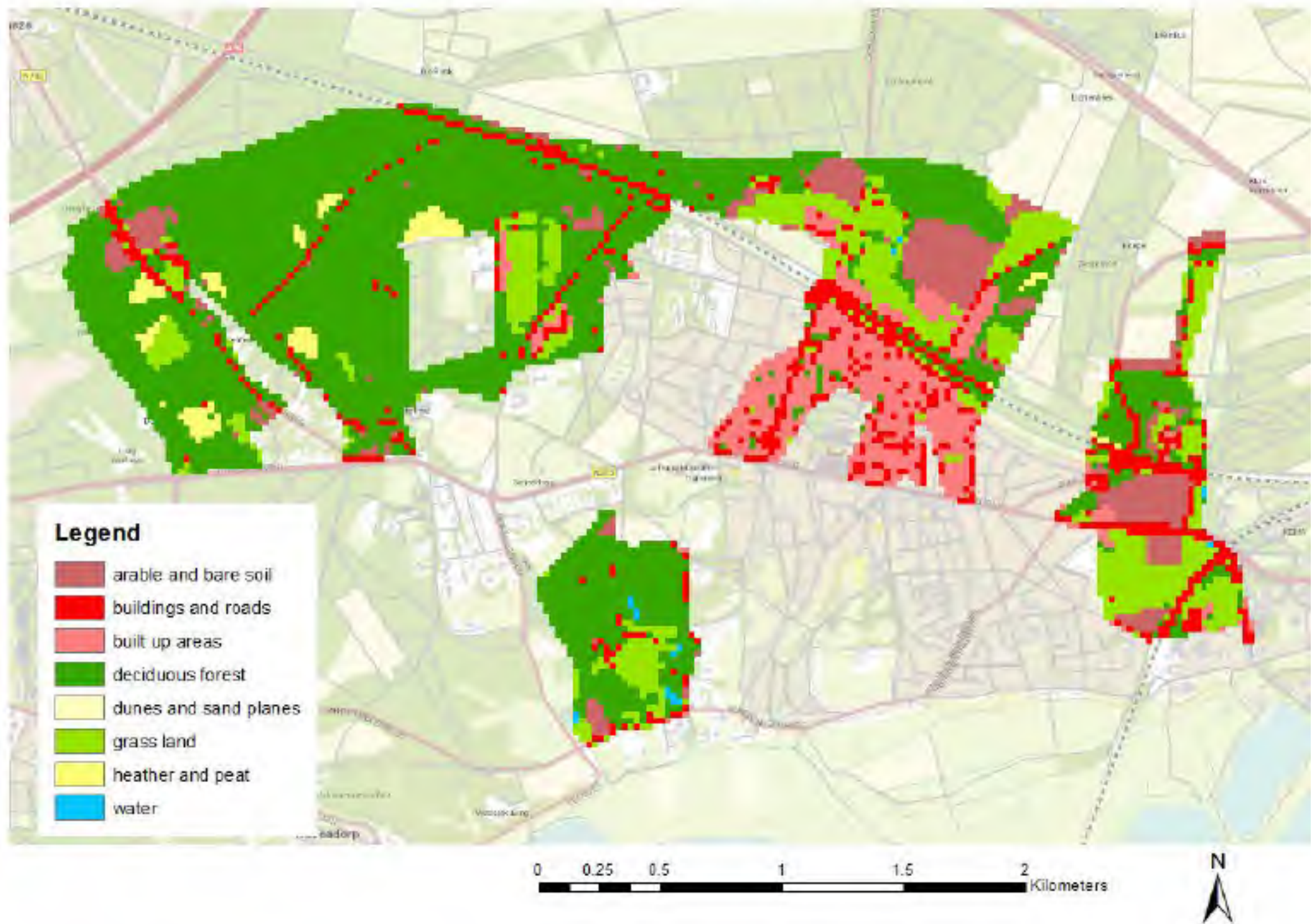
Land use in the original estates from Oosterbeek in 1960



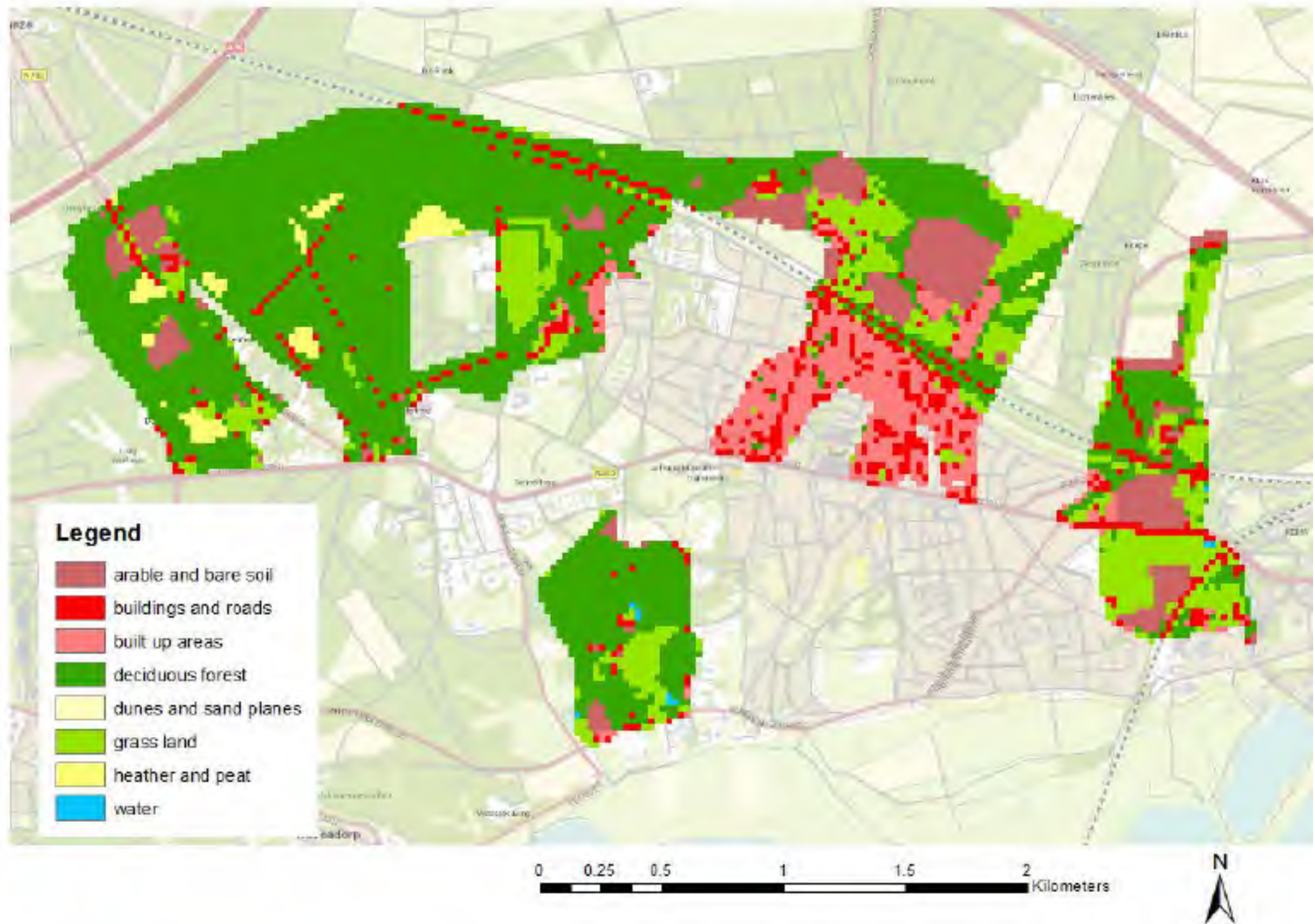
Land use in the original estates from Oosterbeek in 1970



Land use in the original estates from Oosterbeek in 1980



Land use in the original estates from Oosterbeek in 1990



Appendix III

The viewshed analysis maps

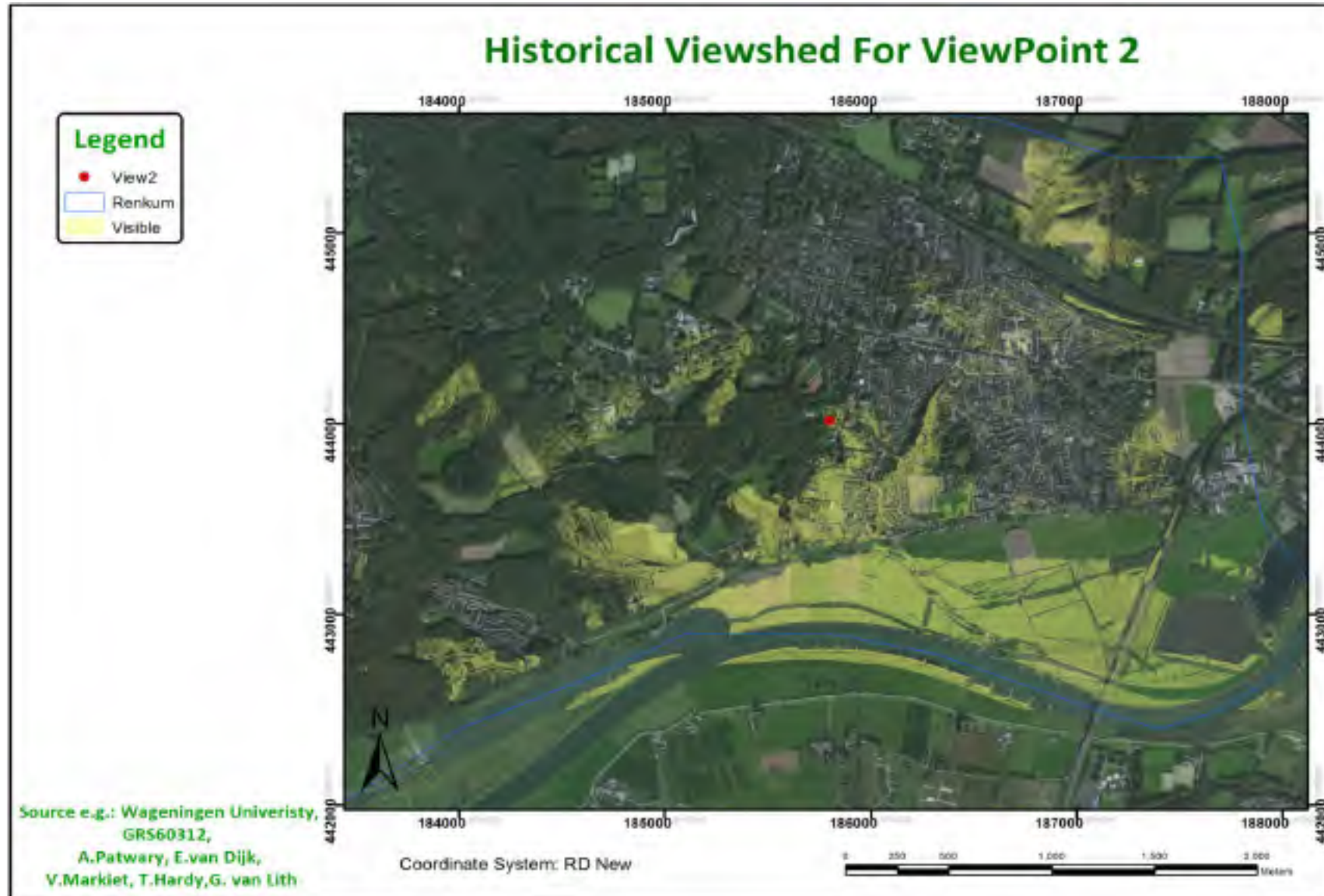


Figure 10 Historical viewshed analysis for the viewpoint 'Sandersweg'

