

## REVEALING EXTENSIVE PROTOHISTORIC FIELD SYSTEMS THROUGH HIGH RESOLUTION LIDAR DATA IN THE NORTHERN PART OF BELGIUM

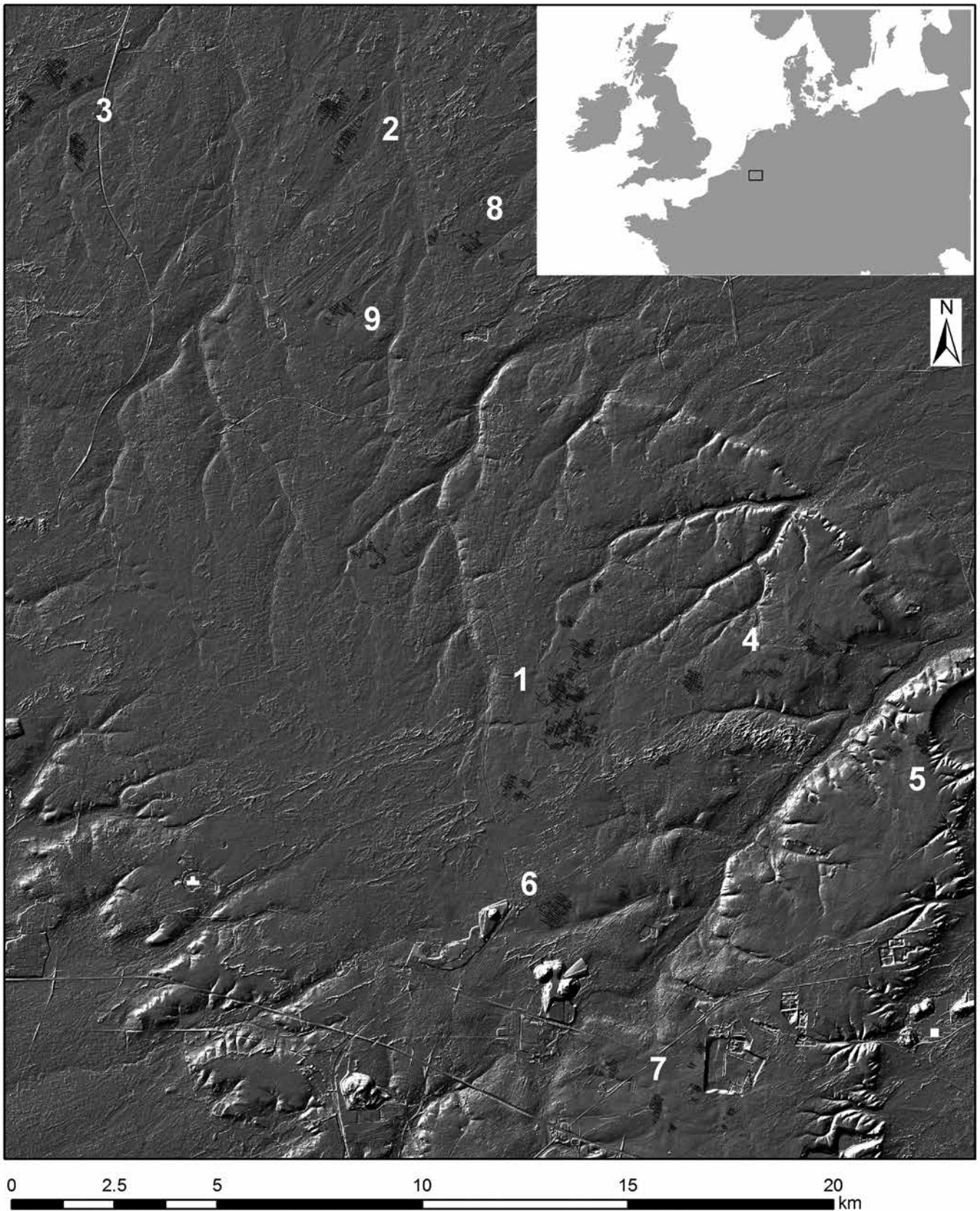
Celtic fields (prehistoric field systems) have been studied throughout large parts of Northwestern Europe (for an overview: Spek et al. 2003). They consist of complexes of rectangular field plots with sides of 20-40m, surrounded by bank structures. Their origin is attributed to the Late Bronze (Hallstatt A-B) and Early Iron Age (Hallstatt C-D) periods, remaining in use to at least the Late Iron Age (La Tène). In Belgium Celtic field research was instigated by the study of aerial photographs, beginning in the 1970s (Brongers 1976). Other papers followed in the late 1970s and 1980s (van Impe 1977; Creemers et al. 1987; Vandekerchove 1987; 1996). Based on these studies the distribution of known Celtic field complexes was foremost situated in the northern part of the so-called Kempisch Plateau (Campine plateau; prov. Limburg/B; **fig. 1**). The combined data from these aerial photographs show clusters of Celtic fields as soil marks in agricultural fields, which in some cases can be combined to reveal larger Celtic field complexes.

Because of its potential for surveying in forested environments (e.g. Devereux et al. 2005; Doneus/Briese 2011; Risbøl/Gjertsen/Skare 2006; Sutler/Schellberg 2006) LIDAR technology offers new possibilities for detailed mapping of surviving field complexes (Doneus et al. 2008). This is illustrated by several studies in the Netherlands (Jager 2008; Oude Rengerink 2004; Willemse 2009) and Germany (Arnold 2011; Doneus/Briese/Kühntreiber 2008), with the detection of new field systems, and the significant extension of previously known complexes. In Flanders (Belgium), a first survey using LIDAR data with a mean resolution of 1 measuring point/4m<sup>2</sup> (Creemers et al. 2011; Paesen et al. 2010) also discovered and mapped previously unknown, very extended (up to 500 ha) and well-preserved prehistoric field systems under forest. Since the end of 2014 new LIDAR data became available, with a mean resolution of 8 measuring points/m<sup>2</sup>. The analysis of these data presents a further extension of the distribution of field complexes on the Campine plateau (**fig. 1**), as well as to another part of the Campine area.

