Nature's Tragic Role at the Alpine Front during World War I
The Consequences

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Abstract: During the First World War, the front between the Austro-Hungarian Empire and the Italian Kingdom ran across hundreds of kilometers through the Alpine mountain range. In this geographical context, the armies had to survive in a hostile environment that abounded with fierce and relentless natural hazards. Despite the widely recognized relevant role of nature on the Alpine front, works focusing on this topic are still few. This article gathers and organizes the information found in literature concerning the impact of nature on casualties. The article further identifies the mechanisms through which natural hazards inflicted losses and evidences the necessity of quantitative data and analyses for reaching a better-supported and improved quantification and characterization of these victims. Despite the still-limited knowledge about the casualties due to natural hazards, the Alpine front represents a historical case of how the consequences of waging war in inhospitable environments go beyond the difficulties concerning fighting and how nature can cause great damage to armies.
Keywords: First World War, Alpine front, Alps, avalanches, frostbite, casualties, natural hazards

Introduction

World War I (WWI) historiography has been largely focused on the western front and strongly anchored in national frameworks.[1] This remains true despite the importance of conducting comparative and

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international studies and recent efforts in these directions.[2] Similarly, interest in the environmental history of this conflict is still sparse although there have been recent studies in this field.[3]

In this historiographical context, the efforts to understand and characterize WWI have emphasized the particular historical circumstances that set the stage for the war's apocalyptic scenarios; for example, industrial power, technological sophistication, universal male conscription, and Europe's global dominance in part through colonialism. It has almost gone unnoticed, however, that these historical circumstances determined one of the most terrible features of this war: the extension of the battlegrounds to extremely inhospitable environments. Indeed, technological sophistication and the availability of personnel and resources, among other things, allowed armies to wage war in inhospitable environments, such as mountain ranges or arid deserts, in a more stable way than in the past. Technology in particular not only allowed armies to reach remote or inaccessible areas, but it also allowed modifying and adapting these places to their needs.

Many of those who experienced this conflict understood that engaging in war in such environments was unique from a historical point of view. Christopher Thornhill, a British intelligence officer, wrote of the campaign in German East Africa, "[this] campaign was unique of its kind: the first tropical warfare waged under modern conditions of transport and armament."[4] Similarly, the General of Artillery Konrad Krafft von Dellmensingen, commander of the German Alpine Corps, said about the Alpine front that, before WWI, "no one would have ever thought that man would be able to pass the winter on the highest peaks surrounded by glaciers and defended by them, and also to fight up there."[5]

The fronts, campaigns, and theaters of war where nature turned into a terrible foe were many. The Alpine and eastern fronts, as well as the Caucasus and East Africa campaigns, represent some examples. Despite this diffusion of cases and the early recognition of their historical relevance, the history of WWI in extreme environments thus far has rarely been the focus of in-depth studies.[6] From the few studies on this topic, it is still possible to outline some of the varied and critical effects that nature had on persons, armies, and nations involved in extreme environments:

- It determined huge numbers of casualties, often larger than the ones caused by the enemy army;
- It modified the army's planning and organization, not just concerning tactical and strategical issues but also their logistical and medical systems;[7]
- It affected the combat employment of troops (e.g., concerning command, control and coordination) and the development and result of military operations;[8]
- It constrained the living conditions of the people deployed;
- It led to improvements in science and technology;

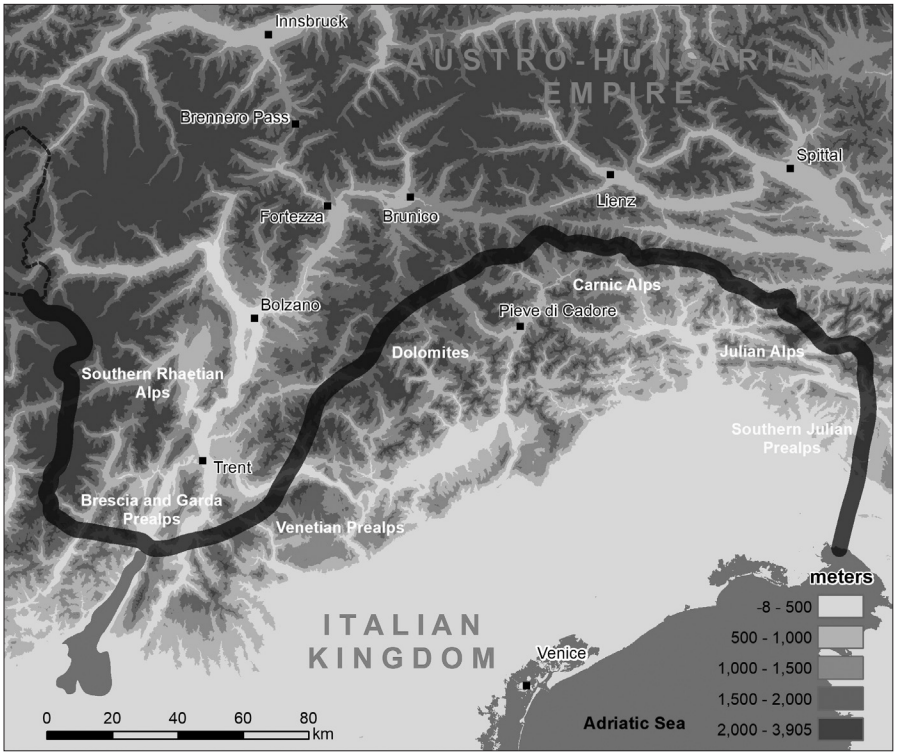
- It influenced the experience of the soldiers and subsequently the characteristics of the literature about the war;
- It shaped the memory of the war and, in some cases, even the construction of national identity;[9]
- It aroused the interest of the Italian nation for the Alps.[10]

The Alpine front could be considered one of the emblematic cases of WWI in extreme environments. Indeed, many of the hundreds of thousands of people who were deployed at that front fought and wintered in some of the highest and most inhospitable mountains in Europe. Namely, many men found themselves deployed in altitudes more than 3,000 meters above sea level, where no human being had ever set foot. The Alpine front ran across peaks, glaciers, cliffs, and valleys of the southeastern Alps, in large part along the border between Italy and Austria-Hungary. In particular, from May 1915, when Italy declared war on Austria-Hungary, the front ran from the northwestern part of the southern Rhaetian Alps to the southern Julian Prealps (figure 1). From October 1917, after the Italian defeat in the Battle of Caporetto, to November 1918, when the Armistice was signed, the front between these two countries was shortened. Thus, from the Venetian Prealps, it turned southern into the Venetian Plain. The main armies involved at the Alpine front were the Italian and the Austro-Hungarian armies. Troops of the German Empire, allied with Austria-Hungary, and of the British Empire, France, the United States, the Czechoslovak Legion, and Romanian Legion, allied with Italy, also participated in certain moments at the front.[11] The experience undergone at the Alps by some of these forces proved unique and invaluable for future wars.

