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Soil Trail as a Tool to Promote Cultural and Geoheritage: The Case Study of Mount Cusna Geosite (Northern Italian Apennines)

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Abstract: The soil is a component of geodiversity, a geoheritage element providing knowledge of how the geosphere works and interacts with other Earth subsystems. To promote soil as a geoheritage element, we aim to create a geotouristic trail focused on soil, geomorphology, and geoarcheology in the area of Mt. Cusna (Tuscan-Emilian Apennine National Park, Northern Italy), where there is a 20-years long-lasting history of research on geopedology, geoarcheology, and geomorphology. Along existing hiking paths, five soil profiles are identified as sites of potential pedological interest, whereas three more sites are selected to show the geomorphological context of the area and one the geoarcheological evidence. The soil evidence allows for the reconstruction of paleoenvironmental and paleoclimatic conditions, and/or retraction of the human impact that has affected the area over time. In order to communicate the information about the geotouristic trail, illustrative panels were prepared for each trail site and underwent a formative evaluation by students attending academic courses in Natural Sciences to improve the offer. Through the trail, it will be possible to enable the visitor to discover the soil concept, which is often poorly known or even underestimated in its scientific and cultural value. Moreover, the cultural opportunities of the Mt. Cusna geosite will be enhanced.

Keywords: soil trail; pedosites; geosite; geoarcheological findings; Tuscan-Emilian Apennine

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1. Introduction

Since the twenty-first century, the attention paid to the geodiversity, defined as "the natural range (diversity) of geological (rocks, minerals, fossils), geomorphological (landform, topography, physical processes), soil and hydrological features. It includes their assemblages, structures, systems and contribution to landscapes" [1] (p. 12), has grown. The soil is one of the various elements constituting geodiversity and its variability on Earth is defined as pedodiversity, i.e., the variation of soil properties (usually characterized by soil classes) within an area [2–4].

Although soil generates important goods and services and provides cultural services [5–7] acting, for example, as an environmental archive, it is slightly taken into consideration in terms of geoconservation and promotion as a potential element of geoheritage (sensu Brilha [8]). However, as stated by Masseroli et al. [9] (and reference therein), often soil is only a secondary topic in geosite inventories, and sometimes the inventories focused only on some of the most important paleosols, leaving out other types of soils that possess cultural heritage.

In particular, the protection of the geoheritage elements is carried out through the establishment of reserves, parks, protected areas and, since the 1990s, through the reconnaissance of the status of geosite or geoheritage sites defined by Brilha [8], as the sites representative of the geodiversity of a region characterized by a high scientific value.

Among geosites, the less known but equally important are the pedosites. A pedosite was defined by Costantini and L'Abate [10] (p. 143) as a "georeferenced soil having cultural heritage, that is, a soil exposure or a soilscape where an extraordinary cultural interest has been recognised [11]". More recently, following the Brilha [8] approach applied for the geosites, Bothelo and Brilha [12] suggested that the term pedosite should be restricted to soil with high scientific value. Whereas, similarly to the geodiversity sites, the "sites of potential pedological interest" indicate those soils with no particular scientific relevance, but with educational, touristic, or other values [9].

Costantini and L'Abate [9] divided pedosites into two distinct categories: soil profiles (i.e., paleosols, soils from archeological and paleontological sites, soils displaying natural and anthropic processes) and soilscapes (i.e., soils characterizing a defined and important cultural landscape, soils as a panoramic beauty, soils occurring in fragile environmental balance, soils that support fragile ecosystems, such as soils related to specific biotopes).

Since soil is an interface between atmosphere, hydrosphere, lithosphere, and biosphere, its formation and development are the result of the combination of different abiotic and biotic factors acting on the Earth's surface. Soil records, as properties and features, the processes and the environmental conditions that govern its development. For this reason, it can be used as a useful archive for the reconstruction of the Earth and human history. Indeed, soil can narrate the paleoenvironmental change and the occurrence of geomorphological processes (e.g., slope processes, fluvial processes), e.g., [13], and can also allow for the retracement of the human presence in an area, e.g., [14]; therefore, becoming an intersection point with other disciplines (e.g., geology, geomorphology, geoarcheology).

The pedosite categories distinguished by Costantini and L'Abate [10] also include those soils in which the scientific and cultural value can be attributed thanks to the presence of an archeological site. For the specific cases of geosites featured by the presence of archeological evidence, new terms were introduced, for instance, geocultural sites [15]; archeo-geosites [16]; and geoarcheomorphosites [17]. Moreover, Pijet-Migoń and Migoń [18] summarized the different kinds of relations existing between cultural heritage and geoheritage, and in the specific case of soils, the cultural landscapes (i.e., landscapes deeply influenced by human action) can be the more inherent ones.

