

Ursidae: The Undergraduate Research Journal at the University of Northern Colorado

Volume 7 | Number 3

Article 3

July 2018

The Impact of World War one on the Forests and Soils of Europe

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Recommended Citation

Heiderscheidt, Drew (2018) "The Impact of World War one on the Forests and Soils of Europe," *Ursidae: The Undergraduate Research Journal at the University of Northern Colorado*: Vol. 7 : No. 3 , Article 3. Available at: <https://digscholarship.unco.edu/urj/vol7/iss3/3>

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Introduction

The First World War was the largest war in the history of the world up until that time.¹ It took place between two sides: the Allied Powers (France, Britain, the United States, and numerous others) and the Central Powers (Germany, the Austro-Hungarian Empire, the Ottoman Empire, and others). With the advent of new technologies of war—such as machine guns, larger artillery pieces, and chemical weapons—it became the deadliest war in history to date. On both sides of the conflict, there were over eight million deaths and millions more wounded.² However, besides the impact of the war on humans, which cannot be understated, the First World War significantly altered the forests and soils of Europe, particularly in France. Forests in Belgium and England were decimated by the war, but in France, the forests were substantially changed, going from diverse ecosystems pre-war to monocultures post-war. The causes of this decimation and transformation were new technologies, such as artillery, and wartime needs for lumber, much of which went into building trenches.

The soils of Europe were also heavily affected by the First World War, and often they became significantly contaminated by heavy metals such as copper (Cu) and lead (Pb), as well as unexploded ordinance.³ Soil contamination was particularly widespread in France, leading to the declaration of the “Zone Rouge” (Red Zone), an area cordoned off by the government and since considered unlivable. Basically, the formation of soil, or pedogenesis, was impacted by processes such as bombturbation and cratering, and the soil horizons became mixed up. The effect of the First World War on the forests and soils of Europe was especially noticeable in France, where the bulk of fighting on the western front was done.

¹ John Keegan, *The First World War* (New York, Vintage Books, 1998), 6.

² *Ibid.*, 6-9

³ P. Souvent, and S. Pirc, “Pollution caused by metallic fragments introduced into soils because of World War I activities,” *Environmental Geology* 40, no. 3 (January 2001): 317.

In this paper, I discuss the human impacts of the First World War on the environment by examining how forests and soil were affected. I specifically look at the pre- and post-war composition of forests and explore the causes of deforestation during World War I, and I also examine two different effects on the soil during the war. First, I discuss soil contamination due to heavy metals and the deploying of chemical weapons, and secondly, I investigate soil disturbance by defensive/offensive actions (such as building trenches) and artillery fire. Within this paper, I have used several different types of sources. First, I used primary sources from soldiers who fought during the First World War, specifically entries from forestry-centric journals that were active from 1914 to 1918 as well as some portions of fiction. I included fiction to contextualize the destruction that artillery wrought on the environment as it was happening and the change in forests and soils afterwards. In terms of secondary sources, I drew from multiple fields of study, including environmental history, geography, geology, biology, and forestry. My decisions about which sources to use were based on their direct relevance to the First World War; I wanted to include statements about forest and soil cover before the war, disturbance of forests and soil during the war, and changes in forests and soil after the war. In effect, these sources are used to synthesize an eco-historical approach to the First World War, specifically in terms of changes the war wrought upon the natural environment. This perspective brings to light new insights on how warfare, particularly artillery, affects the overall environment, especially on a scale as large as the First World War.

Forests in Europe Before and After World War I

The First World War hit the forests of Europe extremely hard. One description of the decimation of the forests, from A.D. Gristwood's novel *The Somme*, describes France, though it could apply to many other areas in Europe during WWI, as a "blasted country" that was akin to a