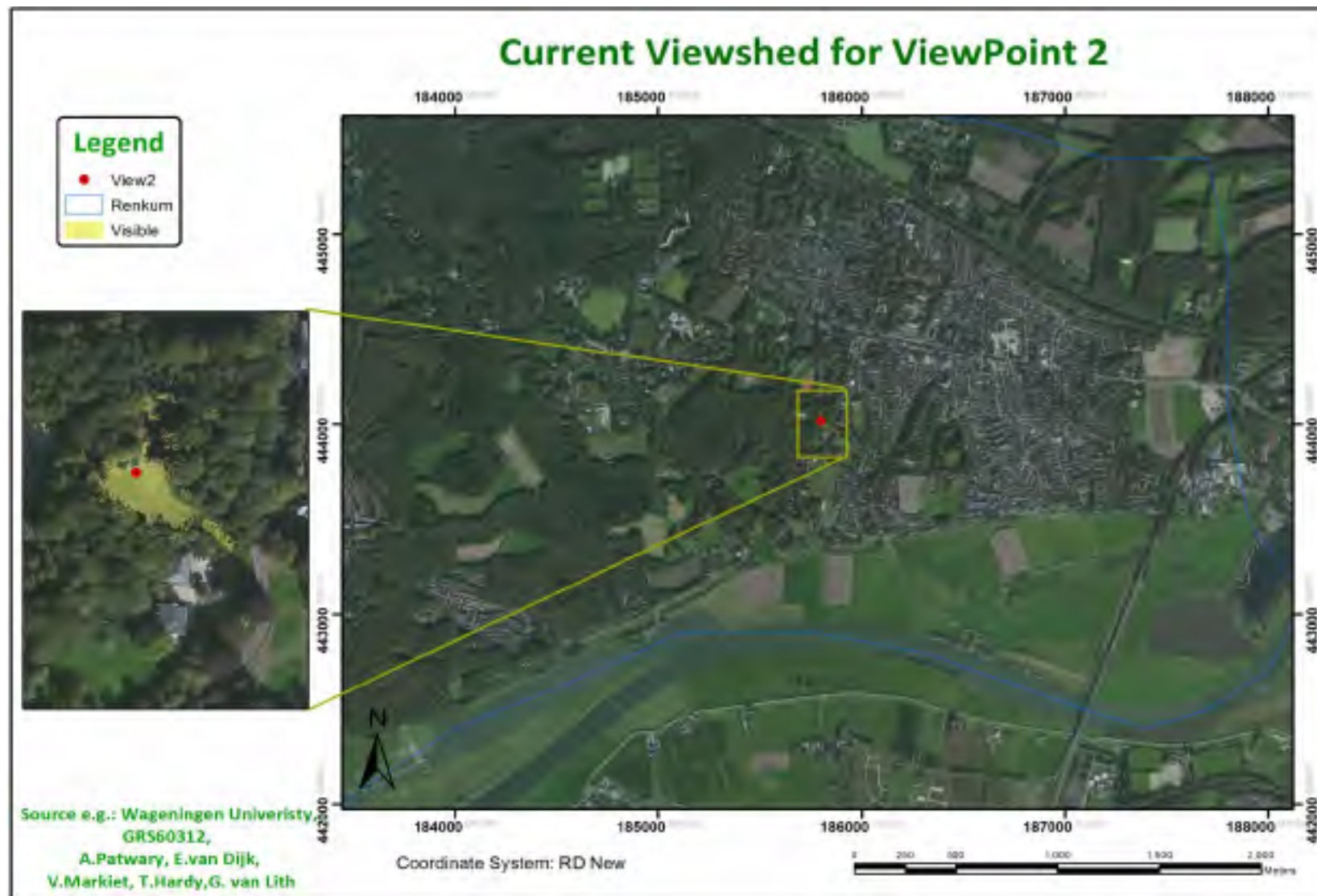


Figure 11 Current (2012) viewshed analysis for the viewpoint 'Sandersweg'. The view is obstructed by trees.

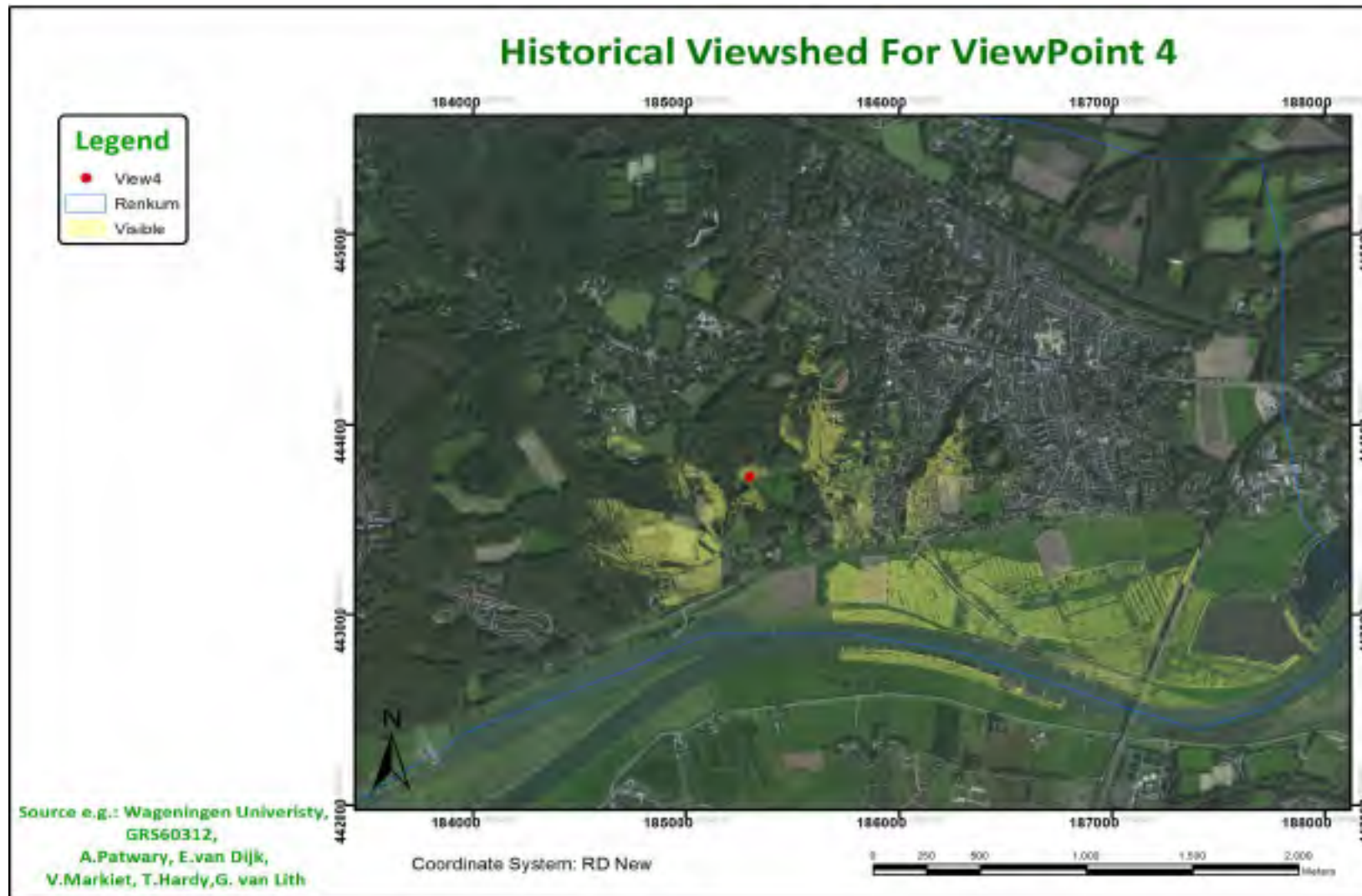


Figure 12 Historical viewshed analysis for viewpoint Hemelseberg. This point on the hill provided a stretched view especially towards the east of Oosterbeek

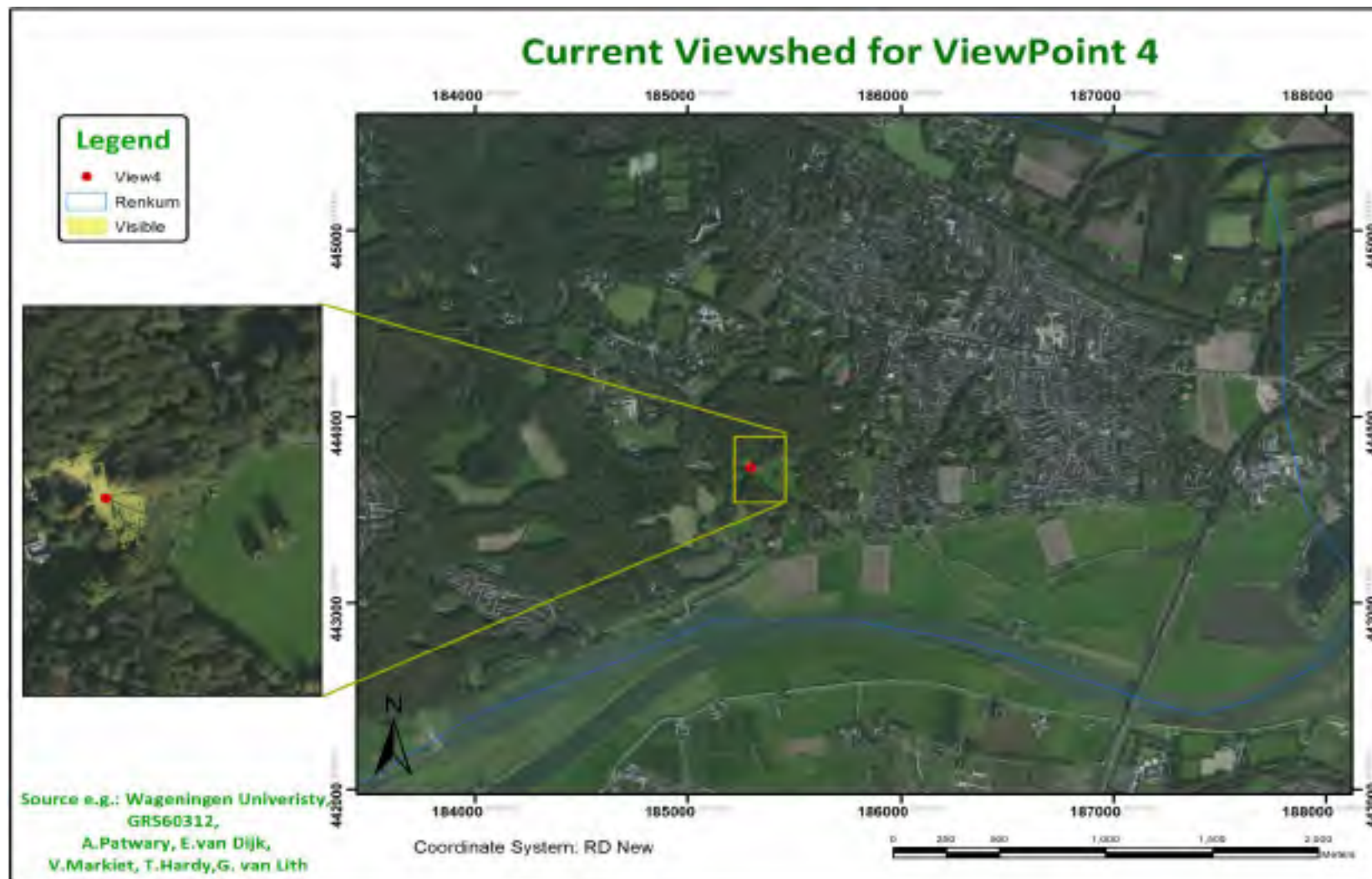


Figure 13 Current view of the Hemelsche berg. The classical view towards the south east has been blocked by treelines.