The literature concerning the Alpine front presents a paradox. Probably every text underlines the central role of nature; still interest in this topic has not been adequately reflected in its historiography, as the studies that focus on this topic are few. In particular, the role of the environment was recognized as dominant in personal testimonies and memoirs that were, to varying degrees, based on individual experiences. These sources include firsthand accounts written during the war, such as diaries and letters, and works composed after the war, such as biographies, autobiographies, and narrative histories. From personal testimonies and memoirs and from their consideration and study, almost all the current knowledge on the role of the environment at the Alpine front was gained.[12]

A reason such narratives are our principal source of knowledge for this topic is primarily owing to their availability. WWI is often remembered as the literary war because of the extensive production of texts by its participants. A second reason is the amount and kind of information that these sources contain regarding natural hazards and their impacts. Natural phenomena were part of war participants' everyday lives, and thus they were a main subject considered in detail in the narrative accounts of war. According to Diego Leoni, "no diary left off to record avalanche accidents."[13] A main part of the information recorded

Figure 1. The Alpine front



The black line represents approximately the line of the front between Austria-Hungary and Italy from May 1915 to October 1917. During this period, some attacks and retreats moved parts of this front for at most a few tens of kilometers. Thus, this line is a simplified representation of the front. The black dashed line (upper left) shows the border with Switzerland.
Source: courtesy of author.

in these narratives could be referred to as factual, as it concerns specific events, places, or periods. This kind of information, which stems from personal observations or from other unknown sources (such as comrades in arms), is crucial, as it provides a remarkably wide range of aspects concerning the characteristics of natural hazards and their impacts.

An especially relevant study that considered personal testimonies and memoirs to increase the understanding about the relationship between people and nature at this front is the one of Diego Leoni. In this work, the author obtained a comprehensive picture of the characteristics of the Alpine front by focusing on the multiple aspects of the relationship of men and armies—not just with the natural environment but also with the machinery and the animals used there. In particular, Leoni compiled a significant number of personal testimonies and memoirs as well as other kinds of sources, such as songs, poems, and official records from archives. These sources included authors with different backgrounds that conducted different activities during the war, such as sol-

diers, officers, nurses, doctors, workers, etc., for both the Italian and the Austro-Hungarian armies. In this way, Leoni was able to explore the various aspects and moments of the Alpine front that he discussed from many points of view. In turn, this led him to find a more complex and detailed understanding of the front than other authors.[14]

Perhaps one of the biggest merits of Leoni's book is that it tells, probably for the first time in such a well-documented way, that for people at the Alpine front the struggle to survive natural hazards and poor health and living conditions was often on par with surviving the enemy's weapons. From this perspective, Leoni's book represents probably the most advanced knowledge of the role of nature at the Alpine front. However, not focusing only on this, the topic appears often scattered, disorganized, and not clearly illustrated inside a dense book that aims to cover almost every aspect of the life at the front. In this way, considering that this represents one of the few in-depth studies, the current knowledge of this topic remains fragmentary, unclear, and uncertain for many aspects. This is particularly true concerning the causes and consequences of the negative role of nature at the Alpine front.

In continuing the discussion on the role of nature at the Alpine front, this article aims to outline the current knowledge of the negative consequences of waging war in such an inhospitable environment. The focus is put on the most important and immediate consequences, the victims and casualties, and on other impacts that had a repercussion on these. Still, it is important to remember that the negative consequences of nature at the Alpine front could be analyzed from many other perspectives, such as the impact on military tactics and strategy.

The information considered in this article includes and integrates that presented by Leoni.[15] It concerns mainly the armies of Austria-Hungary and Italy. Because the goal of this article is to paint a general picture of the negative consequences of nature, the information of the two armies has been mostly treated indistinctly. The analysis of the collected material is organized around three sections: "The Impacts of Natural Hazards," "How Natural Hazards Contributed to Casualties," and "The Estimations on the Number of Casualties Directly Determined by Natural Hazards."

The Impacts of Natural Hazards

Natural hazards represent a distinguishing feature of mountainous areas. The elements and processes corresponding to the different natural components (e.g., geological, hydrological, meteorological, and vegetational) and the relationship between them determine hostile conditions that often lead to death, injury, and missing persons. For example, meteorological elements (e.g., air temperature, pressure, solar radiation, wind, precipitation, and humidity) and particular meteorological phenomena (e.g., thermal inversion, breezes, and storms) in mountains determine cold and wind chill that lead to frostbites and hypothermia; lightning that electrocutes; wind pressure that blows people off-balance, leading

to falls; and exposure to ultraviolet radiation that leads to ophthalmia (inflammation of the eye).[16]

Avalanches, the sudden and rapid downslope movement of masses of snow, are the most widespread and common hazardous processes in high mountains.[17] At the Alpine front, avalanches and cold were the most devastating natural hazards. The majority of the victims were soldiers, which represented the principal portion of the persons at the front. However, there were also many civilian victims who were working at the front, for example, building roads or as carriers for the supply of higher positions. In addition, there were many animal casualties, including livestock, that occupied a particular role in the transportation of things due to their strength, resistance, and adaptation to cold and mountain topography (e.g., mules, horses, and dogs).

Besides the human and animal victims, nature inflicted damage to material things, particularly weapons, roads, military huts, military storages, field hospitals, hotels, dairies, farms, telegraph and telephone lines, and cableways. Leopold Pistoja, a soldier at the front, provided an example of this ravage caused by avalanches and snow precipitation: "In the winter 1916/1917 we had to shovel the installation of the cableway 30 times and to repair it a dozen times."[18]

The human and animal casualties and damage to the essential infrastructure and natural resources (e.g., forests and water springs) had great repercussion on many aspects concerning the front. From this point of view, nature had great influence on, for example, military planning, the outcome of military operations, and the logistics and health systems of the armies.

How Natural Hazards Contributed to Casualties

Natural hazards were one of the three main causes that determined casualties at the Alpine front, together with military actions and illnesses. In addition, natural hazards also contributed indirectly to many of the casualties in the Alpine front through at least two levels of influence. At the first level, nature significantly influenced the battlefield settings and the health and living conditions, both crucial aspects in the determination of casualties. In turn, at the second level of influence on the number and kind of casualties, alpine nature negatively affected those military aspects specifically responsible for providing adequate health and living conditions: logistics and health systems.