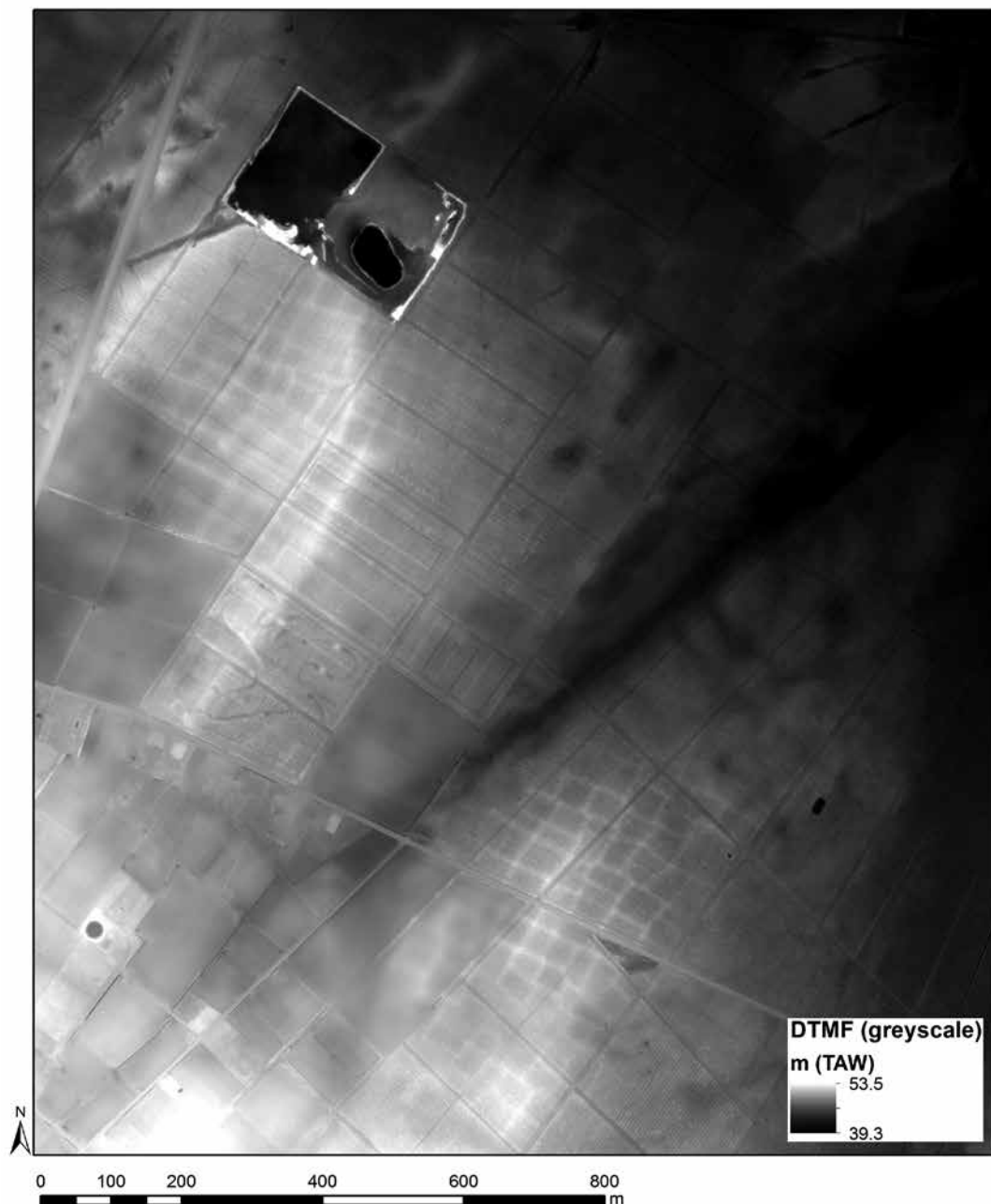
In this paper we present the results and methodology of this mapping effort, and combine this with data of other protohistoric finds and sites in the area. This offers a primary view of the spatial arrangement of the protohistoric landscape of the region.

### MATERIALS AND METHODS

In the last couple of years, the resolution of LIDAR recordings has increased significantly. While products from the beginning of the new millennium, like the Actueel Hoogtebestand Nederland (AHN; Waldus/van der Velde 2006) and the first version of the Digitaal Hoogtemodel Vlaanderen (Digital Terrain Model of Flanders [DTMF]; De Man et al. 2005), have mean resolutions of 1 measuring point every 20m<sup>2</sup>, new scanners offer resolutions of several measuring points per m<sup>2</sup>. In Flanders these »very high« resolution LIDAR recordings were performed first for the coastal area (Deronde et al. 2004) and the riverbanks of the Lower Scheldt river and its tributaries (Bertels et al. 2011). The recordings for a new Digitaal Hoogtemodel Vlaanderen are being conducted from 2014 onwards, and will cover the whole of Flanders. This dataset has a mean resolution of 8 measuring points/m<sup>2</sup>. By the end of 2014 the data for the largest part of the Campine plateau, as well as a number of other areas in Flanders, became available.