In addition to the conservation, the geoheritage enhancement is an important issue that can be carried out through promotion and information activities.

Geotourism is one of the main promotional activities that can be implemented in a geosite [19]. Within the vision of thematic tourism, geotourism consists of the creation of trails along which hikers are guided to increase their own knowledge of the geoheritage, and their awareness of geosciences [20]. It originates from the ideal intersection between the categories of naturalistic/mountain tourism, which allows you to enjoy the beauties of nature, with an emphasis on geological features, and the cultural one, which combines archeological and monumental evidence. Furthermore, it constitutes a type of sustainable tourism [21].

Over the past 10 years, the creation of geotrails has been the main action to enhance areas with peculiar geological, geomorphological, or geopedological evidence. Concerning this latter evidence, in literature, there are few examples where the soil trails have been used to make the general public more aware of the soil relevance for the community [9]. On the island of Anglesey (North-West England), Conway [22], for the first time, focuses a touristic trail on the pedological rarities of the analyzed area, paving the way for the creation of a soil trail. In general, the literature outlines a constantly increasing creation of geotrails, both developed in areas already recognized by the institutions and subject to protection [22–24] and in areas not already undergoing official protection but where geotrails may become a tool to foster their safeguard [25]. In both conditions, the creation of geotrails offers the possibility of innovating or, where non-existent, developing infrastructures and services that can create an opportunity for socio-economic development. In addition, this may favor a push toward greater local awareness of the geological heritage [23,25].

In this scope, soil trails can be a valid tool for furthering soil as a component of the cultural and natural heritage [9], highlighting how the soil variability mirrors the close interaction between the pedosphere and the other spheres. From this perspective, the heritage value of soil sites emerges as a particular archive of the Earth and human history.

To promote soil as an element of geoheritage, we propose the development of a geotouristic trail focused specifically on soil, geoarcheology, and geomorphology. The selected study case is the area of Mt. Cusna geosite, within the Tuscan-Emilian Apennine National Park (Northern Apennines), featured by a long-lasting tradition of scientific research in geopedology, paleopedology, and archeology. Despite this scientific and cultural importance, geotrails have not yet been implemented in Mt. Cusna area and this is an additional reason for the selection of the area.

2. Materials and Methods

2.1. Study Area

The study area is located between Mt. Cusna (2120 m a.s.l.), Mt. Bagioletto (1750 m a.s.l.), and the locality called Prati di Sara (1630 m a.s.l.), in the territory of Villa Minozzo (Emilia Romagna Region) (Figure 1). Since 2001, Mt. Cusna is included in the "Parco Nazionale dell'Appennino Tosco-Emiliano" (Tuscan-Emilian Apennine National Park) and, since 1999, the area has been designed by the European project "Natura2000" as a "Site of Community Importance" in order to prevent it from the loss of its biodiversity. Following Mt. Cimone (2165 m a.s.l.), Mt. Cusna is the second highest peak of the Northern Apennines ridge.