Direct Influence of Natural Hazards on Casualties

Some of the casualties directly determined by mountain environments that are named in literature are casualties due to avalanches, landslides and lightning, those crushed inside huts under the weight of snow, those fallen along the sides of the mountains and into the precipices, and those who suffered from frostbite and hypothermia.[19] Many also were lost and resulted in missing or dead when moving through forests, fog, storms, nighttime, or whiteouts.[20] In the Pasubio Mount, hundreds of carriers were lost in the fog and went missing.[21]

Another direct impact of natural hazards that is important to consider are

psychological damages. In all the fronts of war, these were largely related to military causes and to the health and living conditions of the soldiers. However, at the Alpine front, nature also seemingly represented a major factor of their origin. In literature, there is neither any historical medical report nor specific study that considers this impact of mountain nature. Still there are several sources, for example those cited by Leoni, which mentioned the relevance of nature for the determination of actual mental illnesses and of mental states that could lead to mental illnesses.[22] Fritz Weber mentioned the occurrence of depression and considered that some mental states originated by the environmental context at the front were "very similar to a mental illness."[23] More recently, Alessandro Massignani also considered the presence of depression among those living at the Alpine front due to environmental conditions and Leoni also mentioned the presence of "melancholic depression."[24] Anxiety disorders may have also determined casualties. However, whether doctors and military authorities considered these eventual cases of psychological damages due to the environmental conditions as casualties is unknown.

The last kind of direct casualty by natural hazards to consider, even if its main component was voluntary, are those of self-harm. According to witnesses, many soldiers decided to suffer frostbite to avoid war.[25]

Concerning the distribution of these casualties, Alessio Fornasin, Marco Breschi, and Matteo Manfredini, who studied the mortality among Italian soldiers during WWI, stated that "the soldiers of the corps used in the front line experienced the highest death risks for all causes."[26] The highest death risk at the front line was associated with the fighting and the poor health and living conditions as well as to the frequently hostile environment.[27] Indeed, often the front line corresponded to highly exposed areas to natural hazards, such as places at high elevation characterized by freezing conditions. Conversely, the army rear, which more largely developed in valleys and plains, benefited in general from better environmental conditions.

Other important variables concerning the distribution of the casualties due to natural hazards, besides the spatial location, were the season and the kind of activity that the persons conducted. Carriers of supplies and outdoor workers of any kind, shoveling snow, building roads, etc., were among those with higher exposure to natural hazards. According to Weber, in winter, the casualties of carriers and workers were higher than other groups.[28]

First Level of Indirect Influence of Natural Hazards on Casualties

Nature highly affected two main aspects at a first level of indirect influence on casualties. First were the battle conditions, which in turn led to casualties in military action. This occurred in many ways, most of which can be traced back to the terrain. For example, the slope determined very difficult trafficability conditions for attackers and the exposure of the bedrock determined a deadlier artillery effect.[29] Both of these battle conditions increased the rates of injury.[30]

A second main aspect that was significantly affected by nature were the

health and living conditions of the persons at the front. These conditions were often poor, and therefore they were the basis of the risk associated with each of the main kinds of direct factors determining casualties (i.e., military actions, illnesses, and natural hazards). From this point of view, because it affected health and living conditions, alpine nature influenced the rate of every kind of casualty indirectly but significantly. As an example of this indirect influence on casualties due to illnesses, consider the case of pneumonia, which was diffused at the Alpine front: the incidence of this illness could have been in many instances lower with less crowed shelters, which were in part determined by the rugged topography, and with stronger immune systems of the people, on which the alpine weather had adverse effects. Poor health and living conditions determined by alpine nature also led to casualties due to natural hazards. For example, frostbite was determined by low temperatures, the natural hazard, but also by poor health and living conditions. A document released on 12 December 1915 by the Health Section of the Logistical High Command (*Sezione sanitaria dell'Intendenza generale*) of the Italian Army acknowledged the importance of such conditions that resulted in frostbite. Some of these were at least in part due to alpine nature, such as the nutritional and physical state of the individual, inability to move freely, and the humidity of clothes, mainly footwear.[31]

Leoni provided a detailed description of the health and living conditions at the front.[32] Most of them were also largely present in the other fronts of WWI. These conditions included thirst; hunger; malnutrition; cold; poor personal hygiene; sleep deprivation; strenuous mental and physical efforts; uncomfortable, overcrowded and unhygienic barracks with bad insulation; inadequate burial of dead bodies that determined psychological stress and dangerous hygienic conditions; and the presence of infectious illnesses and rats, lice, fleas, and other parasites and disease vectors. These conditions had a wide variation in time and space inside the Alpine front. The worst was likely suffered by soldiers at the front line and by the Russian and Serbian prisoners of the Austro-Hungarian Army, who were mainly used as workers and carriers.[33]

Soldiers also had to face terrible conditions during military actions, which prevented almost any protection from weather conditions and required great physical exertion. For example, this was the case of an attack to Mount Cardinal launched by a battalion in the summer 1916. Second Lieutenant Angelo Maranesi reported that more than the violence of the battle, it was the effort and the weather that broke the physical resistance of the men. Indeed, the battalion registered in 10 days, in addition to 10 deaths and 50 injured, about 267 sick due to the terrible health and living conditions.[34]

Nature contributed in many ways to the poor health and living conditions present at the Alpine front. One can assume that in general this effect was more adverse on the positions along the sides of the mountains and on their peaks, where the environment was more hostile, rather than in the valleys. The impact of nature on the health and living conditions included:

- Temperature, humidity, wind, slope direction, clouds, and vegetation, which contributed to excess cold and heat;
- The limitations of resources, which contributed to many deprivations.[35] In particular, the insufficient amount of water springs represented a serious problem for drinking, hygienic practices, cooking, and performing some works in many parts of the front.[36] In addition to its limited presence, many of the water sources became polluted during the war, due to the putrefaction of dead bodies and the presence of human waste and of toxic chemical substances that resulted from explosions.[37] Particularly during the summer, when most of the snow had melted, the lack of water was considered a main cause of casualties in some cases. According to Heinz Von Lichem, there were deaths from dehydration in Monte Zugna and in the Pasubio Mount;[38]
- Rugged topography, which limited the potential space for building. This contributed to overcrowded camps and barracks;
- Avalanches and other natural phenomena, which produced cold or fear of an eventual imminent accident, contributing to sleep deprivation;
- Taxing physical and mental activities. Moving required significant exertion due to, for example, slopes, snow, wind, and the fact that people had to carry heavy weight because, mainly in high and rugged places, a large part of the transport of materials for living and fighting had to be done by them.[39] Digging trenches, caves, and tunnels in rock and ice, shoveling snow continuously during the cold season, restoring weapons, telephone and telegraph lines, cableways, and other infrastructure frequently destroyed by weather and avalanches were some of the many other ways through which alpine nature required huge exertions;[40]
- Moods, feelings, and mental states were affected negatively due to the alpine climate. Concerning this impact of the environment, Weber referred to restlessness, agitation, desperation, oppression, anxiety, upheaval of the nervous system, and apathy among the persons at the front.[41] In particular, topography and weather contributed to periods of social isolation, precluding contacts with different or larger groups of persons and with civil society and relatives. This happened, for example, when the movement between different positions was impossible or when letters and news did not reach certain sectors of the front. These living conditions highly affected the troops sense of sadness, loneliness, and melancholy. Similar outcomes also created long periods of inactivity and restriction of move-

ments caused by inclement weather. Moreover, the frequent natural hazards represented a continuous threat that "upset the nervous system" and increased the sense of precariousness and uncertainty.[42] These conditions particularly affected those who were not used to mountain weather.