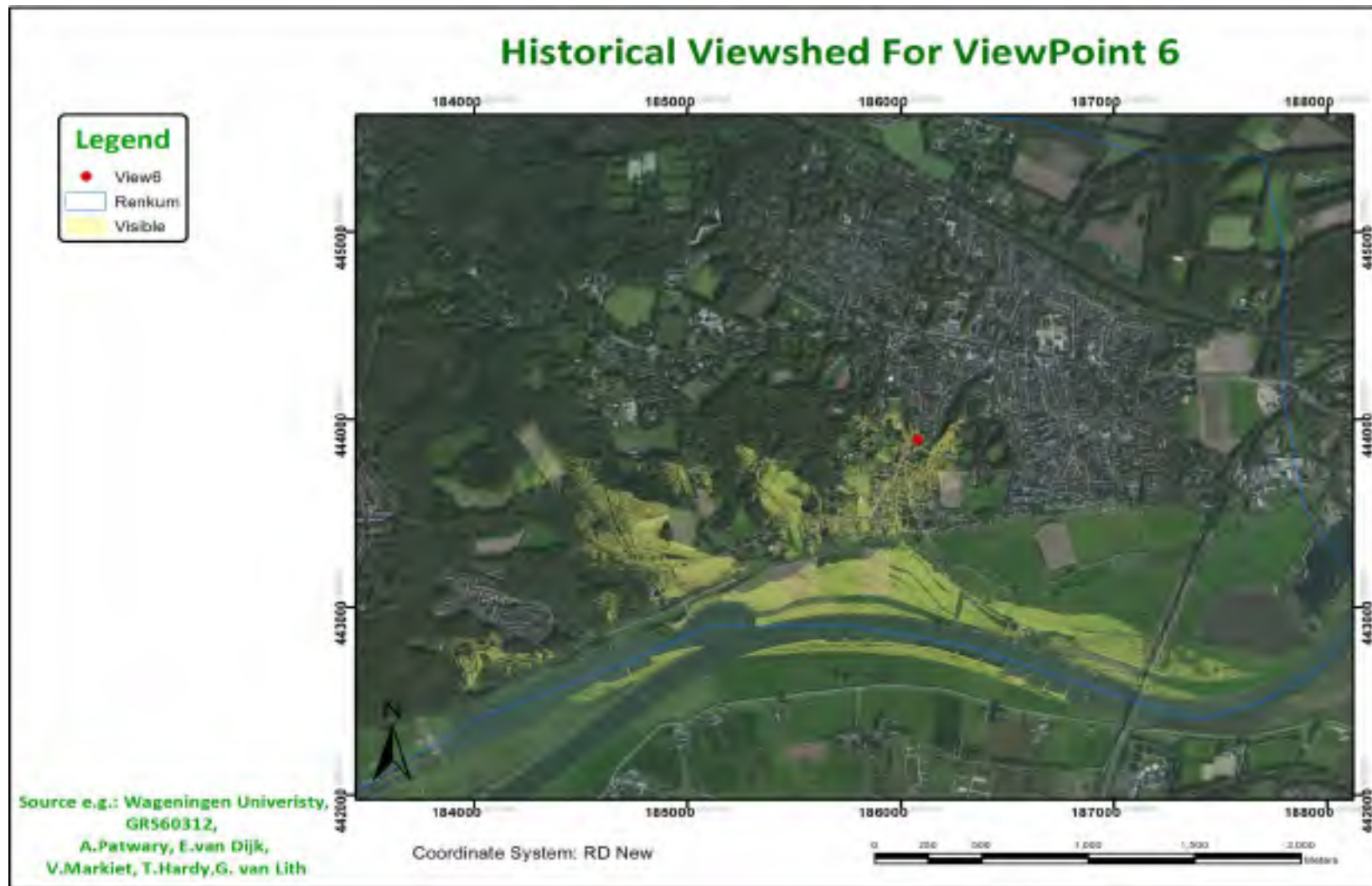


Figure 14 Viewpoint 6, the junction of Weverstraat and Jagerskamp. The view is especially open towards the South east.

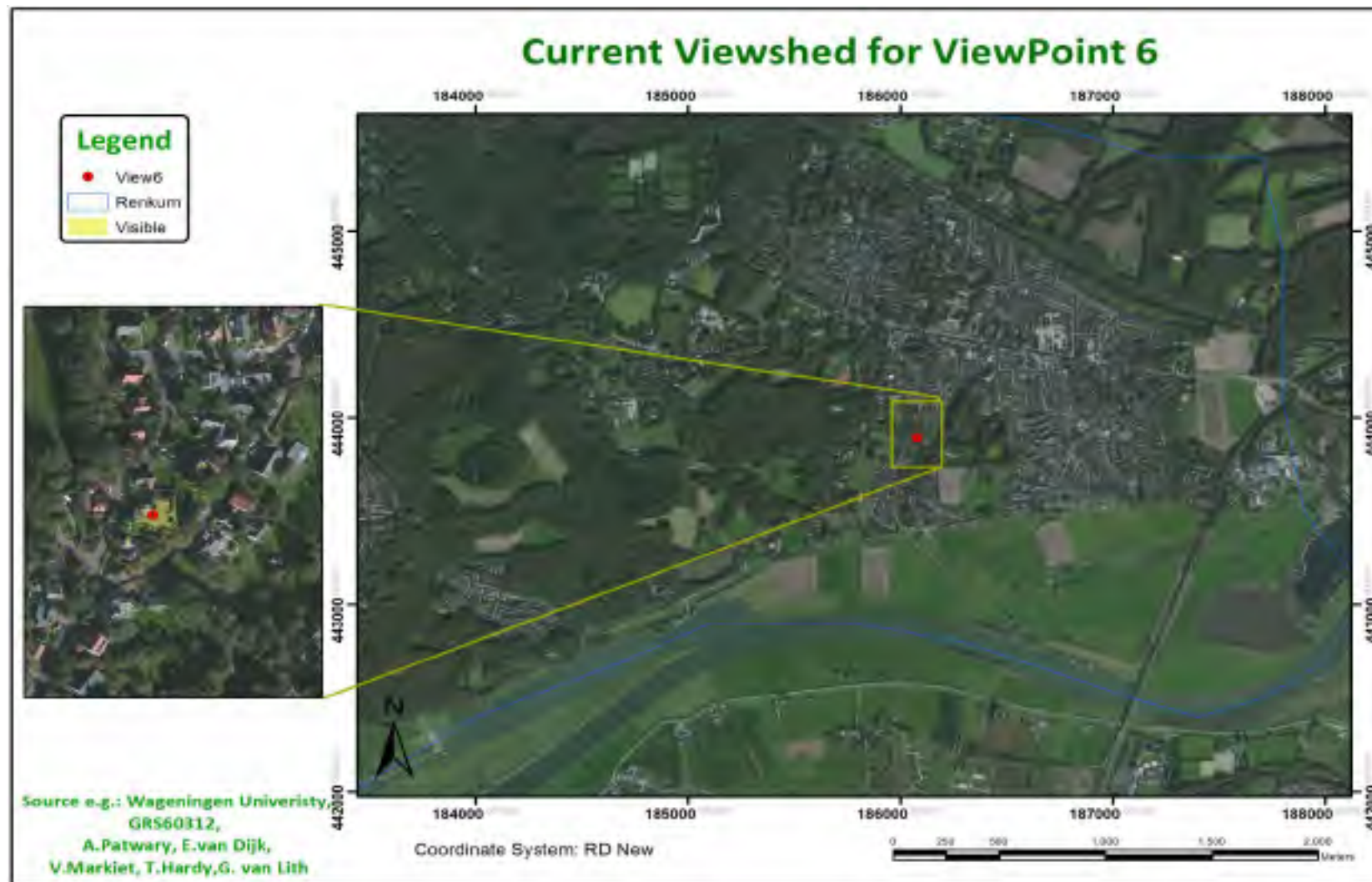


Figure 15 The view has completely disappeared due to houses.