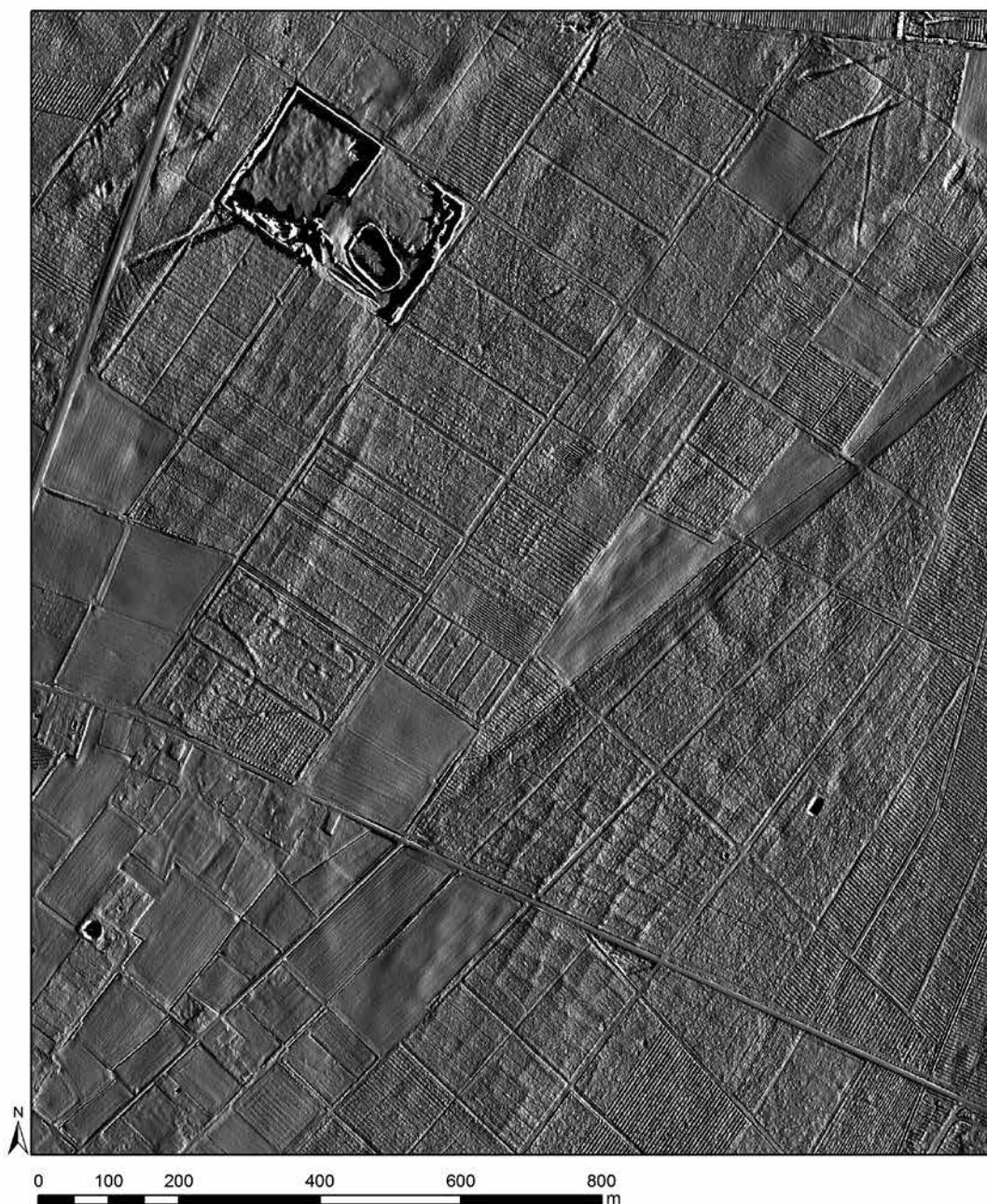


**Fig. 1** Hillshade model of the Campine plateau (prov. Limburg/B), with indication of the Celtic field structures visible on the high resolution LIDAR data: **1** *Muisvenner-Ophoverenheide* complex. – **2** *Kollisbos* complex. – **3** *Lindelse Heide/Holven* complex. – **4** *Gruitrodebos*. – **5** *Dorperheide*. – **6** *Moorsberg*. – **7** *Oeleinderheibos*. – **8** *Kaulille* complex. – **9** *Broekerheide*. – (Illustration DTMF, © Agentschap Geografische Informatie Vlaanderen).



**Fig. 2** Visualization of the DEM data in the area of the *Kolisbos* complex (prov. Limburg/B). Black-white colourscale. – (Illustration DTMF, © Agentschap Geografische Informatie Vlaanderen).

For the analysis of the data Digital Elevation Map (DEM) rasters were derived using Inverse Distance Weighted (IDW) interpolations, with a resolution of 1 m<sup>2</sup> cells. These DEM rasters were processed and analysed using differing visualization techniques, of which black and white colourscale, analytical hillshade, and sky view factor (Zakšek/Oštir/Kokalj 2011) models delivered the best results for the reconnaissance and mapping of the Celtic field systems (figs 2-4). The analysis shows previously unknown ridges and fields in the complexes identified from the previous LIDAR study (Creemers et al. 2011), as well as a number of »new« Celtic field complexes. In the next section we present the results from what appear to be the most extended and best preserved of these, and a summary for the other areas.



**Fig. 3** Visualization of the DEM data in the area of the *Kolisbos* complex (prov. Limburg/B). Combined hillshade model. – (Illustration DTMF, © Agentschap Geografische Informatie Vlaanderen).

## RESULTS

### *The Muisvenner-Ophoverheide complex*

This complex (fig. 5) is located in both forested and arable land, in the central part of the Campine plateau. The field systems detected by aerial photography from the 1970s onwards (van Impe 1977; Creemers et al. 1987; Vandekerchove 1987; Creemers/van Impe 2009) are mostly situated in agricultural plots directly to



**Fig. 4** Visualization of the DEM data in the area of the *Kolisbos* complex (prov. Limburg/B). Sky view factor model. – (Illustration DTMF, © Agentschap Geografische Informatie Vlaanderen).

the east of the forested area. The analysis of the lower resolution LIDAR data foremost extended the field system in the forested regions (Creemers et al. 2011).

The analysis of the high resolution DTMF data shows an impressively large zone with fields present in the entire forested area, as well as in the fields under agriculture to the east and north-east of it. A number of structures is also visible in a small patch of forest in the north of the area, and in agricultural land and forest about 800m south-west of the main complex. Where the ridges of these fields seem to be best preserved, maximum differences in height of 25-30 cm between the top of the ridges and the inner fields are measured.



**Fig. 5** Sky view factor visualization of the *Muisvenner-Ophovenerheide* complex (prov. Limburg/B). – (Illustration DTMF, © Agentschap Geografische Informatie Vlaanderen).

Based on the combined data from aerial photographs and LIDAR the field system has a surface area of at least 500 ha.

### **The *Kolisbos* complex**

Most of this complex (figs 2-4) is situated under forest, near the northern edge of the Campine plateau. Historical maps from the 19<sup>th</sup> century show an area dominated by heathland. The field system was first recognised near the edges of the *Kolisbos* forest (prov. Limburg/B) in the 1980s (Vandekerchove 1987; 1996). The LIDAR data extend the visible Celtic field structures throughout almost the entire forest. The individual

prehistoric field plots appear sharply defined. A striking feature is a distinctly broader and higher ridge, running from north-east to south-west in the western part of the forest. This ridge constitutes the eastern edge of a number of Celtic fields, suggesting that this ridge was part of the complex. The surface area with traces of the field system situated under forest is c. 190 ha.

### **The Lindelse Heide/Holven complex**

This is also located on the northern edge of the Campine plateau, about 5 km to the west of the *Kolisbos*. A number of soil marks was observed here in the 1980s (Vandekerchove 1987). Unfortunately, the high resolution DTMF data is not available for this area at this moment. The lower resolution LIDAR data shows three clusters of fields situated under forest (see also Creemers et al. 2011; c. 100 ha). To the west the fields are bordered by drift sands, which might mask the presence of other field plots. The field system extends further to the north and east, with structures also visible in arable land.

### **Other Celtic field complexes**

The Gruitrodebos is situated c. 2 km to the east of the *Ophovenerheide* complex, and is part of a forest extending c. 5.4 km further to the east-north-east. No Celtic field structures were previously known from here. The new LIDAR data however, shows several patches of Celtic fields spread out throughout the forest, with a total surface area of c. 129 ha (**fig. 6**). To the south-east, and on the other side of a brook valley, also at the Dorperheide previously unknown several smaller clusters of fields are present, totaling a surface area of c. 32 ha. Circa 2 km south of the *Ophovenerheide* complex two patches of field structures are visible on the Moorsberg (c. 56 ha; **fig. 7**). The currently known most southern complex of Celtic field structures on the Campine plateau is located in the Oeleinderheibos (c. 43 ha).