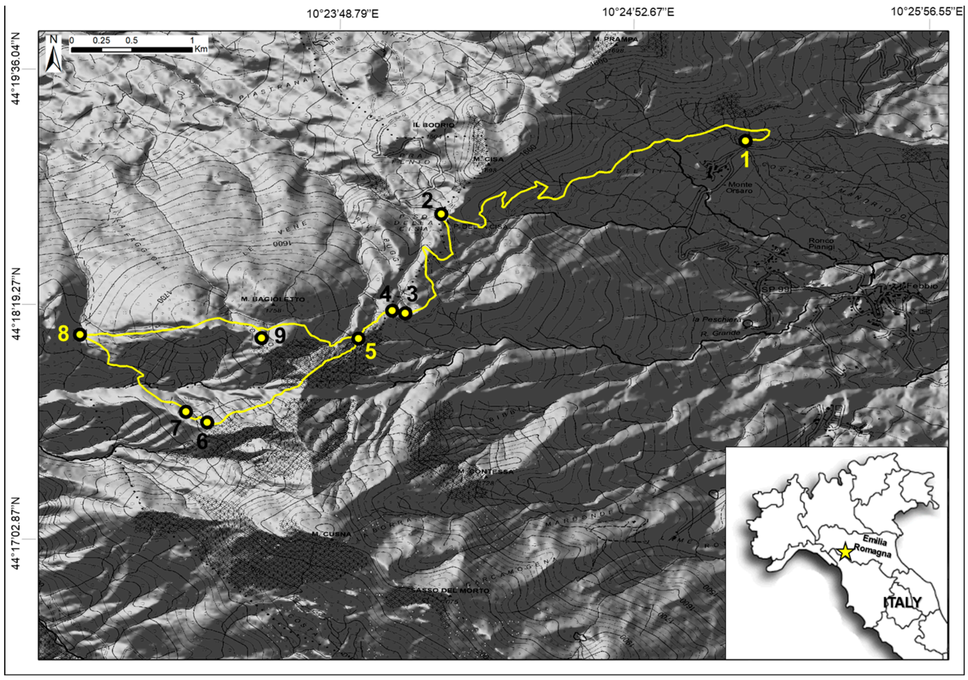

Figure 1. Study area location. The soil trail (yellow line) and the nine stops (yellow dots) plotted on the hillshade derived from the digital elevation model (5 m resolution; Emilia Romagna region) and the topographic database (1:25,000; Emilia Romagna region).

Climate of the area is sub-Mediterranean with abundant and well-distributed precipitation (2000 mm/y), with a summer minimum and a mean annual temperature range from 8.8 °C (Ligonchio, 928 m a.s.l.) to 2.2 °C (Mt. Cimone, 2165 m a.s.l.; observation period for both weather stations 1961–1990) [26]. The study area is located between 1240 and 1763 m a.s.l.; therefore, it should be considered virtually below the current treeline position (1750 m a.s.l. [26]). Vegetation is characterized by an open deciduous forest dominated by beech (*Fagus sylvatica*) with sparse shrubs and grassland species, mainly *Vaccinium myrtillus*, *Juniperus nana*, Thymus sp., and *Laburnum alpinum* [27]. Above the treeline, areas are defined by *Vaccinium myrtillus* with *Nardus stricta* and *Brachypodium genuense* composed of heatlands and acid pastures [28].

The bedrock consists mainly of turbiditic sandstones (locally marlstones) with intercalated sequences of claystones and siltstones [29,30]. The area is characterized by combined geological, geomorphological, and stratigraphic peculiarities; therefore, since 2006, the Emilia Romagna region has designed the NE slope of Mt. Cusna to the extent of the locality called "Le Presse" as a regional geosite (http://sgi.isprambiente.it/GeositiWeb/scheda_geosito.aspx?id_geosito_x=3013; https://geo.regione.emilia-romagna.it/schede/geositi/scheda.jsp?id=451, accessed on 15 April 2023). It was established by recognizing the geomorphological and, above all, geological peculiarities of the area: an outcrop of Monte Modino sandstone superimposed on clayey and marl units derived from the Apennine orogenic phenomenon, which began in the Late Cretaceous. In particular, the overlap of Mt. Modino sandstone with intercalated mudstones, claystones, and marls determines a peculiar reverse anticline testifying past depositional systems, subsequently shaped by tectonic movements that had generated the present structure of the ridge into folds and thrusts [31]. Moreover, the area became a geosite due to the long-lasting scientific research in the area, and in relation to the evidence of glacial circles, revealing the past presence of perennial glaciers, and the active deep-seated gravitational slope deformation (DSGSD), which testify the more recent geomorphological processes affecting the area. On the other hand, although possessing remarkable pedofeatures and characteristics, the soils of Mt. Cusna area have not yet been included in the Italian pedosites inventory (Soilsites—Patrimonio culturale pedologico d'Italia, https://www.crea.gov.it/web/agricoltura-e-ambiente/banche-dati, accessed on 15 April 2023).

In general, the area is characterized by the presence of glacial cirques, till deposits, and generally rounded and hilly slopes (especially in Mt. Bagioletto area), which testify the glacial and periglacial processes that occurred during the Pleistocene and the last glacial phase [31–33] (Figure 2). During the Holocene, gravity and water runoff-related processes have been the most widespread phenomena modeling the surface [29,31] (Figure 2a,b,f–h). Nowadays, Mt. Cusna area is affected by extremely active slope morphodynamics [34] as demonstrated by the presence of rock and debris slides on the main slopes, with varying dimensions and positions, whereas wider colluvial deposits affect the stable and flat slopes between Mt. Bagioletto and Mt. Cusna [31]. Processes related to surface running water shapes the landforms in different ways in accordance with the lithology of the substrate [31] (Figure 2f–h). Due to their semipermeable property, sandstone outcropping is moderately influenced by water runoff and washout phenomena. On the contrary, where the impermeable claystones and marlstones outcrop, water runoff often exposes surfaces and large washout areas are highlighted by the presence of gullies [31].