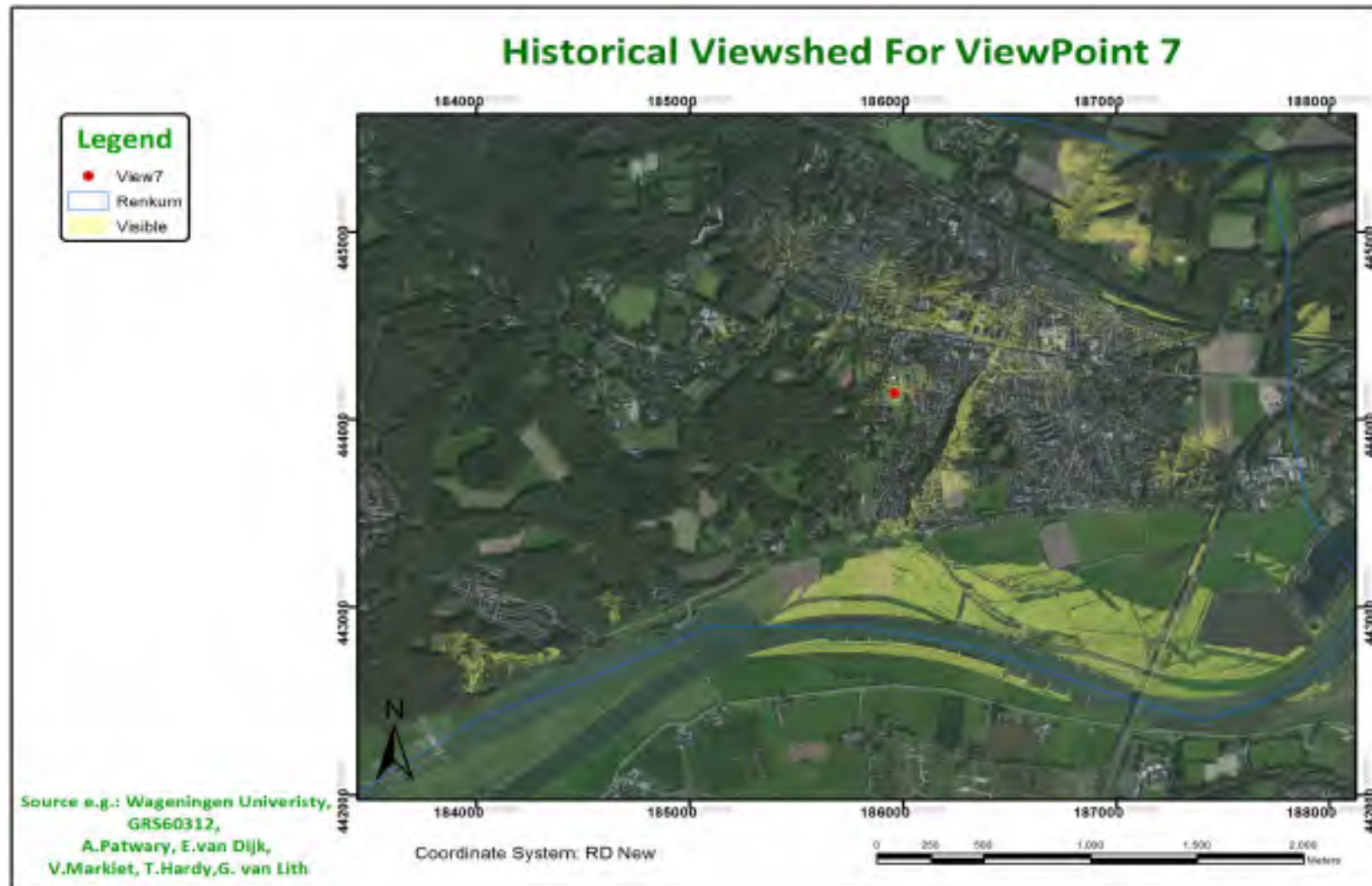


Figure 16 The historical view from point 'Overzicht' . This used to be an important viewpoint looking towards the Rhine and the fields.

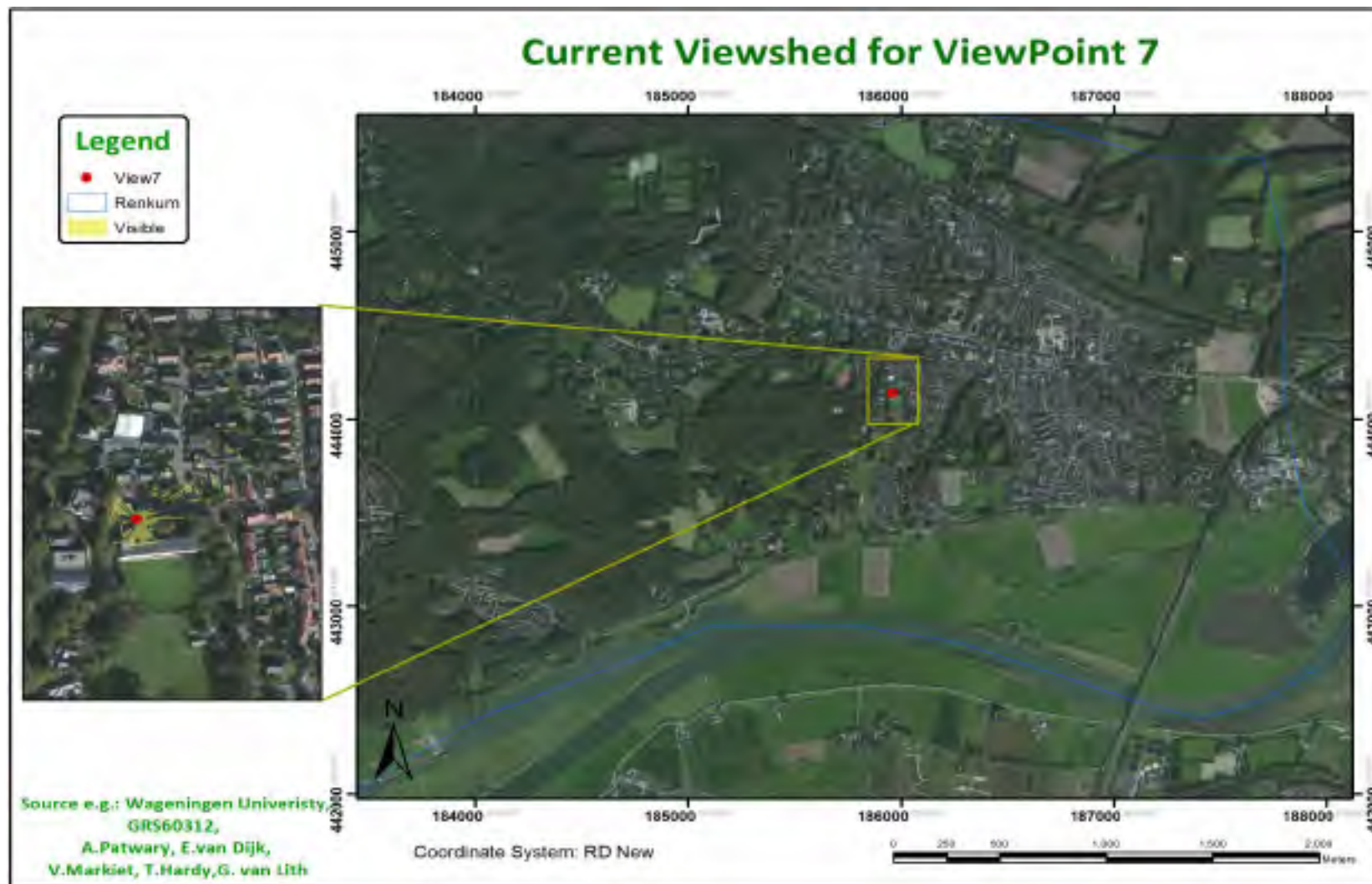


Figure 17 Viewpoint 'overzicht' has been transformed into builtup area. A large senior flat blocks the once so open view.

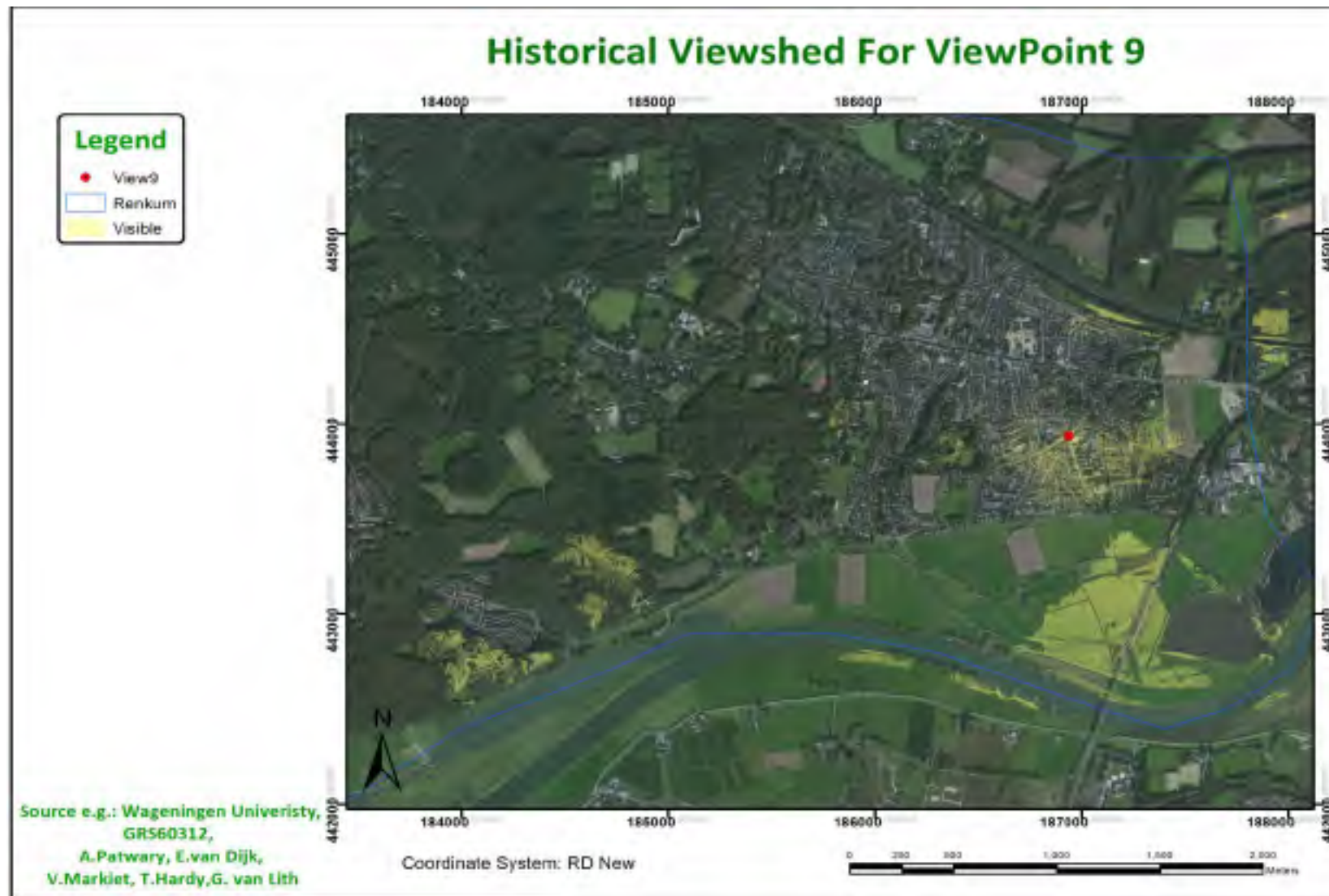


Figure 18 Viewpoint at the junction of 'Jonkheer Nedermeijer van Rosenthalweg & Stenenkruis. The view is especially open towards the south east and due to a low altitude did not provide a complete overview of the Rhine river