“lunar landscape, lifeless, arid and accursed.”⁴ Indeed, researchers estimate that between August 1914 and November 1918, 1.45 billion shells were fired by Germany, France, and Britain, with attacks normally started by massive artillery firing.⁵ This amount of ordinance being fired at a consistent rate (during battles artillery shells rained from the sky constantly) destroyed the forests not only of France, but also of Belgium and other areas. According to P.S. Risdale, who was a forester in the U.S. Army during World War I, northern France’s trees “that have not been blown down or cut through or shattered have been so badly damaged that they will die; others, pitted with bullet holes or wounded by other shot, are now open to disease or insect attack.”⁶ Indeed, many of the forests in France were destroyed by bullets and artillery because so many battles happened there. “Everywhere,” French forester Louis Marin wrote, “forests have been of precious assistance to our soldiers; it is while concealed in them that we have lost the least men.”⁷ According to Marin, the places where forests were most devastated in France were those closest to the battlefield; when trees were shot they would often die because they could not heal and were thus used for other endeavors, such as fire wood and building roads.

Though much damage occurred through weapons of war, the vast majority of forests in Europe during World War I were not damaged directly by warfare but were instead destroyed by overuse. This was especially true in Belgium. According to Risdale, the country’s forests had been “practically destroyed. Much of the timber was used by the Germans for military purposes in the construction of trenches, in road building, in the erection of shelters, barracks, etc.;

⁴ A.D. Gristwood, “The Wasteland,” in *The Vintage Book of War Fiction*, ed. Sebastian Faulks and Jorg Hengen (New York, Vintage Books, 2002), 41. Besides in novels about the First World War, The Somme also inspired J.R.R. Tolkien’s descriptions of Mordor in *The Two Towers* and *The Return of the King*.

⁵ M. Van Meirvenne, T. Meklit, S. Verstraete, M. de Boever, and F. Tack, “Could shelling in the First World War have increased copper concentrations in the soil around Ypres?” *European Journal of Soil Science* 59 (April 2008): 372.

⁶ P.S. Risdale, “Shot, Shell and Soldiers Devastate Forests,” *American Forestry* 22 (1916): 334.

⁷ *Ibid.*, 335.

considerable was used for fire wood, and it has been stated, with what accuracy it is impossible to say, that timber was not used in this way or needed in the military zone [was] shipped to Germany for home consumption.”⁸ Chris Pearson, in his book *Mobilizing Nature*, explains how the war made forestry production a military endeavor, which alarmed many foresters, who had been “trained to believe that their own forest management policies balanced timber exploitation with forests’ long-term future.”⁹ Indeed, the creation of trenches, roads, encampments, and various other military necessities required massive amounts of lumber, whereby huge swaths of Belgian and French forests were cut down.¹⁰ The activities that used the most lumber were the construction of roads and trenches. The roads being built at this point were called corduroy roads because their appearance was similar to that of corduroy fabric, and they demanded much lumber, “the base being made of tree trunks overlaid with branches and these branches overlaid with earth,” which led to the destruction of thousands of trees.¹¹ According to the French Forestry Service, over 350,000 hectares of forest in France alone were cut down during the First World War, an amount that would have been enough for sixty years’ worth of tree harvests.¹² To put into context just how much wood was cut down over the course of the war for such purposes, consider American foresters based in France. During the last two years of the war, American foresters manufactured almost 220 million board feet of lumber; 3,051,137 standard-gauge railway sleepers; 1,926,693 miscellaneous round products (including entanglement poles); and 534,000 cords of firewood—and that was *only during the final two years of the war*, which the

⁸ Risdale, “Shot, Shell and Soldiers Devastate Forests,” 333.

⁹ Chris Pearson, *Mobilizing Nature: The environmental history of war and militarization in Modern France* (New York: Manchester University Press, 2012), 107.

¹⁰ Dorothee Brantz, “Environments of Death: Trench Warfare on the Western Front, 1914-1918,” in *War and the Environment: Military Destruction in the Modern Age*, ed. Charles E. Closmann (College Station, TX: Texas A&M University Press, 2009), 74.

¹¹ Risdale, “Shot, Shell and Soldiers Devastate Forests,” 334.

¹² Brantz, “Environments of Death,” 82.