The first consequence of the presence of such health and living conditions was a varied range of largely widespread and enduring psychological and physical disorders and states present along the entire front. After his study of literature, Leoni registered among these disorders and states: weight loss, cough, exhaustion, depression of the immune system, dereliction, desolation, despair, drowsiness, and misery.[43]

These psychological and physical disorders and states could disappear at some point or could develop into casualties caused by military actions and natural hazards. Another possible line of development entailed that these disorders and states were actually signs and symptoms of illnesses and therefore led to casualties of this kind. Many of the illnesses at the Alpine front were present also at other ones (e.g., malaria, typhus, meningitis, tuberculosis, scabies, ringworm, diphtheria, enteritis, cholera, and scurvy). The health and living conditions determined by the environment played an important role on their diffusion. This role was probably even more important and specific in the diffusion of the illnesses that were prevalent at the Alpine front, including rheumatic pathologies and diseases that were related to the respiratory system and of the illnesses that were characteristic of this front—a kind of cardiac pathology and the nephritis caused by cold.[44]

Second Level of Indirect Influence of Natural Hazards on Casualties

Health and living conditions were determined not only by nature but also by human factors. A crucial aspect affecting the health and living conditions in the Alpine front was the logistic system of the armies.[45] In general, logistics was more inadequate in the Italian Army than in the Austro-Hungarian, particularly at the beginning of the conflict.[46] Still, it represented a great problem for everyone (including the German Alpine Corps while operating at the front from May to October 1915).[47] The deficiencies of the logistics reflected not just on the health and living conditions of the people but also, crucially, on the great discrepancies between the aims and efforts of the armies and the results of the military operations that they conducted.

As for the health and living conditions, the efficiency of the logistic system was also affected by both human and natural factors. The human ones regarded the intrinsic malfunction of the armies and states and the factual or potential offenses of the enemy. Natural elements and processes represented difficulties such as:

- Slope, vegetation, kind of surface of the ground, presence of ice on the ground, hydrography, and weather created diffi-

culties moving.[48] Indeed, it was reported that some positions reached 25 days of total isolation and some others more than a month.[49] The impact of nature on transport occurred at almost every step of the supply chain in the Alps, from the snow that stopped the trains circulating along the valleys to the avalanches that engulfed the carriers and struck cableways supplying the higher positions. Weber reported on streets and paths that were impassable for seven months;[50]

- Rugged topography, landslides, avalanches, and hydrography, which caused difficulties and lack of potential space for construction. This contributed to a shortage of adequate roads, paths, and storehouses. The difficulty constructing roads was represented, for example, by the need of the armies to build bridges over streams or dig tunnels inside mountains but also by the low temperatures and avalanches that workers had to suffer;
- Limited resources and hostile weather, which contributed to a high demand and strong dependency of the armies on the supplies coming from the plains. This led often to an overload of the logistics system.

The larger negative effect of nature on these aspects of the logistic system were present in general in the last part of the logistics chain, namely at the higher locations. There, in general, the topography was more rugged and the atmospheric conditions worse. The support provided by technology, such as through the creation of numerous cableways, was essential but still rarely allowed to completely compensate those disadvantages for the logistic system at the higher areas.

Another issue that had great impact on the health and living conditions of the persons at the front was the health system of the armies. This was important for the armies because, beyond the health and living conditions, it also directly influenced the incidence of the direct factors determining casualties (i.e., military actions, illnesses, and natural hazards) in a substantial way. Leoni provided a good description of the health systems of the armies and the great difficulties that caused disadvantages.[51] Among these difficulties, natural features of the mountain environment played an important role in the following ways:

- Slope, vegetation, kind of surface, presence of ice on the ground, hydrography, and weather, which contributed enormously to the difficulty to move. This led to the inefficiency of the transportation of the injured, materials, and personnel by making them extremely arduous and slow. Moreover, the difficulty moving, combined with the dangerous environmental conditions at high altitudes, required specialized personnel and physical suitability.[52]
- Rugged topography, landslides, avalanches, and hydrography,

> which contributed to an insufficient presence of infrastructure due to the lack of potential space and the difficulty to build it. In particular, the inadequate amount, quality, size, and location of health facilities resulted mainly in a fragmentation of the means and personnel and in a marked inadequacy of the health service at high altitudes.

As for logistics, in general, the negative effects of nature increased with the altitude due to the generally more rugged topography and the worse atmospheric conditions. The main problem at higher elevations was the inadequate amount and quality of the health facilities and personnel, which entailed the development of a complex system greatly dependent on the facilities and personnel at lower altitudes. In this way, the entire health system in general and in particular injured people were doomed to rely largely on the very difficult and slow transportation. This circumstance was particularly challenging considering that the front line of each army, namely, the place where the highest concentration of casualties occurred, often was located at high altitudes.[53] Moreover, in the case of front lines at high altitudes, the enemy created severe difficulties to provide adequate first aid for injured people concurrently with the harsh environment.[54]

The Estimations on the Number of Casualties Directly Determined by Natural Hazards

Documenting war casualties is a general problem for statisticians and historians. In Italy, for example, the discussion on the total number of casualties during WWI is still ongoing. Recently, historians reached new counts on the total number of casualties, including the death of prisoners, death due to influenza, and disability.[55]

In the literature of the war, there are some estimations on the total number of casualties in the Alpine front due to environmental factors (table 1). These estimations present four characteristics: 1) focus on avalanches and disregard other natural hazards; 2) tend to be for both armies together; 3) differ greatly with a wide range between the lowest and highest values; and 4) are not based on any published research.

Many historians and novelists repeated the estimations that were published by other authors or did not indicate the sources at the origin of the estimations that they proposed clearly. Walther Flaig and Lichem based their estimations on the reports of commanders that survived the war and on the testimony of soldiers.[56] However, they neither provided any detailed information of their research methodology nor on their sources.