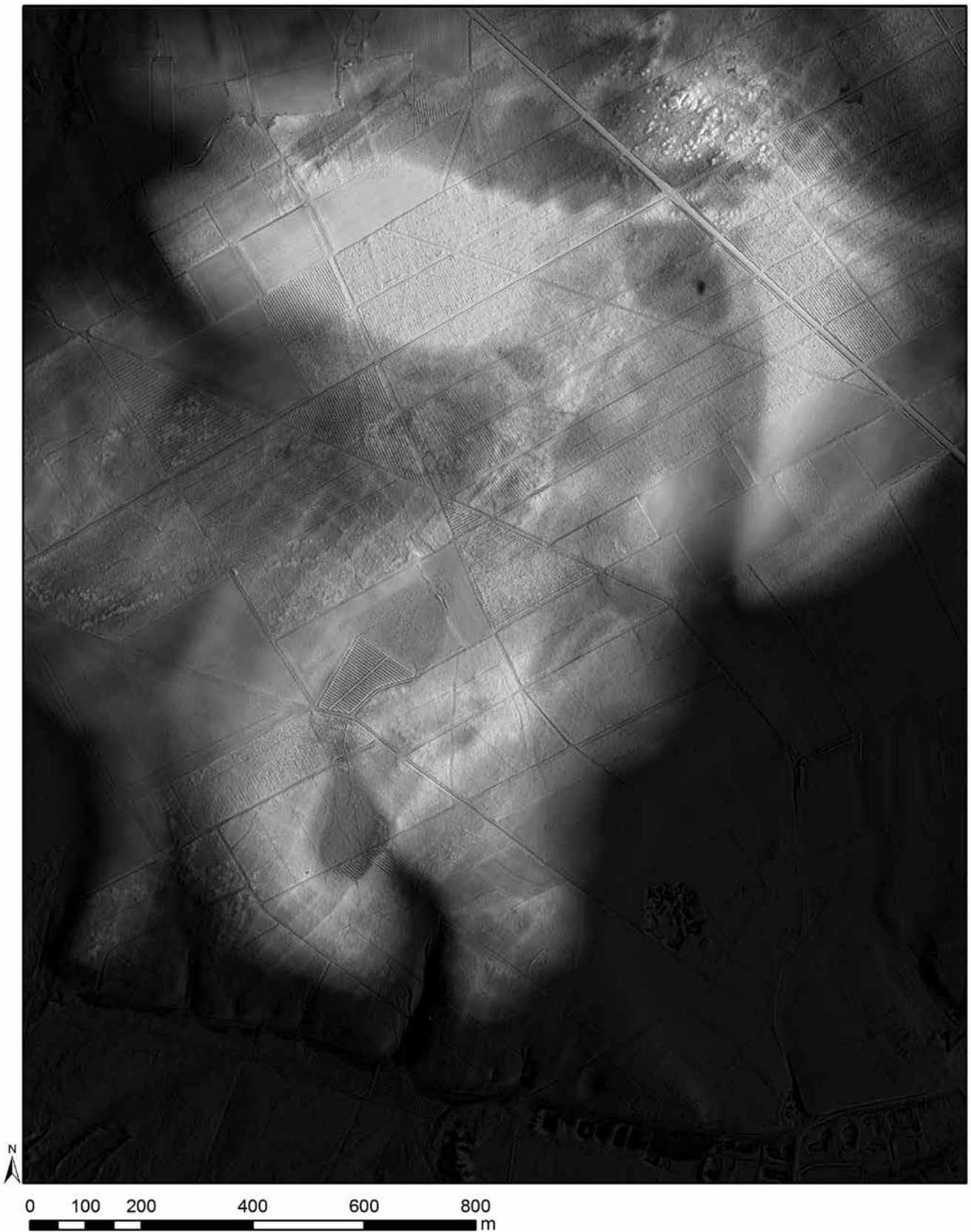
In the northern part of the Campine plateau, and about 3 km to the south-east, at *Kaulille* (prov. Limburg/B), the presence of another extended field system was earlier revealed by aerial photographs (Vandekerchove 1996; van Impe 1977). The DTMF data corroborates this observation. Here, however, most of the fields are recognisable only in arable fields, and appear much less sharply defined than is the case with most of the fields under forest. The combined data hint at a total surface area of c. 260 ha for this complex. On the Campine plateau we finally mention a cluster of fields in the vicinity of the Broekerheide, c. 2.2 km south-west of the *Kaulille* complex (c. 47 ha).

A rather surprising observation is the detection of a field complex in the Antwerp Campine region. The LIDAR data show Celtic fields there throughout most of the domain of a castle (castle domain De Hees [prov. Antwerp/B]; c. 37 ha; **fig. 8**). About 1 km to the west of this complex a small number of structures were formerly observed on aerial photographs (Vandekerchove 1987; 1996).

In general these field systems display the common traits already discovered in the three complexes discussed in more detail (dimension and orientation of the field systems, maximum height of the ridges).

### **Overall distribution**

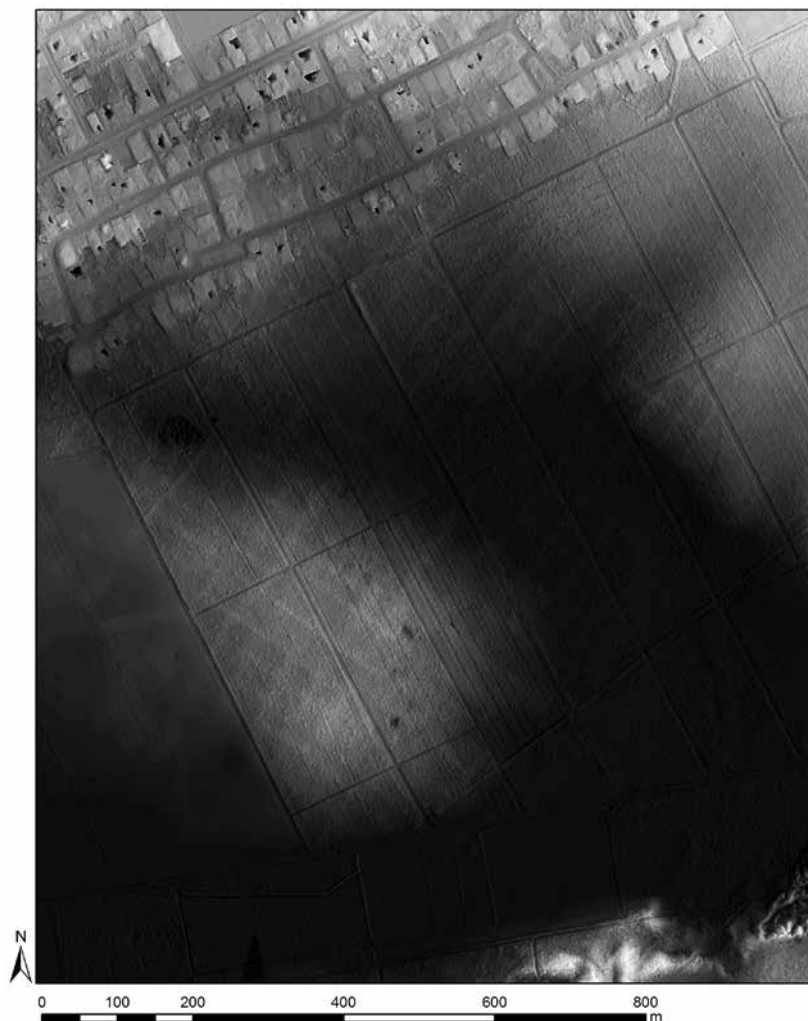
When combined the LIDAR data and earlier investigations of aerial photographs reveal a striking concentration of Celtic fields (**figs 1. 9**) on the northern part of the Campine plateau, thus suggesting the presence