U.S. joined late.¹³ To further contextualize these huge numbers, before the First World War started, the U.S. annually produced only 65 million board feet of lumber.¹⁴

Whether destroyed by warfare itself or as a byproduct of warfare, the forests of Europe were devastated by the First World War. Destruction of forests was particularly acute in France and can still easily be seen today. I would theorize that France was disproportionately affected by the First World War environmentally because the majority of battles on the Western Front took place within France. Joseph Hupy has observed that the forests of France before the First World War were extremely diverse and contained “European beech, European hornbeam, European oak, and English oak.” However, after the war, almost all of these trees had been wiped out. Now forests are dominated by European beech with some Austrian pine, a significant decrease in the diversity of species in the area.¹⁵ Essentially, the forests of Europe were hurt by the First World War because of warfare itself, but also because of an increased need for timber to create things such as corduroy roads and trenches.

Soil Contamination and Disturbance in Europe after World War I

The soils of Europe were also affected by the First World War, especially when it came to contamination by heavy metals, which in some cases were dangerous poisons such as mustard gas. However, it should be made clear that the level of contamination was based on the amount of artillery fired in different areas. In a study of the area surrounding Ypres (site of the First Battle of Ypres in 1914, the Second Battle of Ypres in 1915, and the Third Battle of Ypres in 1917), Meirvenne and colleagues found large concentrations of copper and lead in the soil. The

¹³ Pearson, “Mobilizing Nature,” 109.

¹⁴ Forest Service, USDA, “Status of the interior Columbia Basin: summary of scientific findings,” *General Technical Report (GTR)* (1996): 55.

¹⁵ Joseph P. Hupy and Randal J. Schaetzl, “Soil development on the WWI battlefield of Verdun, France,” *Geoderma* 145 (2008): 39.

background rate of copper in the earth is 17mg kg^{-1} , but when they studied the areas around Ypres, they found that one third of their data contained copper levels higher than the background threshold of 17 mg kg^{-1} ,” and 1.2 percent of their data exceeded 200 mg kg^{-1} .¹⁶ However, the amount of contamination depended on location, with some areas (I would theorize those that had been bombed the most by artillery) having significantly higher amounts of lead and copper present in the soil. According to the research by Meirvenne’s group, the soil inside the war zones “shows an increased frequency of samples with Cu concentrations between 10 and 60 mg kg^{-1} , whereas, to a lesser extent, the area outside the war zone contains more samples with larger Cu contents.”¹⁷

Meerschmann and others came to similar conclusions in the course of their research on soil contamination in Belgium. They found that, while in many areas there were extremely high amounts of soil contamination, particularly in areas where leftover ammunition had been burned after the war, these levels varied geographically (See Fig. 1).¹⁸ Thus, they concluded that “the environmental impact of heavy metals is negligible at a regional scale.”¹⁹ This same issue also pervaded the Slovenian front, where researchers P. Souvent and S. Pirc found that “approximately 1100km^2 of agricultural and forest land were physically damaged and chemically contaminated by the construction of military objects and artillery fire,” and copper, lead, mercury, antimony, and zinc levels were high in soils surrounding these areas.²⁰ All of these studies established that, in some places, the amount of lead and copper contamination in the soil

¹⁶ Meirvenne et al., “Could shelling in the First World War...?”, 374.

¹⁷ Ibid., 376.

¹⁸ Eef Meerschmann, Liesbet Cockx, Mohammad Monirul Islam, Fun Meeuws, and Mare Van Meirvenne, “Geostatistical Assessment of the Impact of World War I on the Spatial Occurrence of Soil Heavy Metals,” *AMBIO* 40 (2011): 417-420.

¹⁹ Meerschmann et al., “Could shelling in the First World War...?”, 420.

²⁰ P. Souvent and S. Pirc, “Pollution caused by metallic fragments introduced into soils because of World War I activities,” *Environmental Geology* 40, no. 3 (January 2001): 317.

was anomalously high. However, in some areas it was also low. This shows that location is important, as certain areas such as Ypres that were heavily bombed with artillery have a significantly higher contamination level than others.

The place where soil contamination was the most acute, however, was in France. After World War I, the French government designated an area stretching from Lille in northern France to southwest of Nancy as the “Zone Rouge,” an area that they declared uninhabitable due to soil contamination as well as unexploded ordinance (see Fig. 2).²¹ The First World War heavily contaminated the soils of Europe with heavy metals, and in some cases poisons from chemical warfare, but the extent of the damage depended on the location, and even within an entire region it varied significantly.