Some sources, such as the Commission for the History of the Alpine Troops and Lichem, wanting to highlight the central importance of natural hazards in the determination of casualties, considered nature-related casualties in relation to those due to military actions and to the total amount of the casualties at the

Table 1. Casualty estimations due to natural hazards at the Alpine front within existing literature

Author, year	Number of casualties	Area	Period
Weber, 1935	Approximately 20,000 killed by avalanches	Whole front	1917
Flaig, 1955	A minimum of 40,000–50,000 killed by avalanches. The average between different estimations is 60,000 killed by avalanches	Whole front	Entire war
Fraser, 1970 (these estimations were proposed also by Roch, 1980)	40,000–80,000 killed by avalanches	Whole front	Entire war
Lichem, 1974 (these estimations were proposed also by Angetter, 1995)	At least 60,000 killed by avalanches. Around 100,000 killed by all the factors related to mountainous environment	Whole front	Entire war
E. Capello, 1968	30,000 killed by avalanches	Whole front	Entire war
Hämmerle, 2014	At least 10,000 killed by avalanches	Dolomites	Entire war

Sources: Weber, Alpenkrieg*; Flaig, Lawinen; Colon Fraser,* L'enigma Delle Valanghe *(Bologna, Italy: Zanichelli, 1970); Andrè Roch,* Neve e Valanghe: Struttura e Origine Delle Valanghe, Le Opere Di Soccorso*;* Tecnologia Della Protezione Contro Le Valanghe *(Milan, Italy: CAI, 1980); Lichem,* Der Einsame Krieg*; Daniela Claudia Angetter, "Dem Tod Geweiht Und Doch Gerettet: Die Sanitätsversorgung Am Isonzo Und in Den Dolomiten 1915–1918," in* Beiträge Zur Neueren Geschichte Österreichs*, ed. Bertrand-Michael Buchmann (Vienna: Lang, 1995), 258; Elena Capello, "Atlante Delle Valanghe Delle Alpi Orientali Italiane. Nel Periodo 1915–1919,"* Pubblicazioni Dell'Istituto Di Geografia Alpina *10, no. 4 (1968); and Christa Hämmerle, "Eroi Sacrificati? Soldati Austro-Ungarici Sul Fronte Sud," in* La Guerra Italo-Austriaca (1915–1918)*, ed. Nicola Labanca and Oswald Überegger (Bologna, Italy: Il Mulino, 2014).*

Alpine front. However, the absence of any data based on a systematic method casts doubts on these findings. For instance, the Commission for the History of the Alpine Troops stated that during the winter of 1915–16, avalanches caused casualties on both the Austro-Hungarian and the Italian armies that in some

cases were equal to the average of those that did not happen in battles due to the winter stasis.[57] According to Lichem, just one-third of the total amount of casualties in the Alpine front were due to the fights against the enemy—the rest were caused by the alpine environment.[58]

In literature, the only estimation of casualties that considered natural hazards other than avalanches is Lichem.[59] He estimated 100,000 dead on the Alpine front due to all the factors linked to the mountainous environment. The most significant absence of any estimation concerns the casualties due to hypothermia, frostbite, and deprivation caused by cold and humidity. Many publications on the Alpine front referred to the relevant number of cases of hypothermia and frostbite, although, as Alessandro Massignani noted, these have been rarely studied.[60] Leoni gathered some of these references from personal testimonies and memoirs, giving clear proof that frostbite at the Alpine front was abundant throughout the conflict.[61]

In 1915, 60 percent of the Italian soldiers in some sectors were moved away from the front due to frostbite.[62] Those sectors included Mount Adamello, where hundreds of frostbite cases per day in November 1915 occurred according to Italian lieutenant Gualtiero Castellini.[63] One year after the beginning of the conflict, frostbite was still a major problem. During the spring of 1916, Austria-Hungary launched a major attack (the Trentino Offensive, 15 May–10 June 1916) that had a relevant impact on the number of frostbites. For example, the Italian 1st Army had 2,868 cases of frostbite between May and July 1916 and 1,411 of these required hospitalization.[64] On 19 November 1916, the chief of staff of the Italian Army, General Luigi Cadorna, wrote to the chief of the Logistical High Command: "The number of cases of frostbite occurred already at this point of the season is a certain indicator that the measures devised and adopted by the Health Office of this High Command are at least inadequate to the real needs."[65] During the winter of 1916–17, Weber reported that at the Pasubio Mount a new fatality occurred daily mainly as a result of hypothermia or of falling in the crevices of the mountain.[66] On 28 February 1917, Lieutenant Felix Hecht noted in his diary: "almost one third of the company suffers from frostbites and coughs tremendously."[67] In November 1917, a British liaison officer on Mount Grappa reported that the men in trenches were weeping—some with ice on their faces—and that "the conducting officer said that three or four of them were freezing to death nightly."[68]

Discussion

Almost all the current knowledge on the negative consequences of alpine nature during WWI relies on personal testimonies and memoirs. An advantage of this kind of sources is that it facilitates an effective comprehension of the tragedy represented by these consequences, mainly due to the narrative form and the emotional and fairly detailed information contained. On the contrary, its disadvantage is represented by the difficulty to collect, analyze, and generalize this information, which is scattered across a vast number of sources, is rarely treated

specifically inside the texts, concerns locally and temporally limited events, is extremely heterogeneous, is sometimes imprecise, and is difficult to distinguish between its objectiveness and subjectiveness.

Leoni's work is unique among the publications on the Alpine front, extracting relevant information on the impact of nature from personal testimonies and memoirs.[69] The amount of this information as well as the selection and contextualization that he presented allowed him to generalize about the features of the front. Occasionally, Leoni supported the information taken from personal testimonies and memoirs with statistics and information for large military units and areas of the front, which he extracted from historical official reports. Although it is important to note that Leoni represents one of the few works that considered historical material with statistics and information for large parts of the front for characterizing the impact of nature, it appears clear that a greater use of this information would be beneficial for the study of this topic. In particular, more quantitative information on casualties, living conditions, and the health and logistics systems would support the generalizations from the testimonies better.

In spite of this limit, the remarkable work of Leoni represents the most advanced, complete, and detailed knowledge of the relationship between men and armies with nature at the Alpine front.[70] Thus, Leoni's work was a main reference on this topic in this article. In particular, this article offers a general idea of the influences of alpine hazards on the history of the front and a model for understanding how nature contributed to casualties. Regarding the ways nature contributed to casualties, many authors recognized the importance of the indirect impact of natural hazards on casualties.[71] However, focusing on and developing this perspective led to a clearer identification of the mechanisms through which natural hazards acted. In particular, the indirect contribution of nature to casualties was based on its role in the determination of the battlefield settings, the health and living conditions, and the logistic and health systems. In addition, this article exposed the limited knowledge and well-supported information in the existing literature about the psychological damages that nature inflicted and the related casualties.

Another weak aspect in the current knowledge on the negative impacts of nature at the Alpine front concerns the distribution of these impacts regarding different variables, such as time, space, kind of impact, type of victims, etc. Fornasin, Breschi, and Manfredini hold that, in the Italian Army, "the soldiers of the corps used in the front line experienced the highest death risks for all causes."[72] As the front line represented often harsher topography and weather compared to the rear, it is highly possible that nature together with the proximity of the enemy had a major influence on higher death rates at the front lines. In addition, according to Weber, the casualties of carriers and workers were higher than other groups in winter.[73] This differential casualty rate according to victim's activities and the season of the year is ascribed at least in large part to the extreme weather.