**Fig. 6** Combined colourscale and hillshade visualization of the Gruitrodebos area (prov. Limburg/B). – (Illustration DTMF, © Agentschap Geografische Informatie Vlaanderen).



**Fig. 7** Combined colourscale and hillshade visualization of the Moorsberg area (prov. Limburg/B). – (Illustration DTMF, © Agentschap Geografische Informatie Vlaanderen).

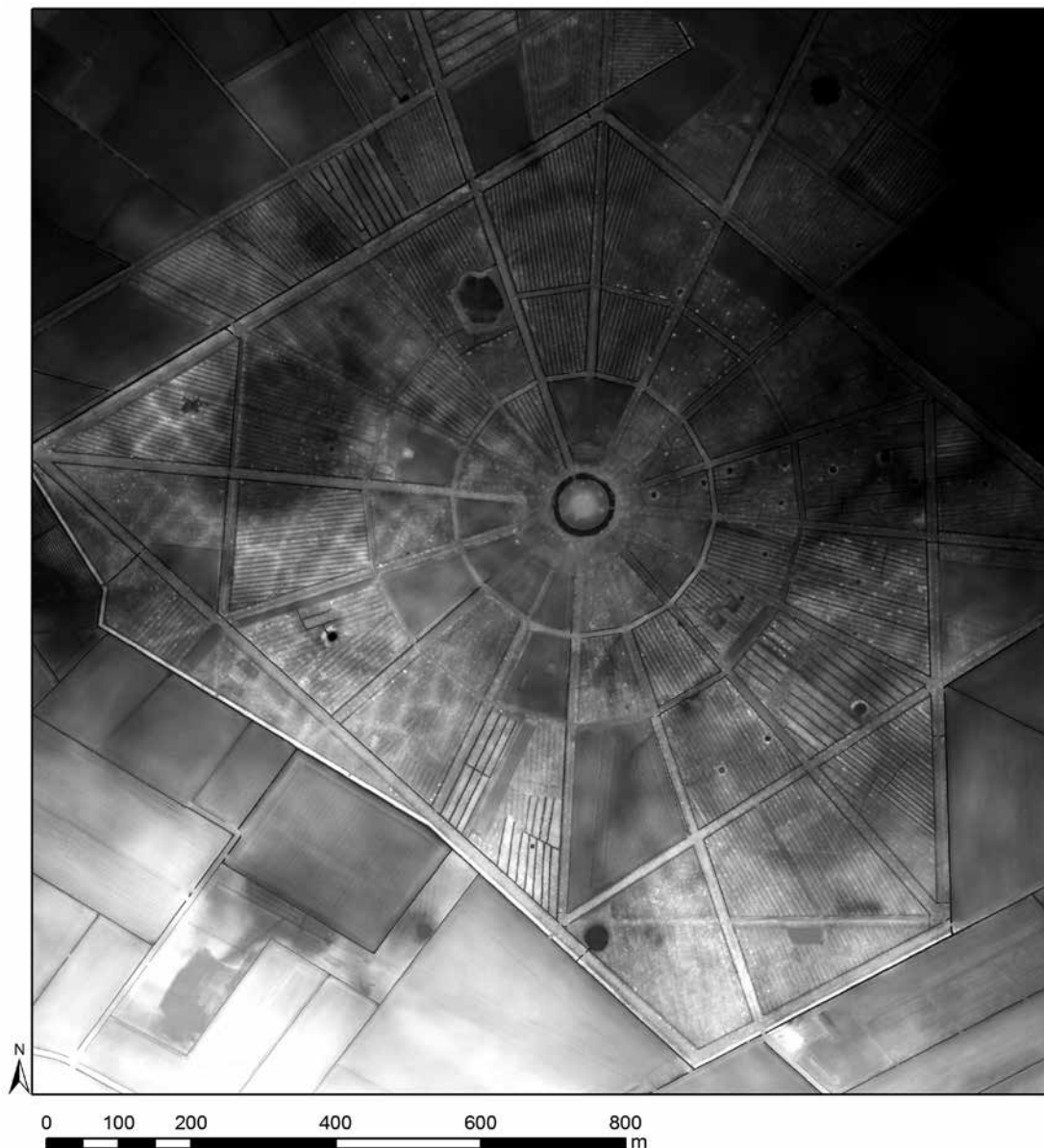


of a rather coherent protohistoric »microregion« with long-term and consistent human activity and land use. This is supported by other archaeological data from settlements and burial sites (fig. 10).

## DISCUSSION

### Geographical and pedological aspects

As in the Netherlands (Kooistra/Maas 2008), the general pedological situation of all field systems demonstrates a preference for dry »podsolised« soils. The detailed Belgian soil map additionally reveals that this patterning coincides with a somewhat richer (loamy sand) soil type when compared to the southern part (sand) of the Campine plateau. A similar observation can be made considering the field complex in the Antwerp Campine area, which is also located within a complex of sandy soils with a higher loam content than in the rest of the sandy soil regions. There is no reason to assume that this observation is somehow biased through aspects of taphonomy, leading to conclude that these protohistoric societies either preferred the exploitation of these soils in general, or the »Celtic field method« of agriculture on these soil types.



**Fig. 8** Black-white colourscale visualization of the De Hees Celtic field complex (prov. Antwerp/B) in the Antwerp Campine area. – (Illustration DTMF, © Agentschap Geografische Informatie Vlaanderen).

On a broad topographical scale all recognised field systems are situated on distinct and extended elevated regions, i. e. on the one hand the Campine plateau, and in the Antwerp Campine area a large ridge constituting the watershed between the Scheldt and Meuse basins.