In the study area, the pedogenesis is strongly influenced by the described morphological conditions and evolution; therefore, the area is characterized by the presence of complex sequences of soils and paleosols. In regard to the present-day pedogenetic phase, Entisols are found on active landforms and mainly on claystones, Inceptisols are developed on more stable surfaces on sandstones and marlstones, whereas Spodosols are located at higher altitudes [29]. A detailed pedological map of the area is missing, but the 1:250,000 soil map of Italy (Carta Ecopedologica d'Italia 1:250,000, Servizi WMS, Geoportale Nazionale, http://www.pcn.minambiente.it/mattm/servizio-wms/, accessed on 10 April 2023) emphasizes the presence of Regosols or Cambisols [35]. Furthermore, in the study area, there are traces of older soil formation in the form of relict paleosols or buried paleosols below colluvial deposits. In particular, along the Mt. Cusna toposequence (i.e., "a sequence of related soils that differ, one from the other, primarily because of topography as a soil-formation factor", https://www.soils.org/publications/soils-glossary/, accessed on 15 April 2023) (Figure 2f–h) different buried soil units have been identified and classified as Luvisols (Alfisols), formed during two distinct stability phases attributed to the Sub-Boreal and the most recent Atlantic period, characterized by a well or moderately developed brunification with clay illuviation [36].

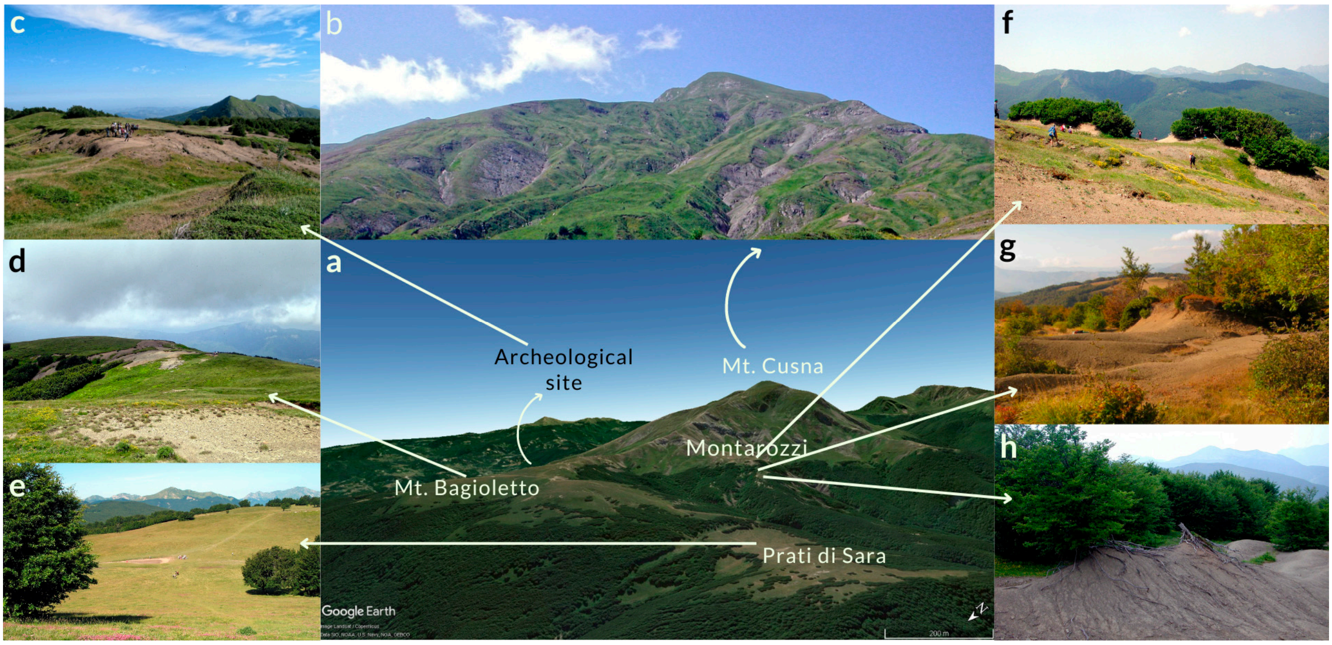

Figure 2. Google Earth image of the study area (**a**) and photographs of main sites of interest: Mt. Cusna (**b**); archeological site (**c**); Mt. Bagioletto (**d**); Prati di Sara (**e**); NW slope of Mt. Cusna (**f**–**h**).

