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# Scratching the surface of war. Airborne laser scans of the Great War conflict landscape in Flanders (Belgium)

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ABSTRACT

In light of the growing interest in the Great War – stimulated by the ongoing centennial commemorations – the conflict landscape in Belgium and France is currently the subject of scientific research projects, archaeological excavations, heritage-related initiatives and exhibitions. However, the extent of the archaeological heritage and surface remains of the Great War remain underestimated. Current heritage management and the proposal for a UNESCO nomination focus on the architectural heritage, commemorative monuments and military cemeteries, thereby overlooking the opportunities to acknowledge the conflict landscape in its totality. This paper explores the application of high-resolution Lidar data (DTM-Flanders II 2013–2015) to investigate a layer of war heritage which, until now, has remained invisible, and reveals a wide range of previously unknown archaeological sites related to the Great War. Traces of the war can be found all over the former front zones and hinterland, ranging from remnants of the heavily shelled and devastated war landscapes to more specific archaeo-geomorphological features of trenches, dugouts and other military infrastructure. Both the nature and the scale of the new information support and further expand the concept of the landscape as the last witness of the war.

## 1. Introduction

Over the past decade, there has been a growing awareness among archaeologists (Desfosses, 2010; Desfossés, Jacques, & Prilaux, 2008; Pollard & Banks, 2007; Saunders, 2002, 2013), heritage managers (Dewilde, Stichelbaut, Van Hollebeeke, Verboven, & Wyffels, 2014; Vandael et al., 2016; Verboven, 2015) and museum professionals (Chielens, Dendooven, & Decoodt, 2006; Stichelbaut & Chielens, 2013, 2016) that the surface remains and archaeological heritage of the Great War are the last witnesses of one of the greatest conflicts in world history. The current proposal to nominate parts of the Great War heritage in Belgium and France as a UNESCO World Heritage site is a reflection of this, although it is limited to architectural heritage, commemorative monuments and military cemeteries (Agentschap Onroerend Erfgoed, 2017a).

In France, the government deemed parts of the devastated front zone to be physically and environmentally too damaged for human habitation and impossible to clean up. Just after the war, a *Zone Rouge* (Red Zone) was defined, with restrictions on housing, farming and forestry (De Matos-Machado, Amat, Arnaud-Fassetta, & Bétard, 2016, p. 8). As a consequence, the land returned to nature, and surface features of the war have been extremely well preserved. In Belgium, on the contrary, the landscape was quickly restored, levelling almost all of the war's surface scars. Despite greater attention on war heritage in recent decades, little is known about the nature and extent of this archaeological heritage on a landscape scale. This applies to buried heritage (Gheyle et al., 2016; Saey et al., 2016a; Stichelbaut et al., 2017a), but even more to surface remains or archaeo-geomorphological features (Hesse, 2014; Thornbush, 2012) such as mine craters (Stichelbaut et al., 2016), shell holes and preserved trenches.

The Flemish Government recently released a high-resolution airborne laser scanning (ALS or Lidar) dataset covering all of Flanders and the Brussels Capital region, opening a range of possibilities for investigating Flanders' war heritage (Informatie Vlaanderen, 2017; see

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more details below in Dataset and Method). Lidar is an optical sensing technology, in this context mounted on an aircraft, used to determine the position and characteristics of the terrain below by analysis of pulsed laser light reflected from the surface. The obtained 3D point cloud is used to create a high-resolution digital elevation model (DEM) of the earth's surface. As part of the laser pulses penetrate vegetation and reflect from the bare soil below, it has the advantage that tree cover and other vegetation can be filtered out.

This dataset is an essential source of information for studying the conflict landscape of the Great War because it enables research at landscape scale, is highly detailed and is complementary to other approaches using historical aerial photography (Stichelbaut et al., 2017a) and geophysical prospection (Masters & Stichelbaut, 2009; Saey et al., 2016b). Geophysical soil sensing gives information in areas where above-ground preservation is absent and Lidar cannot detect surface features, such as agricultural fields. Where Lidar and geophysical soil sensing come together, they give unique, almost three-dimensional insights on the preserved war heritage.

Using geographical techniques such as historical aerial photo interpretation, Lidar analysis, landscape analysis and geophysical soil sensing, we aim to investigate the neglected and overlooked surface remains of the Great War. This paper: (i) explores the extent and preservation of the surface features of the Great War on a landscape scale of research; (ii) fills in the gaps between the known sites that are wrongly considered to be isolated sites and strongly recommends that the holistic landscape in research and heritage management is considered; (iii) suggests a methodology for the efficient use of Lidar data to record surface features on a landscape scale, from a broad-brush approach to the detailed study of feature typology; and (iv) aims to acquire an insight into the density, diversity and distribution of this war heritage. In this way, we aim to contribute to the knowledge on preserved Great War heritage and inform heritage managers and policymakers of the importance of this overlooked layer.