### General taphonomical aspects

A possible masking factor for the detection of Celtic fields could be the location of so-called pluggen soils throughout the coversand region, which limit the possibilities of aerial photography and LIDAR based sur-

veys. On the Campine plateau this appears to be of lesser importance, since the plaggen soils here are rather limited in surface area and in general occur outside the core areas of the Celtic field complexes. The same applies for drift sand complexes (fig. 9), although these locally reworked or covered parts of the Celtic field systems, as seems to be the case in the western part of the *Lindelse Heide/Holven* complex.

The most important taphonomic factor influencing the detection of Celtic fields is undoubtedly their physical preservation. Historical maps in the area show that the general layout and land use in the northern Campine plateau remained relatively stable for centuries. Extended heathlands were partially converted into agricultural plots only in the second part of the 20<sup>th</sup> century. The current »historical« forests were introduced on former heathlands in the 19<sup>th</sup> century, and have remained in use as such up to now. The creation of these forests thus aided the survival of the microtopographical features of these former heathlands. The same holds true for the field complex in the Antwerp Campine area, which is also located in an area that has had a constant land use in the past centuries. The lack of other field complexes in this region can be attributed to the larger impact of (sub-)recent agriculture, when compared to the Campine plateau.

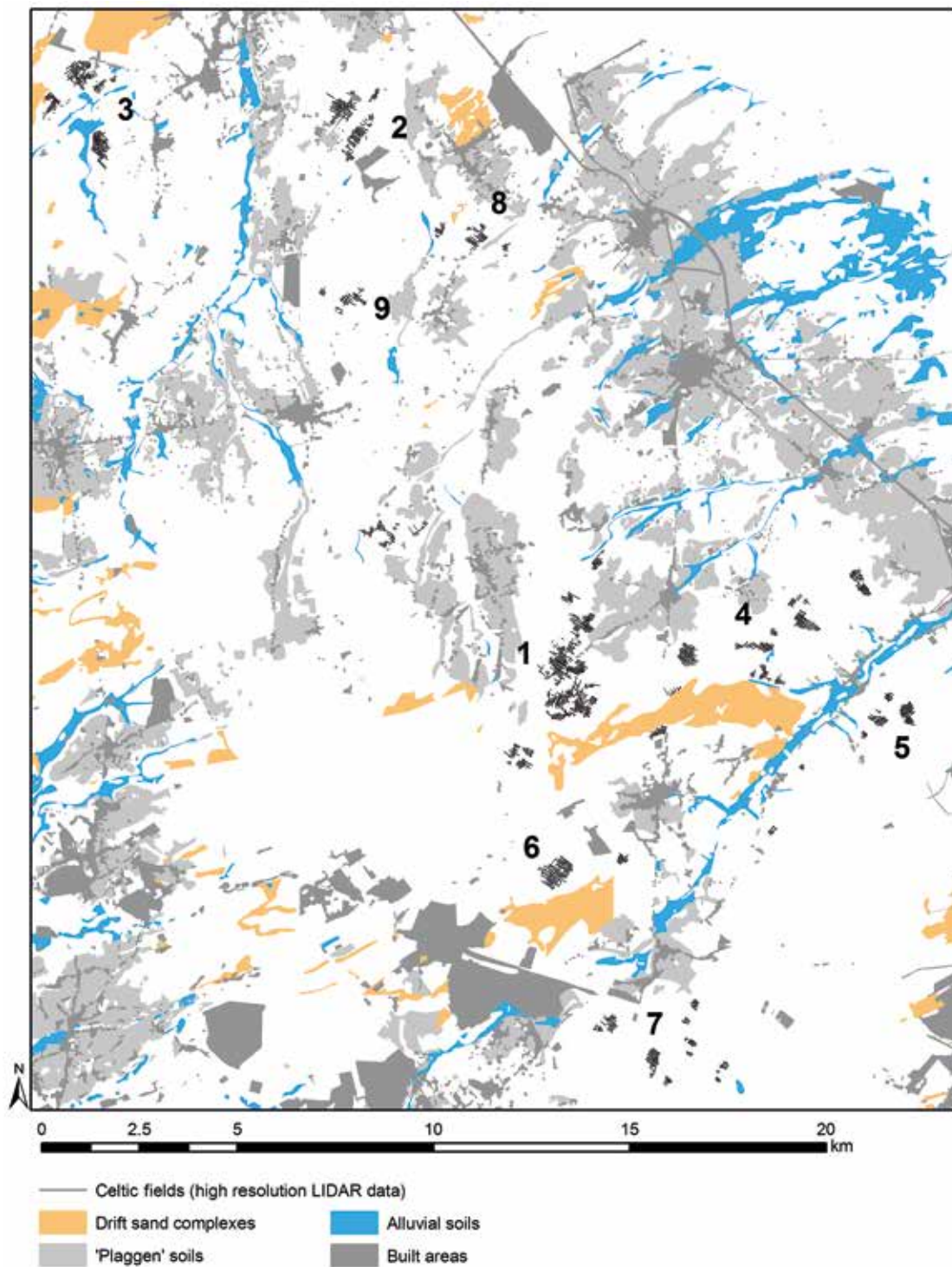
### **Spatial development, relationship with protohistorical settlements and burial grounds**

F. A. Gerritsen (2003, 177) describes possible models for the spatial development of the field systems from the Late Bronze Age onwards. Although the field complexes would not have been in use in their entirety, he concludes that the general layout of the field systems must have been »planned« to some extent from the first phase of development. Bearing witness to this are the similar dimensions and orientations between the different field systems, and the ridges forming a coaxial pattern of longer lines running throughout the complexes. The presence of such coaxial lines is a common trait for most of the above-mentioned complexes in the Flemish Campine region. The strikingly similar dimensions and common orientation of the field plots and the ridges also suggest that these field systems developed in a more regionally planned »scheme«. Most of the field systems are situated in areas where a fairly large number of other protohistoric sites are documented, ranging from the Late Neolithic to Late Iron Age periods. The combined data from these places suggest a long occupation history, with intensifying exploitation from the Late Bronze/Early Iron Age onwards. We present here a summarised view of these sites, with a more detailed discussion of the complex of the *Muisvenner-Ophovenerheide* and the surrounding locations as a case study (fig. 10).

The field walking data indicate that (e. g. at *Ophovenerheide*, *Kolisbos*, *Gruitrodebos*) farmsteads are dispersed throughout the confines of these prehistoric field systems. This accords with observations in other regions (Gerritsen 2003, 170), where this pattern is related to a system of »wandering farmsteads« and shifting exploitation of the field systems. Only parts of the field complexes were in use at the same time. What is visible today is thus an expression of different occupation phases over a longer time span.

