

## **Anthropogenic landforms of warfare origin and their ecological significance: the Verdun Forest, NE France**

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By its unprecedented industrial character, the First World War marked landscapes like no other conflict in the world. As a result of artillery bombardment and building facilities, the relief suffered major disturbances giving rise to millions anthropogenic landforms of warfare origin on the Western front: shell craters, trenches, shelters and gun sites. This landscape made of bumps and holes that dominated the lands of West Flanders and North-eastern France during the four years of war took chaotic aspects on the great battle sites. In some areas, substrate crushing by repeated bombings resulted in a field lowering of several metres. Although these geomorphological legacies of war are still present on these scarred lands, their effects on local environment and on present-day biodiversity patterns are not fully understood. On the battlefield of Verdun, where a huge number and range of conflict-induced landforms may be observed, special attention is being paid to the ecological significance of these anthropogenic landforms in a current landscape matrix dominated by forest. In 2013, an airborne LiDAR mission conducted over the battlefield has brought to light the relief inherited from the fighting that was until now concealed by the Verdun forest planted in the 1930's. Through a digital terrain model (DTM) with centimetre level accuracy, it is now possible to observe the smallest traces of the fighting. A first programmatic mapping work allowed to inventory and to locate these reliefs on the whole 10,000 hectares covered by the DTM. Also, the calculation of their geometry enabled us to quantify the erosion rate due to the military activities on the battlefield. On the basis of these morphometric measurements, a typology was developed to better appreciate the morphological diversity of conflict-induced landforms. The results show that these anthropogenic landforms are generally hollow. Because of this particular morphology, the conflict-induced landforms provide shelters for several animal and plant species. That is the case, for instance, of flooded shell craters, which contributed to the introduction of wetland flora and fauna. Thus, and despite the almost complete destruction of the pre-war landscapes, the battlefield of Verdun now enjoys a strong environmental potential. This led to be included to several ecological networks such as the European Natura 2000 network. It also benefits from the "Forêt d'Exception<sup>®</sup>" label since 2014, involving for the next few years forest managers in a process of sustainable development and preservation of the battlefield.