### 1.1. *Conflict landscapes and Lidar*

Airborne Lidar (light detection and ranging) or ALS is making an extremely valuable contribution to archaeological research. Lidar enables a shift from a site-directed approach to landscape-scale research thanks to the scale of the data and the large areas it covers. It presents a wide chronological range of archaeological features, from prehistory to present-day anthropogenic influence on the landscape (Hesse, 2013, 2016). In a recent review of its applications in archaeology (Masini, Coluzzi, & Lasaponara, 2011), only one project is cited dealing with modern conflict archaeology (Stal et al., 2010). However, in the last five years, with the centenary of the Great War as a driving force and the increasing availability of large-scale Lidar datasets (Opitz & Cowley, 2013) and historical remote-sensing data (Cowley & Stichelbaut, 2012), Lidar is now widely used for conflict archaeology. Hesse introduced the term ‘conflict archaeogeomorphology’ to identify geomorphological traces of conflict (Hesse, 2014), after Thornbush (2012), while Hupy and colleagues see modern warfare as ‘zoomorphic disturbance’ (Hupy & Koehler, 2012) and Stular et al. apply the more general term ‘archaeological topography’ (Stular, 2011, 2014; Stular, Kokalj, Ostir, & Nuninger, 2012). The link with geomorphology and geography is evident, and is particularly valid when focusing on the impact of artillery fire or so-called ‘bombturbation’ (Hupy & Schaetzl, 2006), for instance in the study of the geomorphology of Verdun (Hupy & Schaetzl, 2008).

Most contributions on Lidar and archaeology focus on methodological issues such as visualisation techniques (Kokalj, Zaksek, & Ostir, 2011; Stular et al., 2012; Zaksek, Ostir, & Kokalj, 2011) and good practices in archaeological prospection (Kokalj & Hesse, 2017; Stular, 2014). Although valuable work has been done on (semi)automated detection techniques with archaeological relevance (Sevara, Pregesbauer, Doneus, Verhoeven, & Trinks, 2016), it seems the taboo of automated detection has yet to be tackled (Bennett, Cowley, & De Laet, 2014). Studies on conflict archaeology are rare, although attempts have been made towards automated shell crater classification in Trento, Italy (Magnini, Bettineschi, & De Guio, 2017).

A wide range of regional studies focus on conflict archaeology and Lidar. In Belgium, Stal et al. studied Mount Kemmel (Stal et al., 2010), while Stichelbaut et al. used Lidar-derived digital elevation models (DEM) to identify the surface scars of the tunnelling war beneath the surface (Stichelbaut et al., 2016, 2017b). The geomorphology of conflict is being studied actively in France, specifically in the Champagne-Ardenne (Taborelli, Devos, Bollot, & Desfossés, 2016a, 2017) and Verdun regions (De Matos-Machado, 2014; De Matos-Machado et al., 2015; De Matos-Machado et al., 2016), while Desfossés studied forests in Argonne's Red Zone (Desfossés, 2017; Desfossés et al., 2008).

As mentioned above, Lidar is also used to analyse the impact of different types of artillery shelling (Taborelli et al., 2016b). The Austrian/Italian front (Gietl, Terzer, & Steiner, 2015) and Isonzo or Soča front in Slovenia is receiving much attention (Mlekuž, Košir, & Črešnar, 2016; Novakovic et al., 2014; Stular, 2011), while in Poland, Lidar is used to document prisoner-of-war (PoW) camps and trench systems (Kobiałka, Kostyrko, & Wałdoch, 2016, 2017). As a processual archaeological technique, it is even used to research the material memories and commemorative landscape of war cemeteries (Zalewska, 2016, p. 158). In the UK, so-called ‘home front’ sites (i.e. training camps, PoW camps) have been revealed (Bluesky, 2017; Hanson, 2012a, 2012b; Montgomery & McNeary, 2016). Conflict archaeology not only focuses on the Great War. Lidar has also been used to study a World War II PoW camp in South Wales (Rees-Hughes, Pringle, Russill, Wisniewski, & Doyle, 2016), the post-World War II reconstruction in Poland (Kiarszys, 2016) and the material remains of the Iron Curtain and the Cold War (Rak, Funk, & Starková, 2016).

### 1.2. *The war landscape in Belgium*

From the above literature review, it is evident that Lidar and conflict archaeology are a dynamic and quickly evolving field of research. Although much progress has been made, there is still a need for a more integrated approach combining historical and present-day remote-sensing data, such as Lidar for above-ground features and geophysics for the buried heritage of the conflict. This paper illustrates the integration of historical aerial photography with Lidar data, ranging from the traditional narrow view of individual archaeological sites to an overall perspective at landscape scale.

The research took place in the former front area of the Great War. An area which became notorious because some of the fiercest battles of war took place here (Chielens et al., 2006). After the Battle of the Yser (18–31 October 1914) and the First Battle of Ypres (19 October – 22 November 1914) the war of movement quickly changed into a stalemate in the trenches and both sides dug in for the first winter of the war. On 22 April 1915 German forces launched the first large gas attack between Steenstraat and Langemark (Second Battle of Ypres, 22 April – 25 May 1915) and the following weeks the frontline approached the city of Ypres (Edmonds, 1928). For more than two years there were only minor actions and engagements. In an attempt to break through the stalemate of the Ypres Salient the Allies launched a massive offensive in 1917 (Battle of Messines 7–14 June 1917 and the following Third Battle of Ypres 31 July – 10 November 1917) which did not reach it goals. All territory gained in 1917 was lost during the German Spring Offensive (7–29 April 1918) (Edmonds, 1948).

The above-ground remains of the Great War in Belgium are an underestimated and largely unknown part of war heritage. Although archaeological excavations (Dewilde & Demeyere, 2008; Dewilde, 2006; Dewilde, de Meyer, & Saunders, 2007; Van Hollebeeke, Stichelbaut, & Bourgeois, 2014) and geophysical surveys (see Saey, Stichelbaut, Bourgeois, Van Eetvelde, & Van Meirvenne, 2013 for an overview) have already assessed the importance of underground war heritage in the front zone, surface remains have only been sporadically researched or