Soil contamination also came from another significant source during the First World War: the use of chemical weapons. During the war, five percent of all artillery shells fired had chemical weapons in them, usually mustard gas.²² Chemicals used to produce these weapons still linger in the environment. The study by Meirvenne and colleagues found that “increased amounts of arsenic,” which was used to make chemical weapons, were found in soils surrounding World War I battlefields, particularly ammunition burning sites.²³ This continues to affect people living in these areas, and the same study also found that soils contaminated by mustard gas have continued “for many decades to present both acute and chronic human health risks and risks to groundwater.”²⁴

²¹ Stuart Thornton, “Red Zone,” *National Geographic*, May 1, 2014, <http://www.nationalgeographic.org/news/red-zone/>.

²² Meirvenne et al., “Could shelling in the First World War...?”, 372.

²³ Ibid.

²⁴ Meirvenne et al., “Could shelling in the First World War...?”, 7.

Besides soil contamination, the First World War also led to the disturbance of soil within Europe because of both defensive/offensive reasons, such as building trenches, and artillery fire, which disturbed the soil horizons. According to Giacomo Certini and his colleagues, “considerable human disturbances to soil for defensive purposes was implied by the wide trench systems on the Western Front.”²⁵ As a result of moving the soil for offensive purposes, the soil horizons were disturbed and mixed, interrupting pedogenesis (soil formation).²⁶

Soil was also disturbed by artillery fire. In his essay “Introducing ‘bombturbation,’” Joseph Hupy introduced the term “bombturbation” to describe how soils crater and mix due to warfare and other warfare-related activities.²⁷ Bombturbation was particularly prevalent during the First World War because the shells used exploded directly on impact, whereas in later wars, especially the Second World War, they were designed to explode above the ground. Shells that exploded directly on impact disturbed the soil much more.²⁸ There were various calibers of artillery, ranging from 70 mm shells, which produced small craters less than a meter in diameter, to massive 420 mm shells that produced huge craters ten meters in diameter and often at least five meters deep.²⁹ The extent of soil disturbance in Europe after World War I was massive, especially in areas such as Verdun, France, where researchers have estimated that German and French armies fired upwards of 60 million artillery shells from February to August 1916.³⁰ Hupy and his colleagues discovered that landscape disturbance in Europe averaged at least 20 km on

²⁵ Giacomo Certini, Riccardo Scalenghe, and William I. Woods, “The impact of warfare on the soil environment,” *Earth-Science Review* 127 (2013): 2.

²⁶ *Ibid.*, 2.

²⁷ *Ibid.*, 825-826.

²⁸ *Ibid.*, 828.

²⁹ Joseph P. Hupy and Randall J. Schaetzl, “Introducing ‘bombturbation,’ A Singular Type of Disturbance and Mixing,” *Soil Science* 171, no. 11 (November 2006): 828.

³⁰ Joseph P. Hupy and Thomas Koehler, “Modern warfare as a significant form of zoogeomorphic disturbance upon the landscape,” *Geomorphology* 157-158 (2012): 172.

either side of the trenches, but many areas were even more damaged.³¹ They found that over the course of World War I, there were at least 20 million craters created by artillery fire, but other estimates show that this number could have been upwards of 50 million.³² To put into perspective how much the soil was disturbed by artillery fire, consider Hill 304 in Verdun, France. At the beginning of the First World War, the elevation of Hill 304 was 434 m above sea level. After the war, the elevation of that same hill had dropped four meters to 430 m above sea level.³³

The impact of the artillery shells and the subsequent effect on the environment should also be explained. Shockwaves from the explosion of artillery shells disturbed the soil. The shell exploded, sending out a shockwave that moved “soil and rock. . . excavating most of the soil from the crater as it radiates out in a nearly uniform circle.”³⁴ This changed the composition of the soil, and it especially changed pedogenesis in the area. According to Hupy:

Soil pedons within and adjacent to cratered disturbances have set off on a course of soil developmental evolution much different than similar counterparts on undisturbed portions of the battlefield; this is the butterfly effect of war. Processes such as littering, humification, leaching, lessivage and weathering, which dominated the pre-war soil landscape, have been changed in intensity and pattern as influenced by crater microtopography.³⁵

Thus, as a direct result of the First World War, the soil composition of many parts of Europe was changed. Even today, this soil disturbance can still be clearly seen in Europe, especially in France.