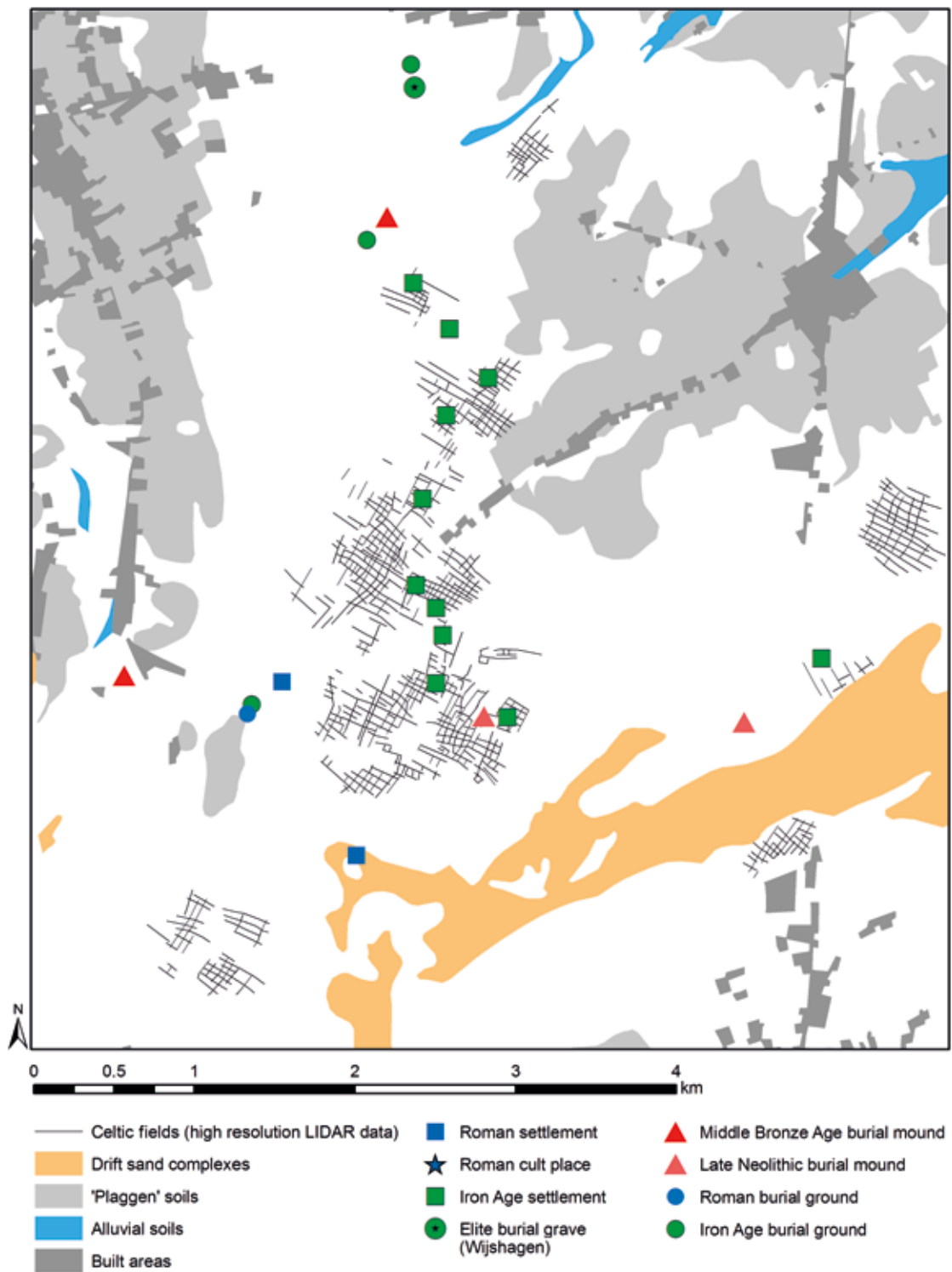
At the *Muisvenner-Ophovenerheide* complex finds from a Late Neolithic burial mound are present at the southern edge of the complex. A Middle Bronze Age barrow (the *Tuudsheuvel*), which was still visible in the early 20<sup>th</sup> century, was situated directly to the north of the field system. That this monument had an important function in the landscape during later times as well is demonstrated by the presence of seven Iron Age urns within the barrow (Dens 1897; Marien 1947). Several other finds indicate the presence of Iron Age burial grounds at the west and north-west edges of the field system (e. g. Creemers/van Impe 1992; overview in Creemers et al. 2011).

A similar patterning, with burial grounds and monuments in the neighbourhood of the field systems appears at the *Kolisbos* and *Lindelse Heide/Holven*. In the *Kolisbos* area this includes several Late Bronze Age/Early



**Fig. 9** Indication of the Celtic field complexes and large-scale taphonomic »masking« factors. – 1 *Muisvenner-Ophovererheide* complex. – 2 *Kolisbos* complex. – 3 *Lindelse Heide/Holven* complex. – 4 *Gruitrodebos*. – 5 *Dorperheide*. – 6 *Moorsberg*. – 7 *Oeleinderheidebos*. – 8 *Kaulille* complex. – 9 *Broekerheide*. – (Illustration Agentschap Onroerend Erfgoed).

Iron Age urnfields (Creemers et al. 2011). Again a similar patterning of prehistoric field systems (van Impe 1977; Vandekerchove 1996) and burial grounds (Engels/van Impe 1985; Roosens/Beex/Bonenfant 1963) appears in the municipalities of Peer and Bocholt-Kaulille (both prov. Limburg/B), to the east of the *Kolisbos*.



**Fig. 10** Schematic representation of the *Muisvenner-Ophoverheide* complex (prov. Limburg/B) and surrounding protohistoric and Roman sites. – (Illustration Agentschap Onroerend Erfgoed).

At the heart of the area with prehistoric field systems on the Campine plateau lies the elite burial ground of Wijshagen-De Rieten (prov. Limburg/B), dating from the 5<sup>th</sup>-4<sup>th</sup> centuries BC (Creemers/van Impe 2009). A small graveyard from the 3<sup>rd</sup> century BC is situated in the immediate surroundings (van Impe/Creemers 1991; Creemers/van Impe 2009). As with the field systems on the Campine plateau, also the region sur-

rounding the complex in the Antwerp Campine area harbours a large number of other protohistoric settlements and burial grounds (Annaert/Goossenaerts 1988; Gautier/Annaert 2006).