The slopes of Mt. Cusna also reserve the remains of temporary settlements of Mesolithic hunters, between the Early and the Mid-Holocene (Mt. Bagioletto site, 1.6 km N from the summit of Mt. Cusna [29]), followed by other sporadic occupations from the Late Holocene to the Roman Age [29,37,38] (Figure 2c).

Historical sources show a progressive colonization of the higher Northern Apennines since the Late Middle Ages [39], with communities surviving on livestock and forest exploitation. Soil profiles from Mt. Bagioletto sites are emblematic and testify the ancient presence of Mesolithic temporary huts proven by the findings of flint and stone artifacts [38]. Furthermore, findings, such as an iron nail with a piece of pottery and a coin from the Roman Empire at the Bagioletto archeological site (Figure 2a,c) reveal the frequentation of the area during the Iron Age and the period of the Roman Empire. On the other hand, the medieval human exploitation of the area is testified by charcoals found in the soil along the NW slope of Mt. Cusna [27]. Finally, traces of pasture and fire setting by humans before the Little Ice Age are preserved into the buried soil at the so-called "Portolo" (Figure 2d) locality near Mt. Bagioletto [27].

2.2. Soil Trail Structuring and Pedosite Selection

The process for structuring the thematic trail consists of two steps in accordance with the methodology proposed by Masseroli et al. [9].

First, the sites of potential pedological interest (i.e., soils with no particular scientific relevance but with educational, touristic, or other values [9]) are individuated based on geopedological, geoarcheological, and geomorphological data gathered in over 20 years of research in the Mt. Cusna area. In particular, geoarcheological investigations of Mesolithic sites allowed for the past environmental conditions of the area to be described using soil data, archeological evidence, and palynological studies [37,38]. In addition, pedoanthracological, soil micromorphology, and dendrochronological analyses carried out by Compostella et al. [26,27] helped in characterizing the Holocene environmental evolution of the area. Two geomorphological maps, within a time distance of 25 years [29,31], were used for the reconstruction of the geomorphological evolution of the area through the representation of landforms and paleosurfaces and their reciprocal distribution. The findings of Mariani et al. [39] allowed for the retracement of the effect of the Little Ice Age (LIA) observable in soils and landforms of this part of the Apennines. Masseroli et al. [36]

provide a detailed reconstruction of how the interactions between the geomorphological context, the Holocene climate variations, and the modification of the vegetation cover and composition influence the soil development of the Mt. Cusna area.

Thereafter, the sites of potential pedological interest are qualitatively selected based on the criteria proposed by Masseroli et al. [9]: accessibility, soil diversity, pedostratigraphy, and visibility. In particular, sites of potential pedological interest were selected by taking into consideration the soil diversity, not in regard to the superficial soil unit, which is similar in almost all the analyzed soils, but along the soil profile, in regard to the buried unit (i.e., paleosol). Therefore, the presence of paleosols with different characteristics and evidence related to anthropic activity was the main criterion for selecting the sites.

In regard to the pedostratigraphy criteria (i.e., profiles composed of different soil units that allow for underlining the soil that can be used as an archive of past environmental conditions and geomorphic dynamics [9]), we also considered archeological findings, since they add information to the soil as a paleoenvironmental archive, which in this case, is more linked to anthropic activity.

In sites where archeological findings are not related to a soil profile, the selected location has been classified for geoarcheological interest only.

To highlight the most significant geomorphological evidence, some panoramic points have been selected to observe the processes and landforms testifying the geomorphological evolution of the area. These locations may be defined as viewpoint geosites in accordance with the definition proposed by Migoń and Pijet-Migoń [40].

Once the sites of potential pedological interest were selected, the trail was structured.

Second, among the selected sites of potential pedological interest, the pedosites were proposed. The identification of the potential pedosites is made following the qualitative evaluation presented by Costantini and L'Abate [10] and based on the following categories: (i) level of interest and (ii) type of scientific interest, (iii) state of conservation, (iv) type and (v) intensity of risk, (vi) level of knowledge, (vii) geological age, (viii) protection and (ix) proposed protection, (x) accessibility, (xi) visibility, (xii) exposure, (xiii) observability (for more details, see [10]).

In order to communicate the information about the trail, for each selected site (sites of potential pedological interest, sites with geoarcheological evidence, geomorphological viewpoint sites), an illustrative panel has been prepared using Canva (free online software; www.canva.com, accessed on 15 April 2023). Moreover, at the beginning of the trail, two introductory panels on the main topics discussed along the trail (geology/geomorphology and geopedology) are proposed.