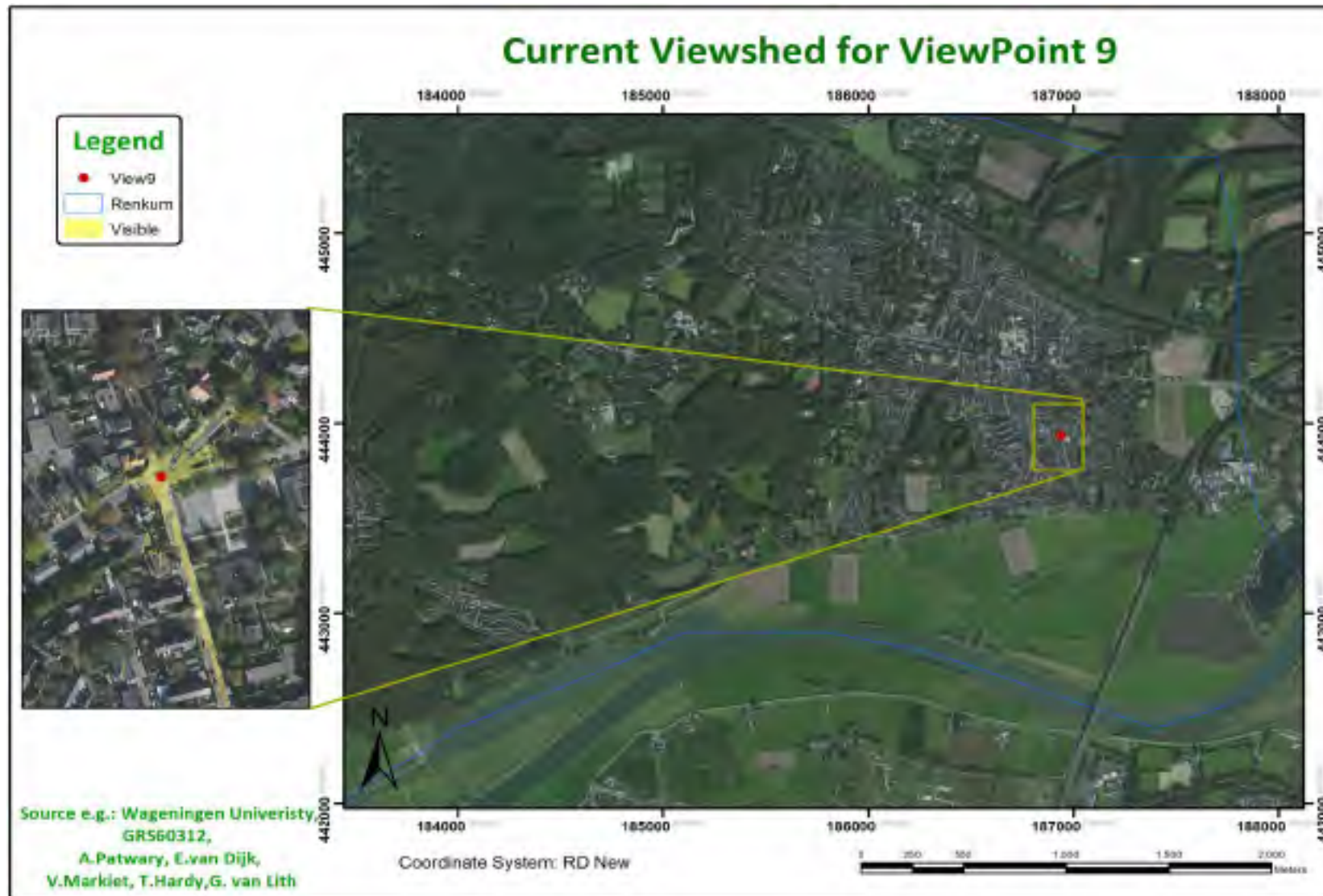


Figure 19 The houses built after the 1940's have changed this open view to a view blocked by houses.

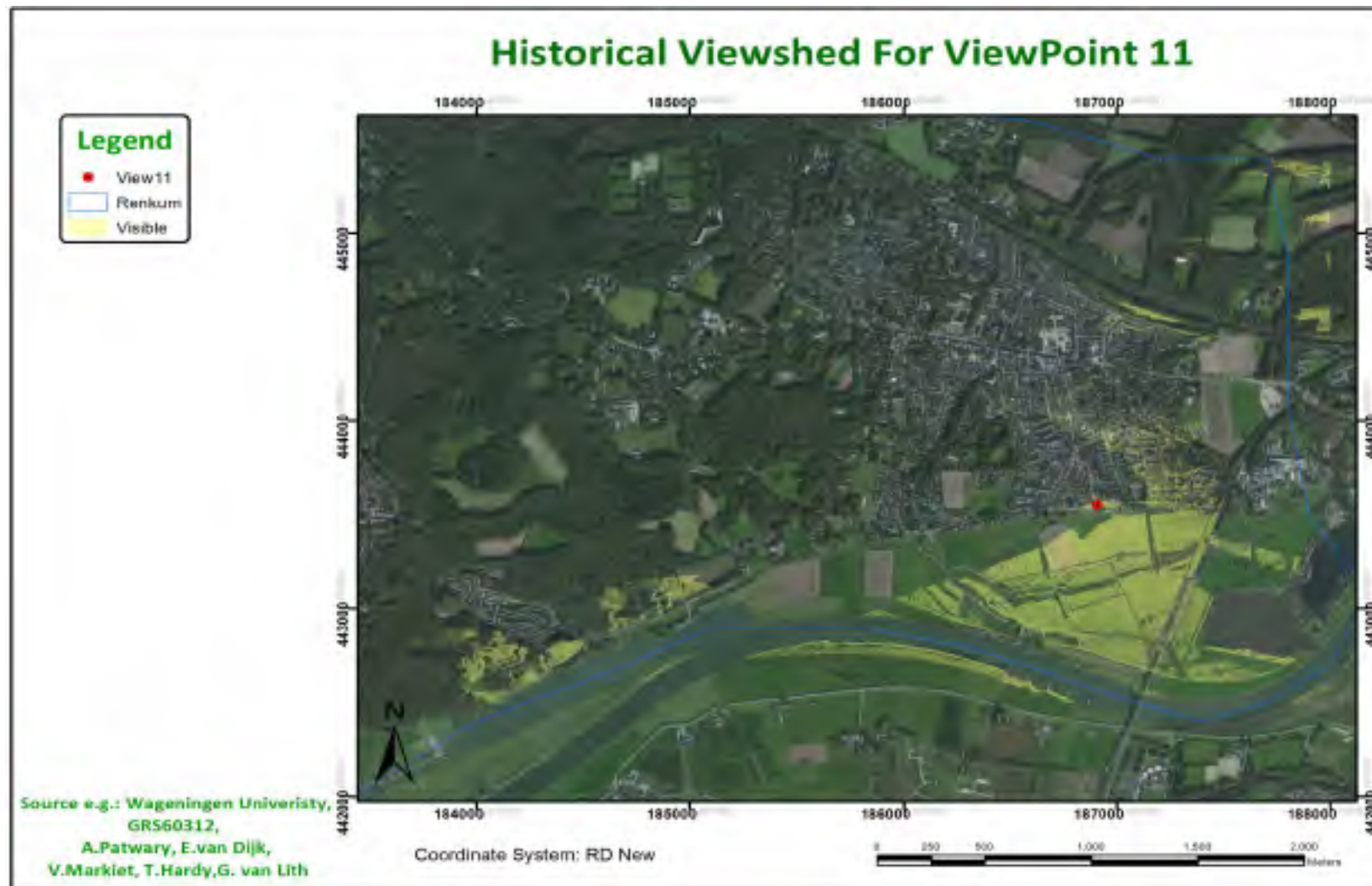


Figure 20 This displays the Benedendorpseweg around 1890 with farm houses and was a stretched road from the church in the west to the Rosande polder in the east.