One of the greatest uncertainties in the literature about the consequences of nature's role at the Alpine front concerns the quantity of casualties determined by natural hazards. The earlier discussion covered the inadequacies of the estimations in literature about the numbers of casualties given that these estimations focused on avalanches and disregarded other natural hazards, considered both armies together, differed greatly between them, and were not based on published research.

These problems in the current knowledge about the number of casualties and the others, mentioned above, about other aspects of the consequences of nature's role at the Alpine front may have a similar reason: the almost complete lack of use of historical statistics and quantitative information in the literature that have regarded this topic. During the war, relevant quantitative information on nature and its negative impacts could be produced only by the armies, which controlled and monitored all aspects of the war. The official WWI histories of Austria and Italy provide some evidence of this. Indeed, sparse information about numbers of casualties due to natural hazards concerning specific periods, parts of the front, or operational formations are available in these works.[74] A clear example that even the largest operational formations kept accounts of avalanche victims and reported them comes from a telegram of General Cadorna on 13 March 1916, which says "avalanches rage so much that for the day 11 [11 March 1916], over 700 victims are counted although it is still missing data concerning the 2nd Army."[75]

The Italian Army's High Command included the Meteorological Section, which was responsible for the study of the weather and its relationships with the needs of the army. This office collected thousands of reports on avalanches that occurred at the front.[76] However, the analysis of these reports was never published and the reports themselves are not publicly available. Besides these reports, other information produced by this section was published during the war, mainly for the prevention and management of the risk associated with these hazards. Carlo Capello studied these publications of the Meteorological Section of the Italian Army.[77]

In conclusion, considering the lack of quantitative information, the estimations on the number of casualties currently present in the literature were the only way to fill the gap between the narratives, which have rightly emphasized the relevance of the negative consequences of natural hazards and the necessity of numbers for characterizing these consequences better. Nevertheless, authors cannot continue to rely solely on estimations that are not supported by any published research. This article reaffirms the relevance of the topic and the necessity of quantitative data and analyses concerning large parts of the front. In particular, historical or current statistics would be essential for supporting the generalizations obtained so far from the personal testimonies and memoirs. Moreover, quantitative data and analyses are needed to conduct a better characterization of the impacts of nature on the front. Specifically, this need concerns: 1) the magnitude of these impacts particularly the number of casualties, 2) the

distribution of these impacts according to different variables (e.g., time, space, kind of impact, kind of victims, etc.), and 3) a comparison of these impacts between the Italian and the Austro-Hungarian armies.

It appears clear in this article, even with the current limitations in the knowledge of casualties caused by natural hazards, that the relevance of nature in warfare can exceed its constraining effect on planning and applying tactics and strategies. In extreme environments such as that of the Alpine front, the challenge of fighting due to the difficulties to move and to communicate, for example, could become secondary when considering nature's injurious potential.

Endnotes

1. Ross Anderson, *The Forgotten Front: The East African Campaign, 1914–1918* (Stroud, UK: Tempus Publishing, 2004); Altay Atlı, "Baptism by Snow: The Ottoman Experience of Winter Warfare During the First World War," in *Other Fronts, Other Wars?*, ed. Joachim Bürgschwentner, Matthias Egger, and Gunda Barth-Scalmani (Leiden, Netherlands: Brill, 2014), https://doi.org/10.1163/9789004279513_005; Gunda Barth-Scalmani, "The Memory Landscape of the South-Western Front: Cultural Legacy, Promotion of Tourism, or European Heritage?," in *Other Fronts, Other Wars?*, https://doi.org/10.1163/9789004279513_022; R. J. B. Bosworth, "Review of *The Italian Army and the First World War*, by John Gooch," *English Historical Review* 130, no. 547 (2015): 1591–92, https://doi.org/10.1093/ehr/cev277; Joachim Bürgschwentner, Matthias Egger, and Gunda Barth-Scalmani, "Introduction: Approaching the Centenary, 1914–2014," in *Other Fronts, Other Wars?*, https://doi.org/https://doi.org/10.1163/9789004279513_002; John Gooch, *The Italian Army and the First World War* (Cambridge, UK: Cambridge University Press, 2014), https://doi.org/10.1017/CBO9781139042956; Jörn Leonhard, *Die Büchse Der Pandora: Geschichte Des Ersten Weltkriegs* (Munich, Germany: Beck, 2014); and Olivier Compagnon and Pierre Purseigle, "Geographies of Mobilization and Territories of Belligerence during the First World War," *Annales. Histoire, Sciences Sociales* (English ed.) 71, no. 1 (2016): 37–60, https://doi.org/10.1017/S2398568217000024.
2. Hew Strachan, "Towards a Comparative History of World War I. Some Reflexions," *Militaergeschichtliche Zeitschrift* 67, no. 2 (2008): 339–44, https://doi.org/10.1524/mgzs.2008.67.2.339. Also see, for example, Bürgschwentner, Egger, and Barth-Scalmani, "Introduction"; Hew Strachan, ed., *The Oxford Illustrated History of the First World War* (Oxford, UK: Oxford University Press, 2014); and Richard P. Tucker et al., eds., *Environmental Histories of the First World War* (Cambridge, UK: Cambridge University Press, 2018), https://doi.org/10.1017/9781108554237.
3. Tait Keller, "Mobilizing Nature for the First World War," in *Environmental Histories of the First World War*, 1–16, https://doi.org/10.1017/9781108554237.001; Shawn M. Reagin, "The First World War on the Periphery: The Effect of the Environment on British Soldiers in German East Africa, 1914–1918," *Scientia Militaria* 46, no. 2 (January 2018), https://doi.org/10.5787/46-2-1203. Also, see for example, Bürgschwentner, Egger, and Barth-Scalmani, eds., *Other Fronts, Other Wars?*, https://doi.org/10.1163/9789004279513; Selena Daly, Martina Salvante, and Vanda Wilcox, eds., *Landscapes of the First World War* (Cham, Switzerland: Springer International, 2018), https://doi.org/10.1007/978-3-319-89411-9; Frank Jacob and Sarah K. Danielsson, eds., *War and Geography* (Leiden, Netherlands: Brill, 2017), https://doi.org/10.30965/9783657783779; and Tucker et al., *Environmental History of the First World War*.
4. Reagin, "The First World War on the Periphery," 35.
5. Gunther Langes, *Guerra Fra Rocce e Ghiacci: La Guerra Mondiale 1914–1918 in Alta Montagna* (Bolzano, Italy: Athesia, 1981), 14.