In addition, to facilitate the publication and consequent dissemination of information about this soil trail, a presentation panel is designed, which summarizes the essential features of the soil trail using symbols and brief texts.

Language used for all the texts is simple, with few technical words and some anecdotes are introduced to make the panels more attractive.

In our case study and in accordance with Bruno and Wallace [41], a formative evaluation phase was planned. Thirteen students of Natural Sciences B.Sc. of the University of Milano were involved to evaluate the panel design and contents, in participation of their annual mandatory field educational activity in the Mt. Cusna area. Generally, these students know "what soil is", but some of them have never seen or observed it properly. Moreover, they did not visit the area before that moment. The panels were evaluated in accordance with different criteria:

1. Illustrative panel location: Is the panel positioned correctly and does it properly show what to observe?
2. Graphic design: Is the panel well-organized? Is it easy to read? Do images support the text? Is the background color suitable?
3. Content: Is the content well-explained? Are they suitable for the potential users (tourists, excursionists, hikers, mountaineers)?

4. Text: Is the text clear? Are there many technical terms? Is it very long/short? Is it well-organized?
5. Images: Are the images integrated with the text? Are they clear? Are they easy to interpret?
6. Symbology: Are the symbols used clear? Do they make the panel easier to understand? Are they intuitive and clearly visible?

The panels were then modified in accordance with the received evaluation and advice.

3. Results

3.1. Trail Structuring

The trail is designed to narrate the Holocene evolution of the Mt. Cusna area. Starting from the glacial processes that shaped the main landforms, the trail allows for the retracement of the succession of different climatic and environmental phases that have characterized the area (climate and vegetation factors), taking into account the evidence of human presence in the area (anthropic factor). The itinerary is about 8.2 km long and has a difference in height of about 570 m a.s.l. (Figure 3).

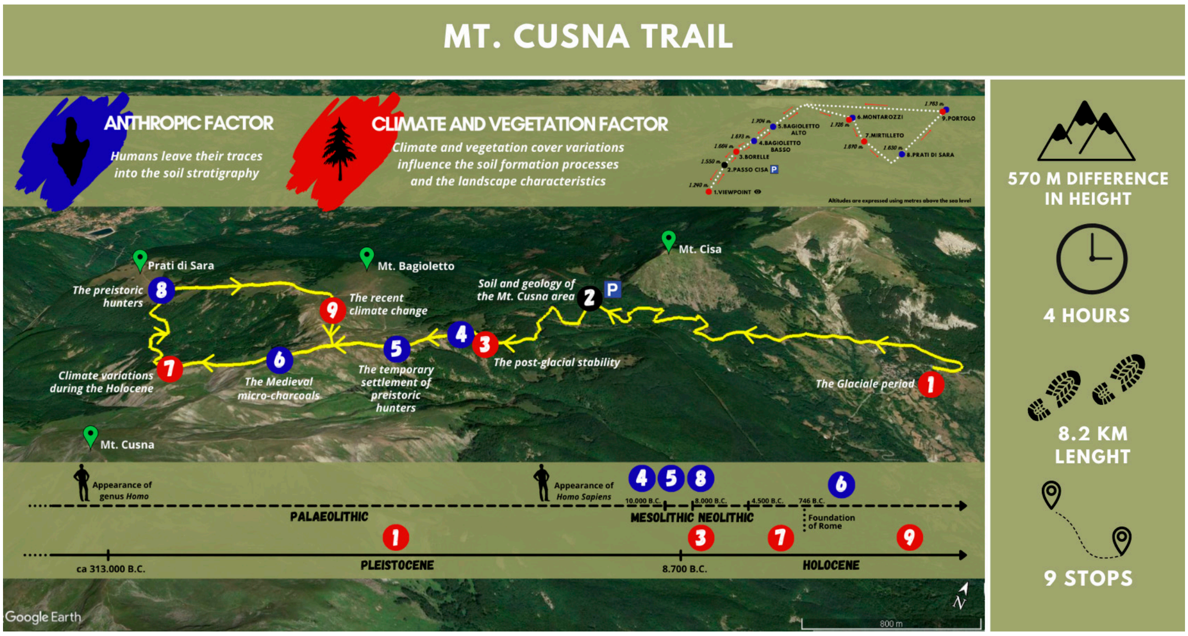

Figure 3. Details of the Mt. Cusna trail.

The multidisciplinary and multi-analytical approach used to study and characterize this area allowed for the selection of nine stops along the already existing paths (Figure 3 and Table 1).

Stops 1 and 3 focus on the geomorphological context of the area, whereas Stop 2 illustrates some basic information about the area.