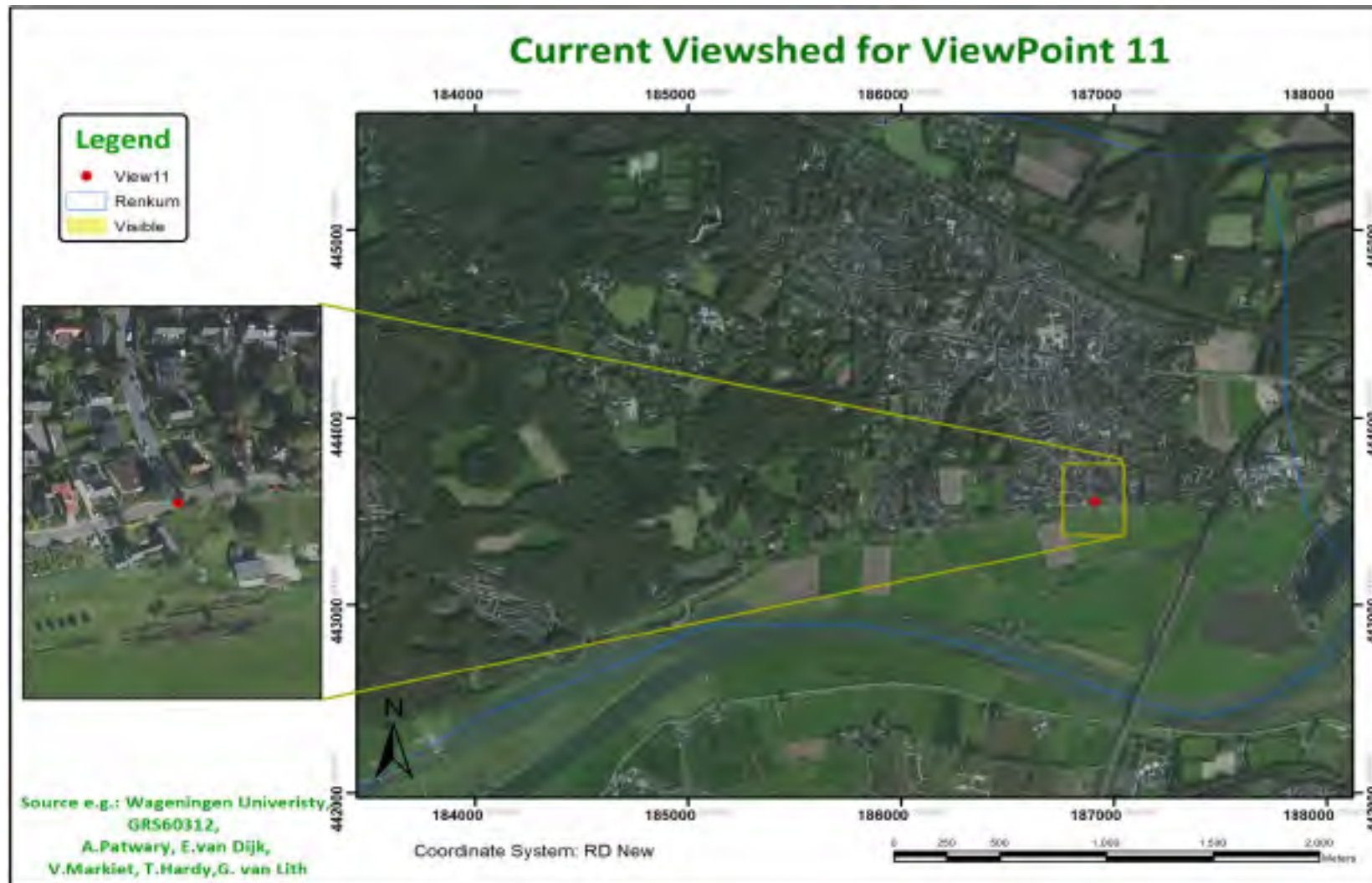


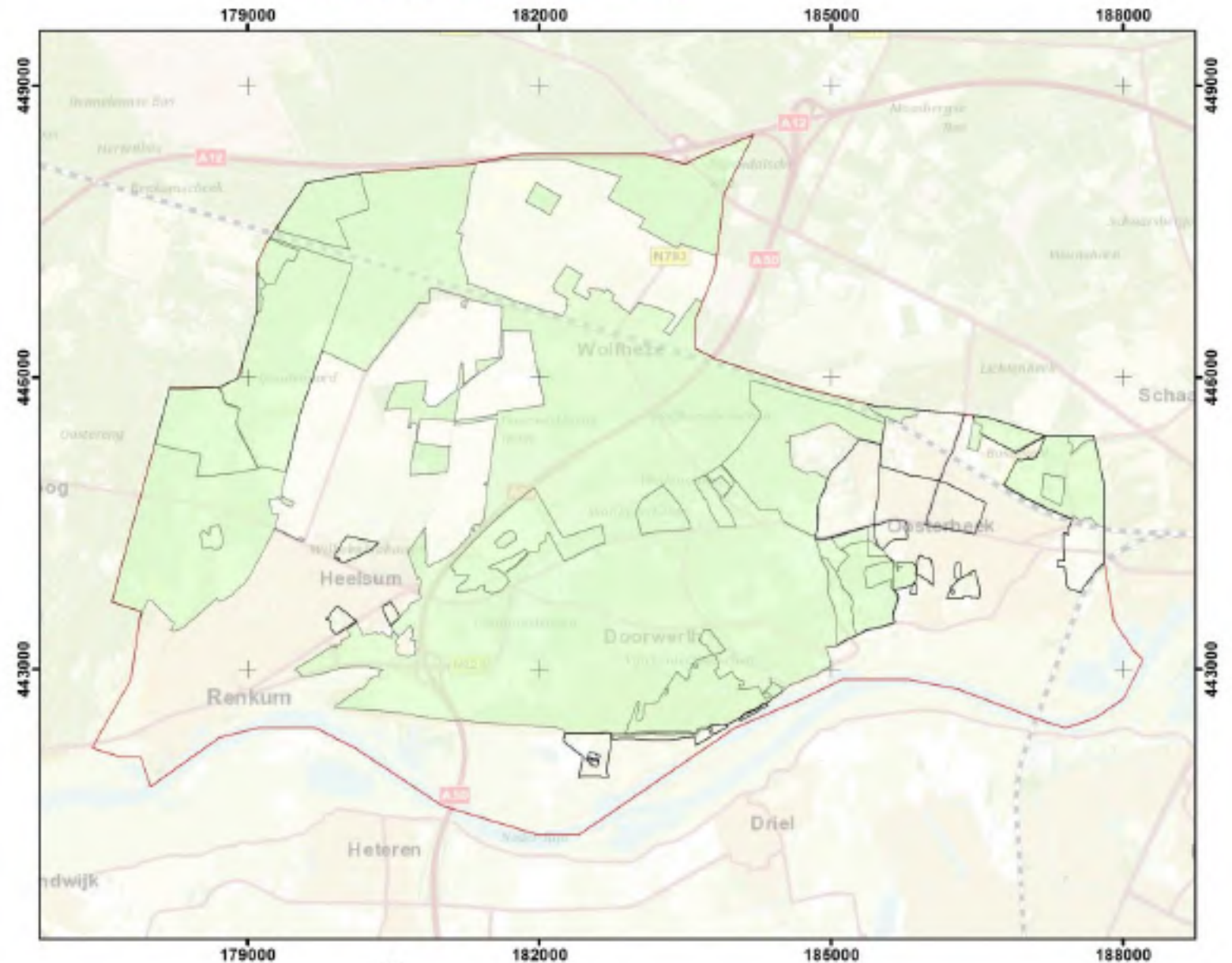
Figure 21 De Benedorpseweg is the last main road on the southern part of Oosterbeek. The open parts of the arable land and the river are mostly blocked by trees and houses. The view in this analysis only gives an indication. In real life one can see between houses and trees and actually see the river and the bridge.

Appendix IV

Mapping the current situation

The following are the requested current situation maps.

habitat directive area

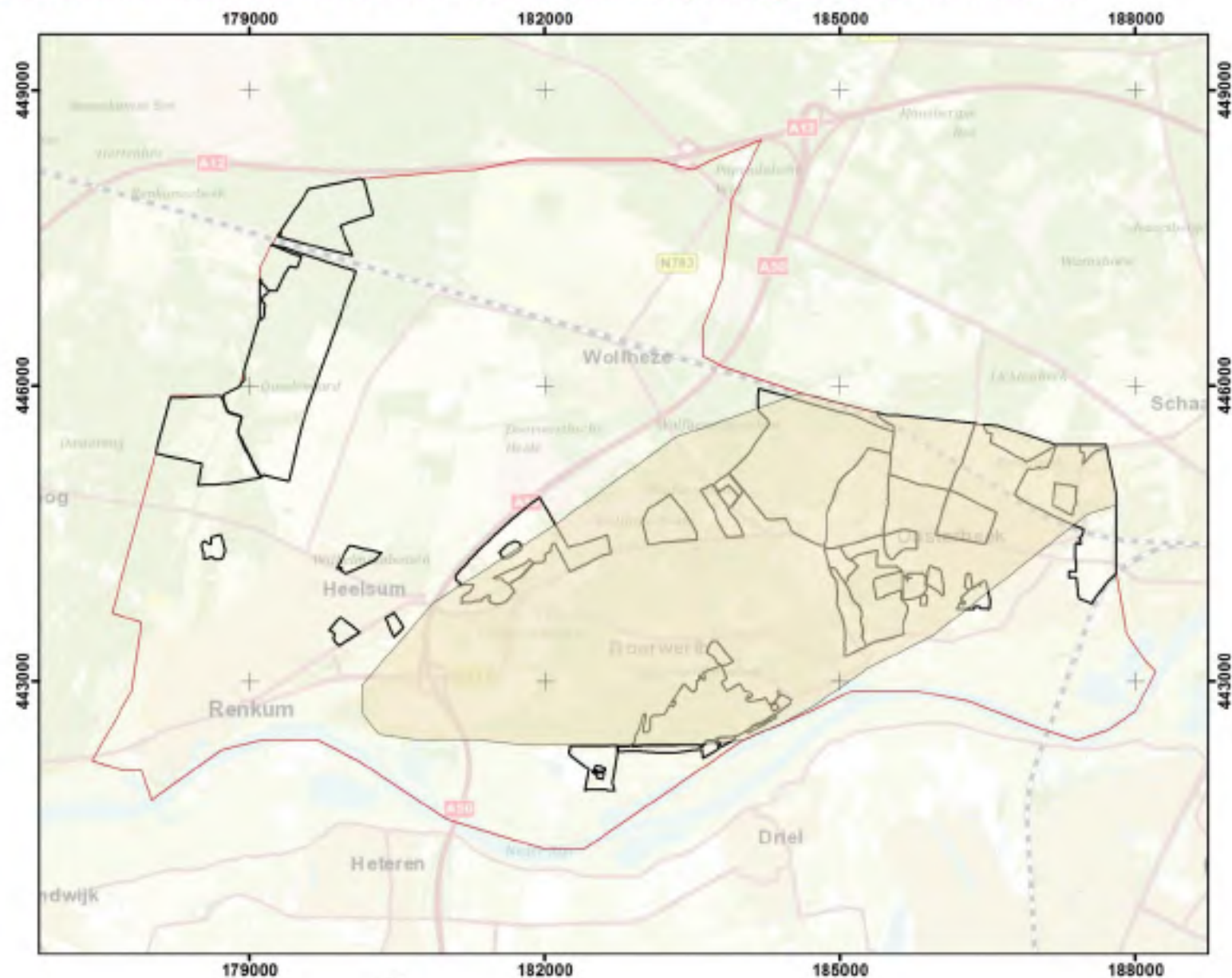


Source e.g.: Wageningen University,
GRS60312,
A.Patwary, E.van Dijk,
V.Markiet, T.Hardy, G. van Lith

Coordinate System: RD New

0 0.5 1 2 3 4 5 km

Belvedere and UNESCO areas in the municipality of Renkum 2002

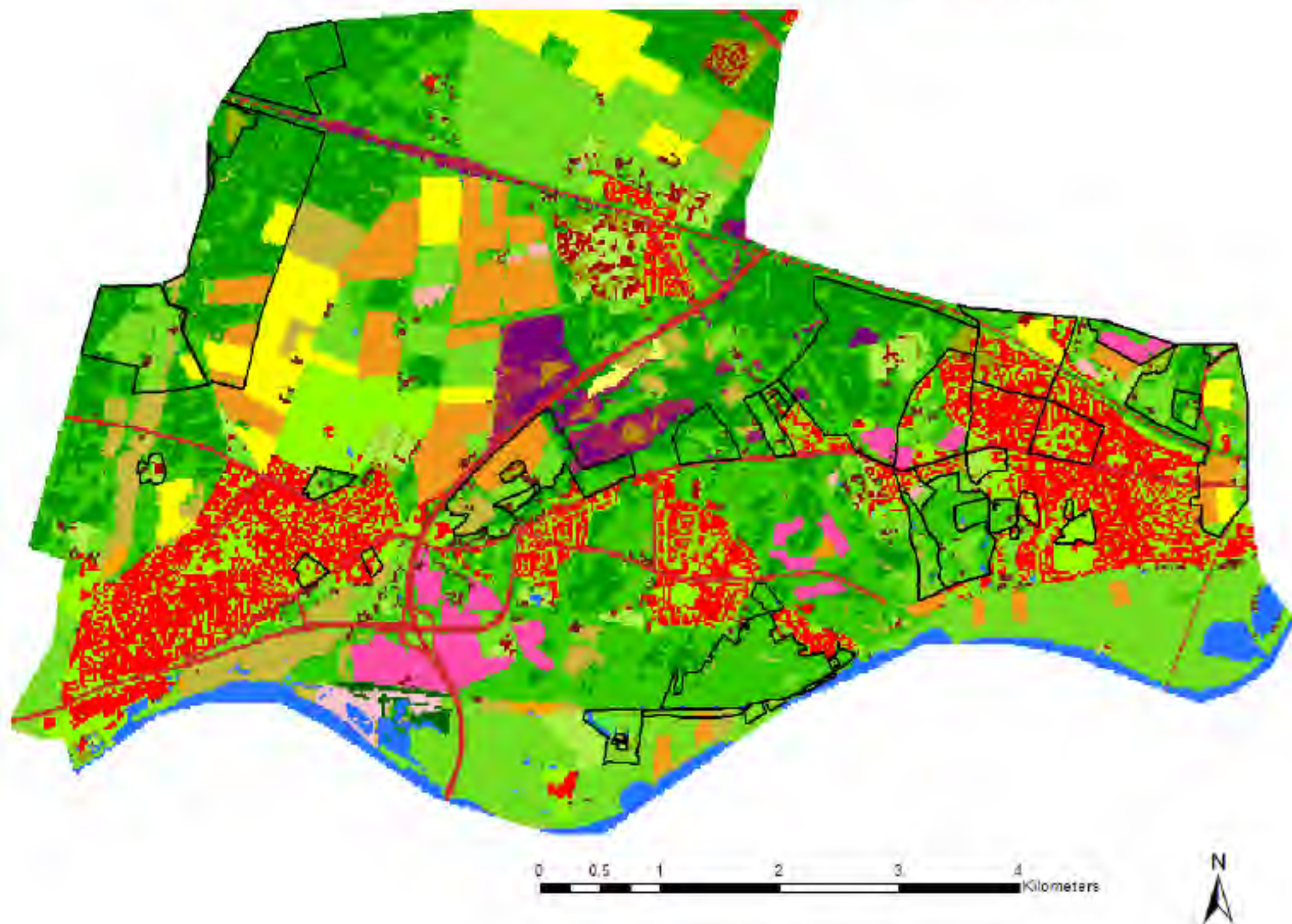


Source e.g.: Wageningen University,
GRS60312,
A.Patwary, E.van Dijk,
V.Markiet, T.Hardy, G. van Lith