Another byproduct of the artillery shells was an impact on the water table of local areas:

“in some instances, impermeable bedrock and soil layers are breached by cratering, depriving the

³¹ Hupy, “Bombturbation,” 828.

³² *Ibid.*, 826.

³³ Hupy, “Bombturbation,” 829.

³⁴ *Ibid.*, 830.

³⁵ Hupy, “Zoogeomorphic Disturbance,” 174.

vegetation of its former source of (shallow) water.”³⁶ This also changed the way water flowed through the soil and often concentrated it into craters. According to Hupy, such a process would “(1) attract micro and macrofauna which (2) accelerate the humification of the organic matter within. The faster than expected weather of the bedrock fragments in the crater bottoms is likely due to the increased amounts of water moving through the craters.”³⁷ This, of course, increased the infiltration of water into the soil (see Fig. 3). However, it also led to the rapid growth of the O (the layers of soil with much organic matter) and A (topsoil) horizons, which in turn favored plant growth further acidifying the solum, which is normally entirely unweathered.³⁸ In conclusion, as a result of the First World War, soils were both contaminated and disturbed significantly even in the soil composition itself.

Conclusion

The First World War was the biggest war the world had ever seen up to 1914. With a massive death count and an unprecedented amount of destruction, many simply referred to World War I as “the Great War.” However, it seems that little attention has been paid to how the war affected the environment. Whether it was intended or not, environmental destruction was a byproduct of the war. Forests in Europe were devastated, especially in France, because of artillery and the building of trenches and roads. The land, in essence, became a desolate wasteland (see Fig. 4). Soil was also affected by the war, with many areas experiencing soil contamination from heavy metals and chemicals that still impact them today (see the Zone Rouge in France). The soil was also disturbed by the war, with soil horizons and water tables being completely changed by bombturbation and the cratering of the landscape. One can observe

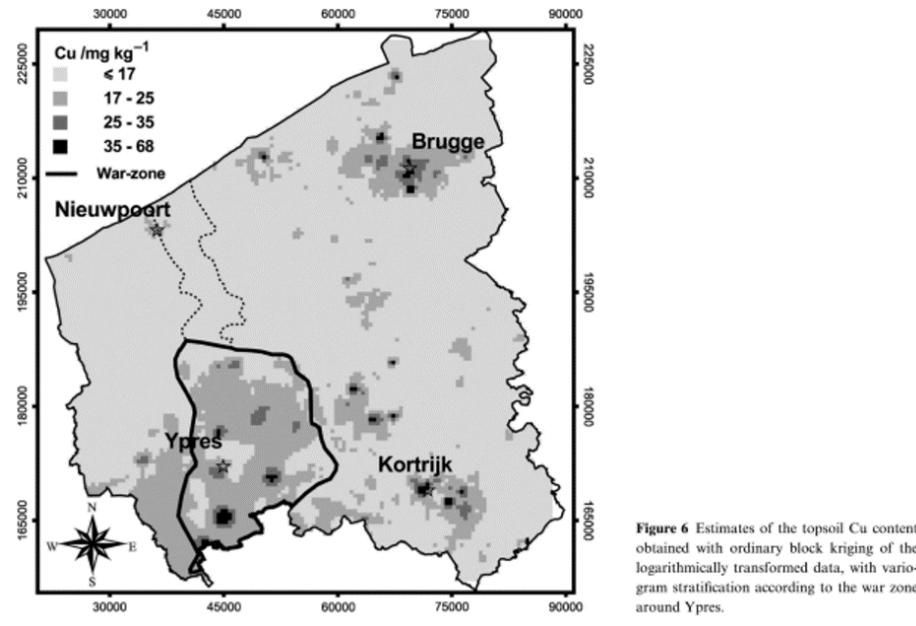
³⁶ Hupy, “Bombturbation,” 826.