In particular, Stop 1 is located along the road at a panoramic viewpoint. From there, watching towards south-west, from right to left, it is possible to observe the sequence of peaks of Mt. Cusna ridge. The crest of the ridge assumes, when observed from the plain, a particular shape, which recalls a giant sleeping man. For this reason, the protected area until 2005 was called the Park of the Giant (Parco del Gigante). Below the crest of the ridge, between 2100 m and 1900 m a.s.l., glacial cirques, shaped during the Pleistocene, are also visible. These landforms testify to the past presence of glaciers in the area. At this stop, the panel containing the technical characteristics of the trail (e.g., difference in height, length, travel time), the description of the topics addressed, and the position of the various stops are inserted (Figure 3).

Table 1. Summary of the nine stops with the related topics and locations are reported.

Stop Number	Name	Main Topic	Distance from the Start of the Trail (km)	Coordinates (WGS84)	Main References
1	Panoramic viewpoint: The glacial traces	Geomorphological traces of glacial processes.	0	44°19′01″ N 19°25′23″ E	[29,31]
2	Introductory panels: 1. The soil; 2. The geology of Mt. Cusna	1. General explanation of soil formation and soil features. 2. General information of geological and geomorphological context of the area.	ca 2.9	44°18′41″ N 10°24′01″ E	[31,42]
3	Le Borelle: Post-glacial traces	Landforms due to the erosive action of water runoff.	ca 4.2	44°18′14″ N 10°23′51″ E	[31,38]
4	Bagioletto Basso: The buried soil	Buried soil related to the Atlantic soil preserving archeological findings.	ca 4.5	44°18′15″ N 10°23′47″ E	[38]
5	Bagioletto Alto: The Mesolithic "Terre Nere"	Buried soil and geoarcheological evidence of human impact over time.	ca 5.9	44°18′08″ N 10°23′38″ E	[38]
6	Montarozzi: Medieval charcoals and tilted trees	Soil and the surrounding landscape records the occurrence of slope stability and instability phases.	ca 6.2	44°17′46″ N 10°22′58″ E	[26,27]
7	Mirtilleto: A polycyclic soil	The paleoenvironmental and paleoclimatic reconstruction of the entire Holocene observing the characteristics of two soil profiles. Evidence of a toposequence.	ca 6.5	44°17′49″ N 10°22′52″ E	[36]
8	Prati di Sara: Past environment	The story of the past landscape and the interaction with biosphere and humans.	ca 7.5	44°18′08″ N 10°22′23″ E	[38]
9	Portolo: Pastures and the Little Ice Age	The medieval frequentation of the area and the evidence of the LIA.	ca 8.2	44°18′08″ N 10°23′12″ E	[26,27,38]

Stop 2 at Passo Cisa was planned as a place to provide basic information to better understand the trail, such as the geological context of the area and significant notions about soil.

Stop 3 is located along the path at "Le Borelle" locality. From this viewpoint, the Mt. Cusna slope shows the evidence of water runoff processes. Rill and gully erosion affects the soil, developed during the Atlantic period (ca 5.520–2.000 B.C.), leaving some edges of the paleosurface visible, which characterizes the Mt. Cusna slope (Figure 2b).

In the following six stops, except for Stop 8 (as detailed below), soil profiles are selected as sites of potential pedological interest. In each of the five sites of potential pedological interest, the soil evidence allows for the reconstruction of paleoenvironmental and paleoclimatic conditions, and/or retraction of the human impact that has affected the area over time. In particular, the soil has mainly recorded, through its physical and chemical properties and pedological features, the influence of climatic variations, the changes in vegetation cover and geomorphological processes, while, in some sites, the presence of traces and/or archeological findings highlight how humans have affected the area over time.

All profiles selected as sites of potential pedological interest are easily accessible by excursionists and clearly visible, they are located along the path, and are exposed along natural scarps. The surface soil unit, in almost all sites of potential pedological interest, is developed from colluvial deposits and with a low degree of evolution. The paleosols, on the other hand, despite being a leached brown soil in all profiles, have specific and different characteristics for each site selected.

Stops 4, 5, 6, and 9 have an interesting pedostratigraphy from both a geopeological, geomorphological and, above all, geoarcheological viewpoint, while Stop 7 reveals particular geopedological and geomorphological evidence.

All the profiles selected allow us to focus on how the combined analysis and interpretation of geomorphology, geopedological, and geoarcheological evidence of the area are essentially important for understanding the evolution of the area.

Description of the main evidence of the sites of potential pedological interest is proposed below.