6. There are a few exceptions, including Reagin, "The First World War on the Periphery," who focused on the East Africa campaign; Atlı, "Baptism by Snow," who concentrated on the Caucasian and Galician front; and Diego Leoni, *La Guerra Verticale: Uomini, Animali e Macchine Sul Fronte Di Montagna 1915–1918* (Torino, Italy: Einaudi Storia, 2015), who studied the Alpine front.
7. Mauricio Nicolas Vergara, Aldino Bondesan, and Francesco Ferrarese, "GIS Analysis of the Trafficability Determined by Slope in the Eastern Tyrol Front (WWI, Eastern Alps): A Military History Reading," *Cartography and Geographic Information Science* 45, no. 6 (2018): 477–94, https://doi.org/10.1080/15230406.2017.1399828; and Mauricio Nicolas Vergara and Aldino Bondesan, "The Cadore Offensive: Theoretical Military Geography Considerations," in *Military Geoscience: Bridging History to Current Operations*, ed. Peter L. Guth (Cham, Switzerland: Springer, 2020), 67–83, https://doi.org/https://doi.org/10.1007/978-3-030-32173-4.
8. Vergara, Bondesan, and Ferrarese, "GIS Analysis of the Trafficability Determined by Slope in the Eastern Tyrol Front (WWI, Eastern Alps)"; Mauricio Nicolas Vergara et al., "The Geomorphological Constraints of the Italian/Austro-Hungarian Front in the Dolomites during the First World War," *Geografia Fisica e Dinamica Quaternaria* 43, no. 1 (2020): 167–90.
9. Marco Armiero, *Le Montagne Della Patria. Natura e Nazione Nella Storia d'Italia. Secoli XIX e XX* (Torino, Italy: Einaudi Storia, 2013).
10. Armiero, *Le Montagne Della Patria*.
11. *American Armies and Battlefields in Europe* (Washington, DC: U.S. Army Center of Military History, 1992).
12. See, for example, Leoni, *La Guerra Verticale*; and Heinz Von Lichem, *Guerra in Solitudine: Prima Documentazione Complessiva Della Guerra in Montagna 1915–1918 Dalle Alpi Giulie Al Passo Dello Stelvio* (Bolzano, Italy: Athesia, 1996).
13. Leoni, *La Guerra Verticale*.
14. Leoni, *La Guerra Verticale*.
15. Leoni, *La Guerra Verticale*.
16. Stefano Micheletti, Gianni Marigo, and Renata Pelosini, *Meteorologia Alpina* (Trento, Italy: AINEVA, 2010).
17. James S. Gardner, Robert W. Rhoades, and Christoph Stadel, "People in the Mountains," in *Mountain Geography: Physical and Human Dimensions*, ed. Martin F. Price et al. (Berkeley: University of California Press, 2013), https://doi.org/10.1525/9780520956971-014.
18. See Heinz Von Lichem, *La Guerra in Montagna, 1915–1918*, vol. 1 (Bolzano, Italy: Athesia, 1991).
19. Antonio Berti, *Guerra in Ampezzo e Cadore*, *1915–1917* (Milan, Italy: Mursia, 1996); Leoni, *La Guerra Verticale*; Heinz Von Lichem, *Der Einsame Krieg: Erste Gesamtdokumentation Des Gebirgskrieges 1915–1918 von Den Julischen Alpen Bis Zum Stilfser Joch* (Munich, Germany: Athesia, 1974); Lichem, *La Guerra in Montagna*; Alessandro Massignani, "La Guerra Combattuta in Trentino," in *Annali, n. 17–22, 2009–2014* (Rovereto, Italy: Museo storico italiano della guerra, 2015), 418; and Fritz Weber, *Tappe Della Disfatta* (Milan, Italy: Mursia, 1965).
20. See, for example, Walther Schaumann, *La Grande Guerra 1915–1918. Storia e Itinerari. Dolomiti Occidentali: Val Di Fanes, Tofane, Marmolada, Falzarego, Col Di Lana, Passo S. Pellegrino*, vol. 2 (Bassano del Grappa, Italy: Ghedina & Tassotti, 1984).
21. Weber, *Tappe Della Disfatta*.
22. Leoni, *La Guerra Verticale*.
23. Weber, *Tappe Della Disfatta*, 92.
24. Massignani, "La Guerra Combattuta in Trentino"; and Leoni, *La Guerra Verticale*, 171.
25. Leoni, *La Guerra Verticale*.
26. Alessio Fornasin, Marco Breschi, and Matteo Manfredini, "Deaths and Survivors in War: The Italian Soldiers in WWI," *Demographic Research* 40, no. 22 (2019): 599–626, https://doi.org/10.4054/DemRes.2019.40.22.
27. Fornasin, Breschi, and Manfredini, "Deaths and Survivors in War."