Coordinate System: RD New

0 0.5 1 2 3 4 5 km

Land Use map of the Municipality of Renkum 2008



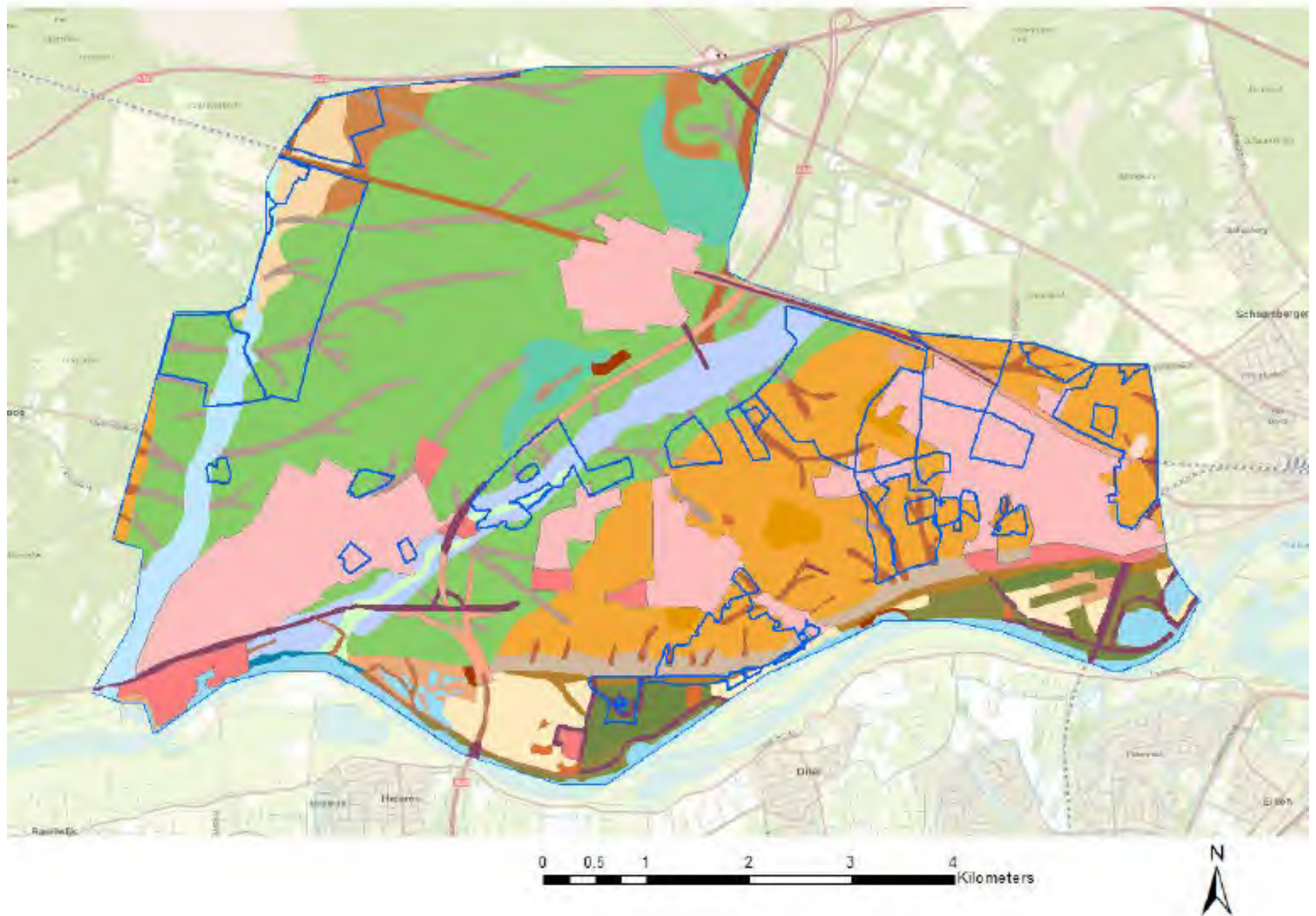
Legend

Land Use

OMSCHRIJVING

	1 - Agrarisch gras
	11 - Loofbos
	12 - Naaldbos
	16 - Zoet water
	18 - Bebouwing in primair bebouwd gebied
	19 - Bebouwing in secundair bebouwd gebied
	2 - Mais
	20 - Bos in primair bebouwd gebied
	22 - Bos in secundair bebouwd gebied
	23 - Gras in primair bebouwd gebied
	25 - Hoofdwegen en spoorwegen
	26 - Bebouwing in het buitengebied
	28 - Gras in secundair bebouwd gebied
	35 - Open stuifzand en/ of rivierzand
	36 - Heide
	37 - Matig vergraste heide
	38 - Sterk vergraste heide
	41 - Overige moerasvegetatie
	42 - Rietvegetatie
	43 - Bos in moerasgebied
	45 - Natuurgraslanden
	5 - Granen
	6 - Overige gewassen
	61 - Boomkwekerijen
	8 - Glastuinbouw
	9 - Boomgaarden
	Estate boundaries