³⁷ Hupy, “Soil Development,” 45.

³⁸ Certini et al., “The impact of warfare on the soil environment,” 3.

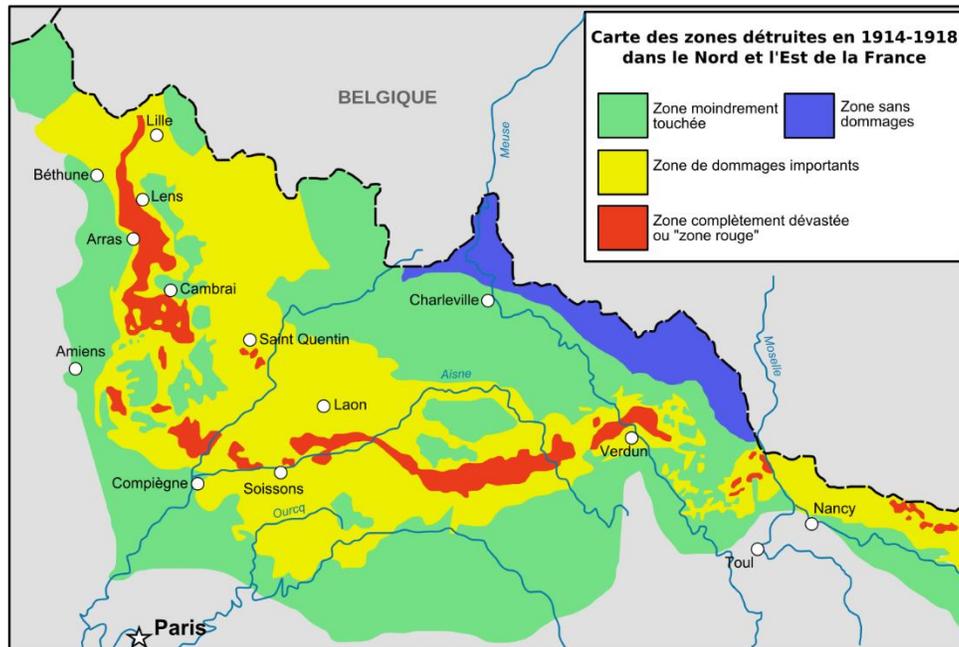
the war's environmental impacts in the monoculture forests and numerous craters still present in World War I battlefields today.

Figure 1



Source: M. Van Meirvenne, T. Meplit, S. Verstraete, M. de Boever, and F. Tack, “Could shelling in the First World War have increased copper concentrations in the soil around Ypres?” *European Journal of Soil Science* 59 (April 2008): 378.

Figure 2



Source: Wikimedia.com, September 16, 2008, <https://goo.gl/9r2YLu>.

Figure 3

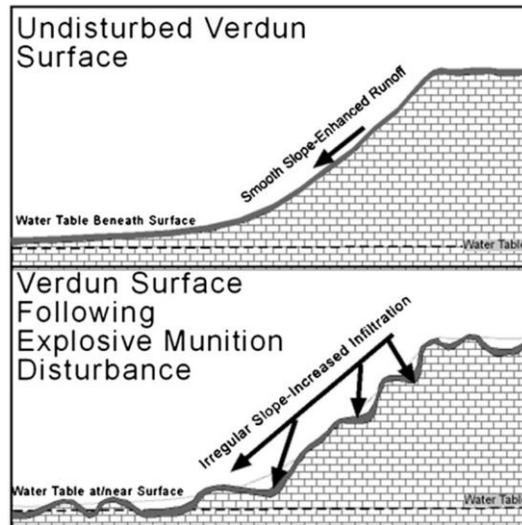


Fig. 6. Generalized diagram illustrating the impact of bombturbative activities on slope hydrology and, subsequently weathering and soil development.

Source: Joseph P. Hupy and Thomas Koehler, "Modern warfare as a significant form of zoogeomorphic disturbance upon the landscape," *Geomorphology* 157-158 (2012): 175.

Figure 4



Source: reddit.com, January 11, 2015, <http://i.imgur.com/HvAy67I.jpg>.

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