28. Weber, *Tappe Della Disfatta*.
29. Vergara, Bondesan, and Ferrarese, "GIS Analysis of the Trafficability Determined by Slope in the Eastern Tyrol Front (WWI, Eastern Alps)."
30. Leoni, *La Guerra Verticale*. Chapter 7 provides more details of the importance of natural features for battles at the Alpine front.
31. Direzione generale dei servizi logistici ed amministrativi Ministero della guerra, "Provvedimenti per La Campagna Invernale 1915–1916" (Rome: Ufficio Storico dello Stato Maggiore dell'Esercito, n.d.), F1/183/6. See Leoni, *La Guerra Verticale*, 161.
32. Leoni, *La Guerra Verticale*.
33. See Fornasin, Breschi, and Manfredini, "Deaths and Survivors in War"; and Leoni, *La Guerra Verticale*.
34. Angelo Maranesi, "Ricordi Di Guerra: Con Gli Alpini in Valsugana (Dicembre 1915–Giugno 1916)," *Italia Augusta*, July 1927. See Leoni, *La Guerra Verticale*, 188. It can be deduced from the source that the deaths and casualties were due to military actions, while the sick were likely due to the vulnerability of the troops to weather.
35. Luigi Nava, *Operazioni Militari Della 4. Armata Nei Primi Quattro Mesi Della Campagna Di Guerra 1915* (Cherasco, Italy: Raselli, 1922); and Leoni, *La Guerra Verticale.*
36. Leoni, *La Guerra Verticale*.
37. Leoni, *La Guerra Verticale*.
38. Heinz Von Lichem, *La Guerra in Montagna, 1915–1918: Il Fronte Trentino e Dolomitico Da Rovereto a Passo Monte Croce Comelico*, vol. 2 (Bolzano, Italy: Athesia, 1993).
39. Leoni, *La Guerra Verticale*.
40. For more detailed information about these efforts see, for example, Leoni, *La Guerra Verticale*, 128, 142.
41. Fritz Weber, *Alpenkrieg* (Vienna: Köllisch, 1935); and Weber, *Tappe Della Disfatta*.
42. Weber, *Tappe Della Disfatta*.
43. Leoni, *La Guerra Verticale*.
44. See Leoni, *La Guerra Verticale*, 189, for more information about illnesses characteristic of the Alpine front.
45. For a good description of the logistic system of the armies and its relevance, see Leoni, *La Guerra Verticale*, chap. 8.
46. Leoni, *La Guerra Verticale*.
47. Leoni, *La Guerra Verticale*.
48. For more information, see Leoni, *La Guerra Verticale*; and Weber, *Alpenkrieg*.
49. Berti, *Guerra in Ampezzo e Cadore*; and Luigi Cadorna, "La Seconda Campagna Invernale" (Rome: Ufficio Storico dello Stato Maggiore dell'Esercito, 1917), Fondo L-3, Busta 42.
50. Weber, *Tappe Della Disfatta*.
51. Leoni, *La Guerra Verticale*.
52. Leoni, *La Guerra Verticale*.
53. Fornasin, Breschi, and Manfredini, "Deaths and Survivors in War."
54. Leoni, *La Guerra Verticale*.
55. Alessio Fornasin, "The Italian Army's Losses in the First World War," *Population* 72, no. 1 (2017), https://doi.org/10.3917/popu.1701.0039; P. Scolè, "I Morti," in *Dizionario Storico Della Prima Guerra Mondiale*, ed. Nicola Labanca (Rome-Bari, Italy: Laterza, 2014); Alessio Fornasin, "Quanti Soldati Italiani Morirono in Prigionia Nella Prima Guerra Mondiale?," *Contemporanea* 21, no. 2 (2018): 223–39; Alessio Fornasin, Marco Breschi, and Matteo Manfredini, "Spanish Flu in Italy: New Data, New Questions," *Infezioni in Medicina* 26, no. 1 (2018); and Fabiano Quagliaroli, "Le Pensioni per Gli Invalidi Della Prima Guerra Mondiale," *Contemporanea* 19, no. 1 (2016).
56. Walther Flaig, *Lawinen: Abenteuer Und Erfahrung, Erlebnis Und Lehre*, 2d ed. (Wiesbaden, Germany: Brockhaus, 1955); and Lichem, *La Guerra in Montagna, 1915–1918*.
57. Emilio Faldella, ed., *Storia Delle Truppe Alpine* (Milan, Italy: Cavalotti Editori, 1972).
58. Lichem, *La Guerra in Montagna*.
59. Lichem, *Der Einsame Krieg*.

60. Massignani, "La Guerra Combattuta in Trentino."
61. Leoni, *La Guerra Verticale*, chap. 9.
62. "Relazione Del Corpo Sanitario" (Rome: Ufficio storico dello Stato maggiore dell'esercito, n.d), B I, 40–42. See Leoni, *La Guerra Verticale*.
63. Gualtiero Castellini, *Tre Anni Di Guerra. Diario* (Milan, Italy: Treves, 1919); and Gualtiero Castellini, *Lettere, 1915–1918* (Milan, Italy: Treves, 1921). See Leoni, *La Guerra Verticale*.
64. Direzione di sanità I Armata, "Norme Contro i Congelamenti," Fondo E-7, Carteggio sanitario della Prima guerra mondiale (1914–1927), b 44, fascc. 398–99 (Rome: Ufficio storico dello Stato maggiore dell'esercito, 1916). See Leoni, *La Guerra Verticale*.
65. Ufficio storico Stato maggiore dell'esercito, "Le Operazioni del 1916," in *L'esercito Italiano Nella Grande Guerra, 1915–1918* (Rome: Instituto poligrafico dello stato, 1931), 614.
66. Weber, *Tappe Della Disfatta*.
67. Felix Hecht, *Diario Di Guerra Da Corno Di Cavento* (Trento, Italy: Manfrini, 1995).
68. James Edmonds and Henry Rodolph Davies, *Military Operations, Italy, 1915–1919* (London: Her Majesty's Stationery Office, 1949), 116.
69. Leoni, *La Guerra Verticale*.
70. *Leoni, La Guerra Verticale*.
71. See, for example, Leoni, *La Guerra Verticale*; and Weber, *Alpenkrieg*.
72. Fornasin, Breschi, and Manfredini, "Deaths and Survivors in War," 616.
73. Weber, *Tappe Della Disfatta*.
74. Österreichischen Bundesministerium für Heereswesen und Kriegsarchiv, "Von Der Einnahme von Brest-Litowsk Bis Zur Jahreswende," in Österreich-Ungarns Letzter Krieg*, 1914–18*, trans. Stan Hanna (Vienna: Verlag der Militärwissenschaftlichen Mitteilungen, n.d.); Österreichischen Bundesministerium für Heereswesen und Kriegsarchiv, "Die Ereignisse von Jänner Bis Ende Juli," in *Österreich-Ungarns Letzter Krieg*; Österreichischen Bundesministerium für Heereswesen und Kriegsarchiv, "Die Ereignisse von August Bis Zur Jahreswende," in *Österreich-Ungarns Letzter Krieg*; Österreichischen Bundesministerium für Heereswesen und Kriegsarchiv, "Das Kriegsjahr 1917," in *Österreich-Ungarns Letzter Krieg*; Ufficio storico Stato maggiore dell'esercito, "Le Operazioni Del 1915," in *L'esercito Italiano Nella Grande Guerra, 1915–1918* (Rome: Instituto poligrafico dello stato, 1929); and Stato maggiore dell'esercito, "Le Operazioni Del 1916."
75. Stato maggiore dell'esercito, "Le Operazioni Del 1916," 174.
76. Ettore Ricci, "Nota Sul Contributo Dato Dall'Esercito Nazionale Alla Illustrazione Della Climatologia Friulana e Della Morfologia Delle Alpi e Prealpi Carniche e Giulie, Nel 1915–19," in *Extracted from "Atti Del XII Congresso Geografico Italiano"* (Udine, Italy: Tipografia D. del Bianco e figlio, 1938).
77. From April 2016 to April 2017, the author conducted a fruitless search tracing the reports of the Meteorological Section on avalanche accidents and victims at the Alpine front. Many archives and personnel of different institutions were consulted based on the documents found at the Historic Office of the General Staff of the Army (Rome), including the Alpine Training Center of the Alpine Troops Command (Aosta), the Alpine Troops Command and the Service Meteomont (Bolzano), the Alpine Troops History Museum (Trento), the Cartographic Archive of the Military Geography Institute of the Italian Army (Florence), and the National Library of the Italian Alpine Club (Turin). Carlo Capello, "Le Ricerche Sulle Valanghe in Italia. Dalle Origini Al 1965," *Pubblicazioni Dell'Istituto Di Geografia Alpina* 9, no. 3 (1968).