### **Chronology**

Palynological analysis on burial mounds in the Netherlands (Casparie/Groenman-van Waateringe 1980) reveals that already by the Middle Bronze Age an intensely exploited cultural landscape existed. A first large-scale »cultural« structuring of the landscape took place during this period (Arnoldussen/Fokkens 2008). On the Campine plateau palynological analysis similarly demonstrates a decline in woodland and the emergence of heathlands in the course of the Subboreal period (Munaut 1967). The location of the Middle Bronze Age barrow of the Tuudsheuvel as well as a Neolithic barrow possibly formed points of focus in the landscape throughout the later prehistory, serving as markers in the layout of the field system (cf. Gerritsen 2003, 179 for similar observations in the Netherlands; Arnold 2011, 447 for Schleswig-Holstein). These older monuments were valued and incorporated in the spatial structuring of the cultural landscape, but the appearance of Celtic fields in the Late Bronze/Early Iron Age is clearly testimonial to a new phase in the structuring of the landscape.

The available excavation and field walking data on sites surrounding and within the Celtic field complexes indicate that their occupation is mainly to be situated in the Hallstatt C-D period, perhaps also in the Early La Tène period. Iron Age burial fields were discovered within the confines of several of the field systems. Most of them are dated largely within the Hallstatt C-D period. The elite burials at Meeuwen-Gruitrode (prov. Limburg/B) from the 5<sup>th</sup> century BC, and a grave field with somewhat later burials, indicate that these Celtic field systems possibly were still in use in this period.

### **CONCLUSIONS**

The analysis of LIDAR data is contributing vastly to the detection and evaluation of Celtic field complexes in Flanders. It shows that the area of the Campine plateau harbours impressively extended field systems of several hundreds of hectares, containing thousands of field plots – far more extended than was previously assumed. The surface area of the largest complexes on the Campine plateau is only comparable to the largest complexes known in Northwestern Europe. This survey thus provides a new spatial framework for the study of the cultural biography of these protohistoric cultural landscapes. The presence of other protohistoric sites within the confines or surrounding the field systems suggests that the complexes on the Campine plateau were mainly in use during the Hallstatt C-D and Early La Tène periods and incorporated older monuments (Late Neolithic and Middle Bronze Age barrows) in their layout. On a broader regional scale the »Celtic field method« of agriculture in Flanders seems to be related to the presence of slightly richer (loamier) sandy soils, i.e. the northern part of the Campine plateau and a region in the Antwerp Campine region. Considering the preservation potential for Celtic field structures, the historically »stable« forests of the northern Campine plateau clearly offer unique possibilities for the study of protohistoric cultural landscapes in the wider region. In any case, ranking among the largest prehistoric monuments in Northwestern Europe, the heritage value of these landscapes should not be underestimated. They provide an enormous source of information, but also great challenges for heritage management. Archaeological field evaluation research to assess the information value of these newly discovered complexes has recently been started. The combined data begin to sketch the development of an intensely exploited protohistoric cultural landscape for which the field systems provided a continued structural and structuring framework.

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### *Zusammenfassung / Summary / Résumé*

#### **Zu durch hoch aufgelöste LiDAR-Scans neu entdeckten, großflächigen prähistorischen Feldsystemen im nördlichen Belgien**

Viele neue vorgeschichtliche Fundstellen, vor allem auch Celtic Fields, wurden aus der Luft in den Kempen entdeckt. Die Auswertung von LiDAR-Prospektionen mit einer mittleren Auflösung von 8 Messpunkten/m<sup>2</sup> hat eine große Zahl bisher unbekannter Celtic Fields zutage gefördert, wobei sich nun Feldsysteme über mehrere Hundert Hektar erstrecken. Das Auftreten anderer archäologischer Funde und Fundstellen innerhalb oder am Rand der Begrenzungen lässt vermuten, dass die Feldsysteme im Kempenland hauptsächlich in der Hallstatt- (Ha C-D) und Frühlatènezeit verwendet wurden. Aus überregionaler Perspektive betrachtet scheint es, als wäre die Verbreitung von Celtic Fields in Flandern an Gebiete mit etwas fruchtbareren (lehmgigen) Sandböden gekoppelt, wie sie vor allem im nördlichen Bereich der Kempen und in den Antwerpener Kempen auftreten. Diese neu entdeckte und weitreichend strukturierte Landschaft gibt einen wichtigen Rahmen für weitere landschaftsarchäologische Forschungen und Denkmalpflegemaßnahmen vor.

#### **Revealing Extensive Protohistoric Field Systems through High Resolution LIDAR Data in the Northern Part of Belgium**

Through the analysis of new LIDAR data with a mean resolution of 8 measuring points/m<sup>2</sup> a survey was conducted of the Campine plateau, an area which is known to harbour many protohistoric sites, including several field complexes (Celtic fields) as revealed through aerial photography and a previous LIDAR survey with a lower resolution. This approach revealed a large number of previously unknown Celtic fields, extending these prehistoric field complexes to several hundreds of hectares. The presence of other known archaeological finds and sites within the confines or surrounding the field systems suggests that the complexes on the Campine plateau were mainly in use during the Hallstatt C-D and Early La Tène periods. On a broader regional scale the distribution of Celtic fields in Flanders seems to be related to areas with slightly richer (loamier) sandy soils, i.e. the northern part of the Campine plateau and a region in the Antwerp Campine region. These newly discovered and extended structured complexes foremost provide an important framework for further spatial analysis, research and management of the protohistoric landscape.



## La découverte des parcellaires protohistoriques étendues dans le nord de la Belgique par LIDAR à haute résolution

De nombreux sites protohistoriques et notamment des Celtic fields sont connus par prospections aériennes sur le plateau de la Campine. Une prospection menée par l'analyse de nouvelles données LIDAR à résolution moyenne de 8 measuring points/m<sup>2</sup> sur cette région révèle un grand nombre de Celtic fields très étendus et inconnus jusqu'à aujourd'hui. Certains de ces systèmes couvrent maintenant plusieurs centaines d'hectares. Les sites archéologiques et les trouvailles associées suggèrent que ces parcellaires ont été exploités surtout au Hallstatt C-D et à la période de La Tène. A plus grande échelle il semble que la répartition de ces Celtic fields corresponde aux régions à sol sablonneux-limoneux dans le nord du plateau de la Campine et en la Campine anveroise, sols plus riches que les sols sablonneux aux alentours. Ces nouvelles découvertes procurent surtout un cadre important pour l'exécution de nouvelles recherches et analyses spatiales mais aussi pour la gestion des sites et du paysage protohistorique.

### *Schlüsselwörter / Keywords / Mots clés*

Belgien / Eisenzeit / Prospektion / LiDAR / Landschaftsarchäologie / Landwirtschaft  
Belgium / Iron Age / remote sensing / landscape archaeology / agriculture  
Belgique / âge du Fer / prospection / LIDAR / archéologie du paysage / agriculture

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