Geomorphology in Renkum



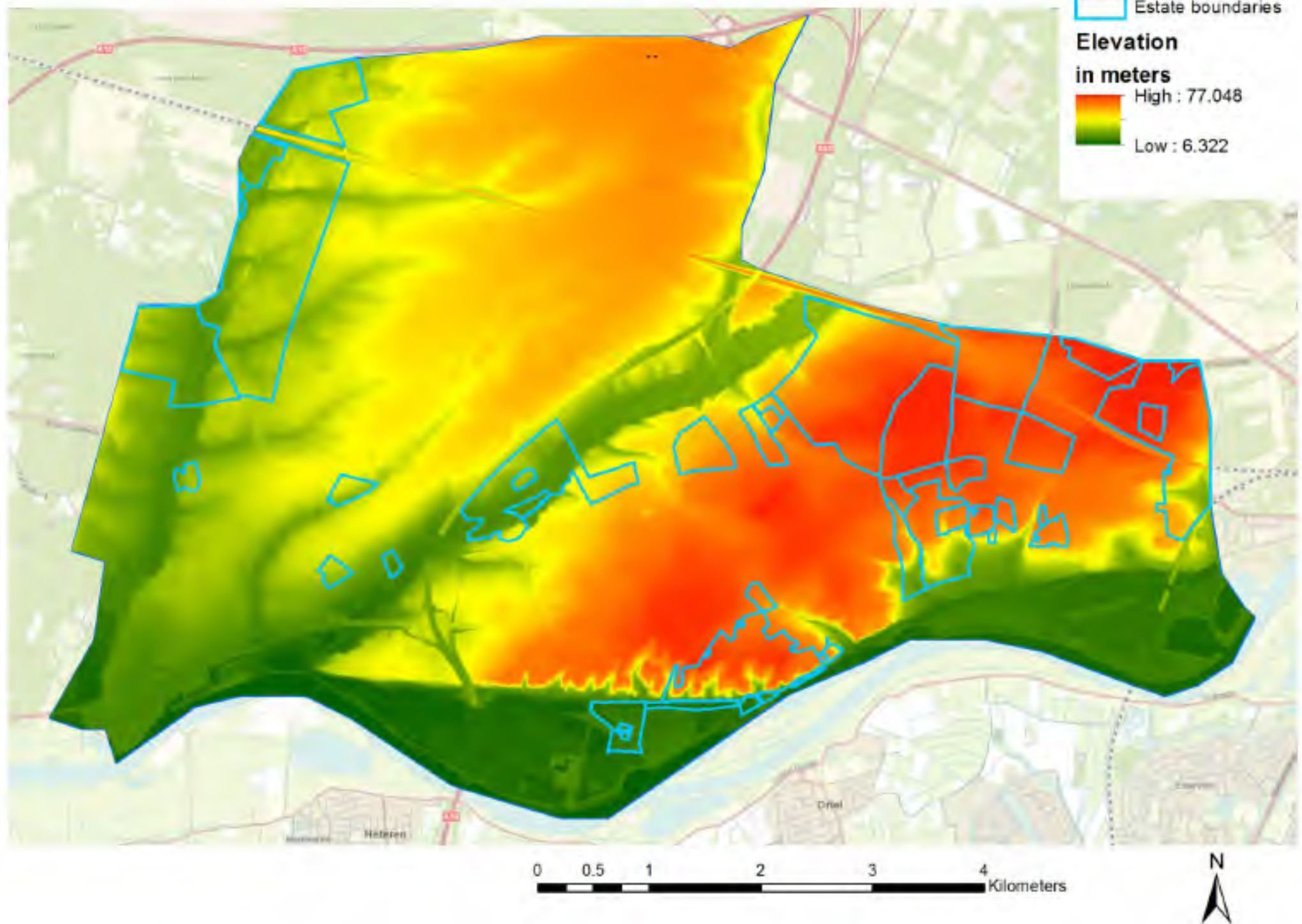
Legend

 Estate boundaries

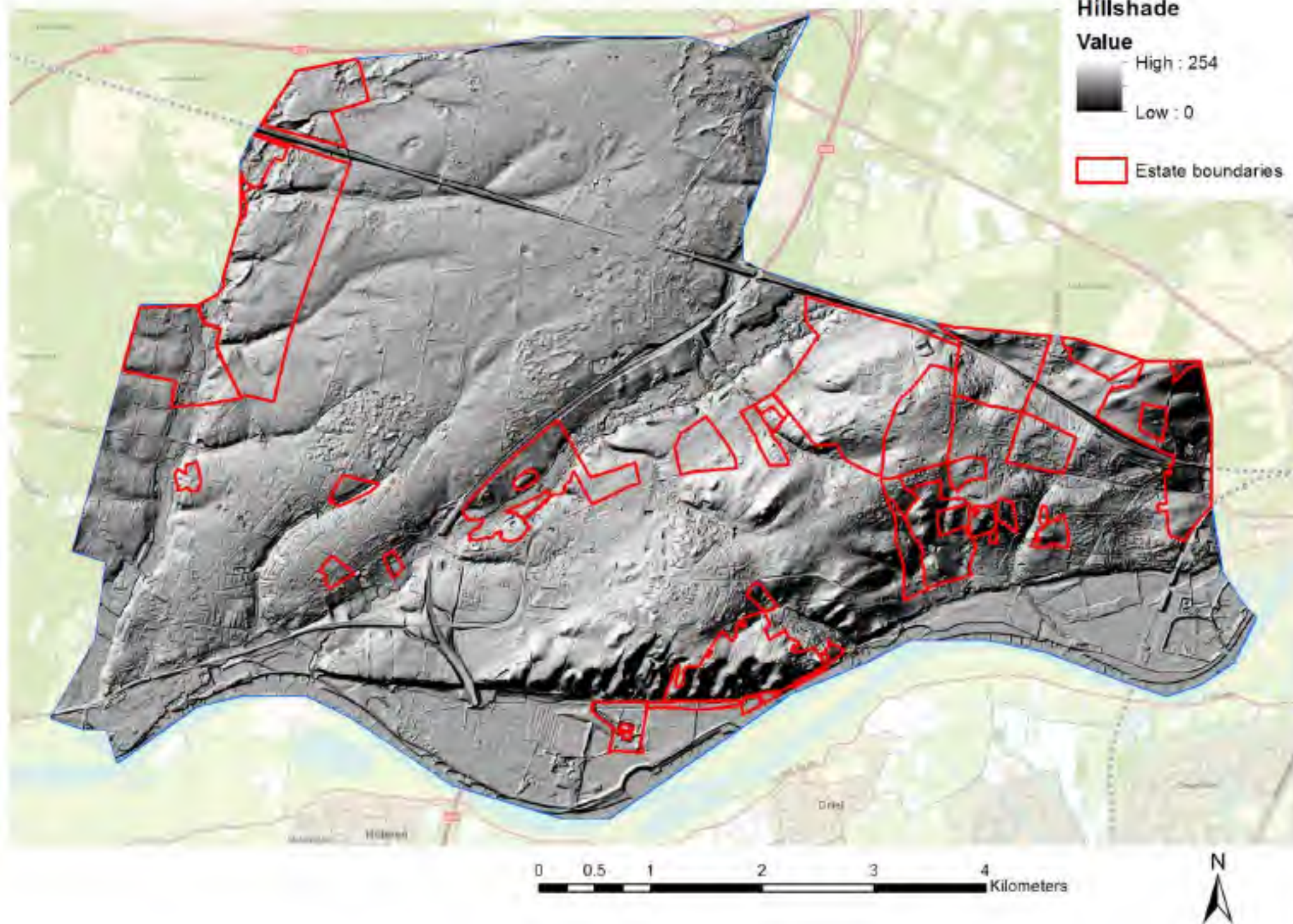
OMSCHRIJVING

	Bebouwing
	Beekdalbodem (hooggelegen)
	Beekdalbodem (laaggelegen)
	Beekdalbodem met veen
	Beekdalbodem, zonder veen, laaggelegen
	Droog dal (+/- dekzand/loss)
	Droog dal (+/-dekzand/loss)
	Geul van meanderend afwateringssysteem
	Groeve
	Hoge dijk
	Hoge stuwwal
	Holle weg
	Laag landduin
	Laagte ontstaan door afgraving
	Lage dijk
	Lage landduinen + bijbehorende vlakten/laagten
	Lage landduinen met bijbehorende vlakten en laagten
	Lage storthopen met ijzerkuilen en/of grind-/zand- en kleigaten
	Meanderruggen en geulen in uiterwaard
	Middenhoge dijk
	Ondergraven stuwwalzijde
	Smeltwaterwaai (sand)
	Smeltwaterwaai (sand), bedekt met dekzand
	Storchoop, opgehoogd of opgespoten terrein
	Stuwwalplateau
	Vlakte in uiterwaard (hooggelegen)
	Vlakte ontstaan door afgraving of egalisatie
	Vorm in bebouwing
	Water
	Welvingen in uiterwaard (hooggelegen)
	Welvingen in uiterwaard (laaggelegen)

Elevation of the municipality of Renkum




Hillshaded Elevation of the municipality of Renkum





Slope of the municipality of Renkum


Legend


 Estate boundaries


Slope in Degrees

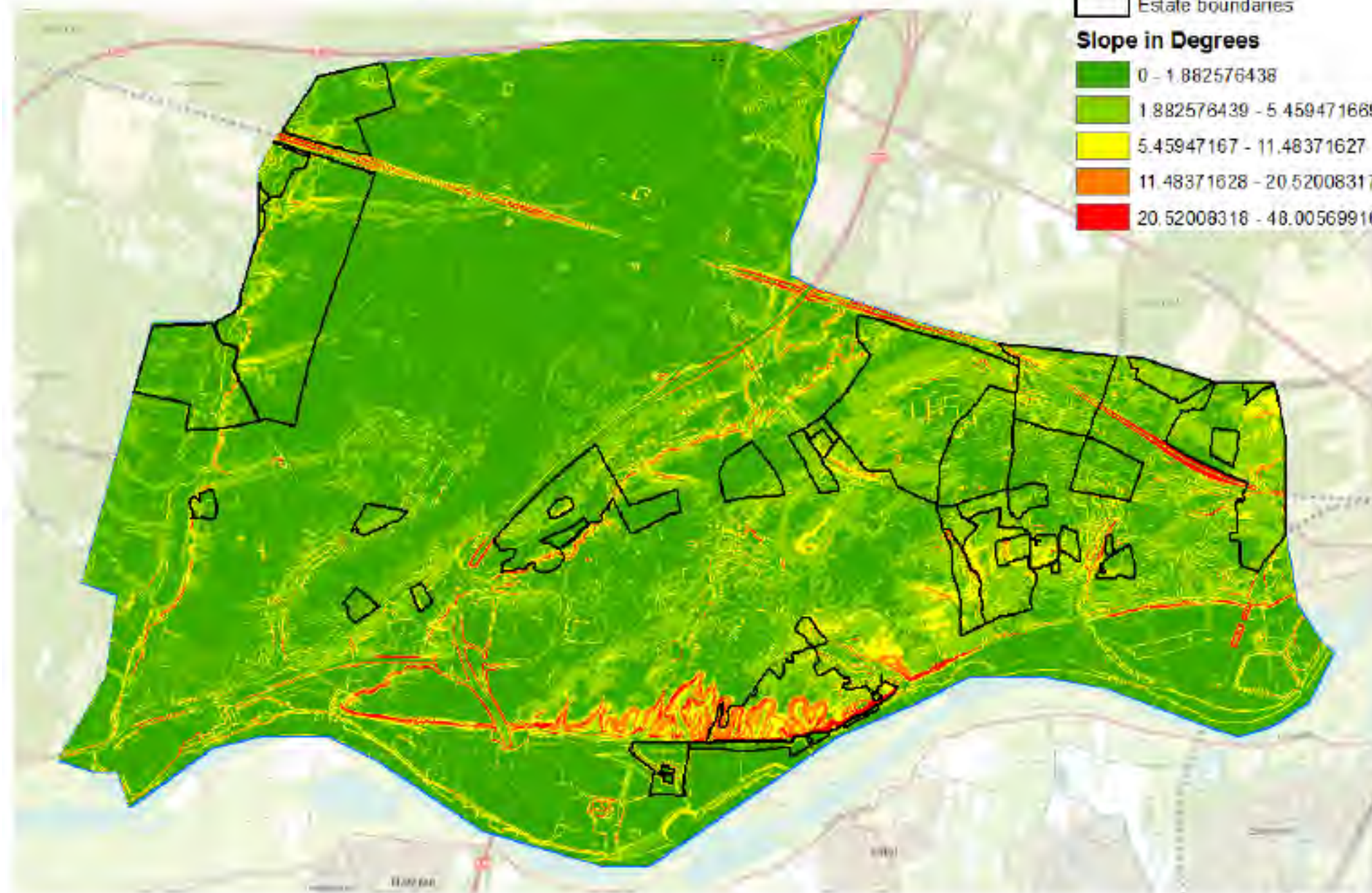
 0 - 1.882576438

 1.882576439 - 5.459471669

 5.45947167 - 11.48371627

 11.48371628 - 20.52008317

 20.52008318 - 48.00569916



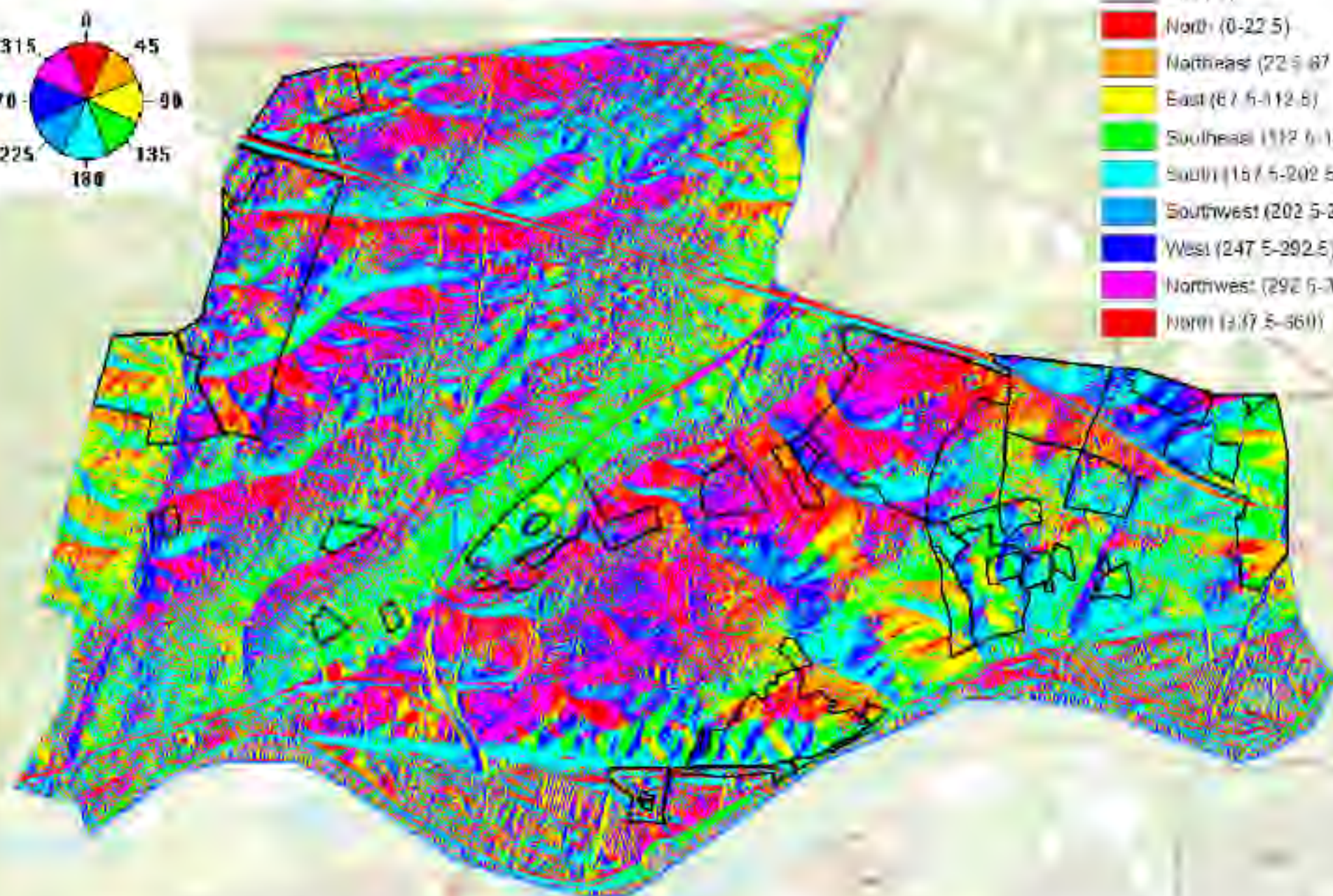
0 0.5 1 2 3 4 Kilometers



Aspect of the municipality of Renkum

Legend

- Flat (0-1)
- North (0-22.5)
- Northeast (22.5-67.5)
- East (67.5-112.5)
- Southeast (112.5-157.5)
- South (157.5-202.5)
- Southwest (202.5-247.5)
- West (247.5-292.5)
- Northwest (292.5-337.5)
- North (337.5-360)



0 0.5 1 2 3 kilometers



Stream-network of the Municipality of Renkum