Stop 4—Bagioletto Basso—The profile shows three different soil units that testify the alternation of many phases of stability and instability. The two more superficial soil units are both characterized by a low degree of development as they are developed from colluvial deposits (Figure 4a). The different grain size distribution (i.e., gravel and sandy-silty) of the two deposits testifies a different contribution of material over time, highlighting how the soil can trace the instability events. The third soil unit is located at the bottom of the profile and is characterized by a dark horizon rich in clay and hematite (Figure 4a). It is only a portion of the brown leached soil developed during the Atlantic period, which was eroded and buried by upstream sediments. About 350 manufactured flint artefacts dating back to the Mesolithic were found within these sediments, testifying to human occupation in the upstream area, and how even human traces have been subject to the same processes involving the soil.

Stop 5—Bagioletto Alto—The selected soil profile is composed of three units (Figure 4b). As in the previous stop, the soil surface unit is the result of the current pedogenesis developed starting from a colluvial deposit. This soil unit shows a basic horizon differentiation; inside it, artefacts related to the Iron Age were found. The buried paleosol has a preserved, very rich in clay horizon belonging to a brown leached soil, developed during a period characterized by a mild climate and dense forest cover (Figure 4b). During the Mesolithic, hunter-gatherers temporarily settled in this area in basic huts near a large and dense oak forest. The buried black horizon found at the bottom of the profile reveals how they carried out their daily activities around the essential fireplace, including cooking and producing the flint tools that have been found at the Bagioletto Basso.

Discovered in 1977, the site was the subject of recurrent archeological excavations in 1978, 1979, and 1980 [38] (Figure 2c).

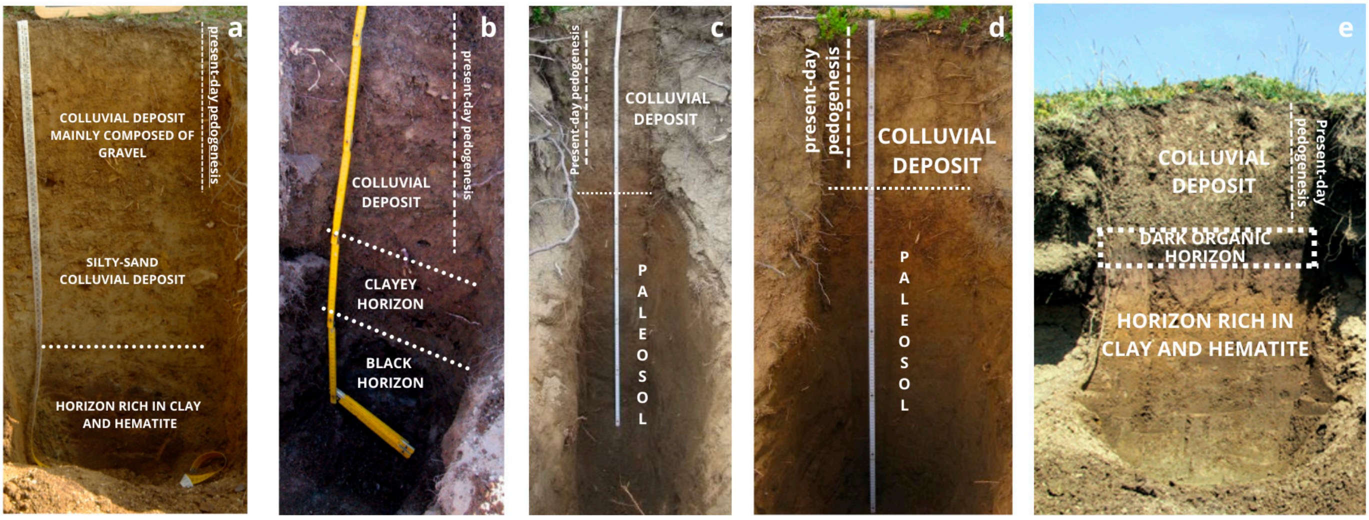

Figure 4. Soil profiles of sites of potential pedological interest selected for the trails. (**a**) Stop 4—Bagioletto Basso; (**b**) Stop 5—Bagioletto Alto; (**c**) Stop 6—Montarozzi; (**d**) Stop 7—Mirtilleto; (**e**) Stop 9—Portolo.

Stop 6—Montarozzi—The soil profile is composed of two units, a more superficial and poorly developed one and a buried brown leached paleosol developed during the Atlantic period (Figure 4c). The paleosol was eroded and truncated by a colluvial event probably caused by a phase of climatic instability, the instability could be promoted by the slash and burn carried out during the Medieval period, as evidenced by the charcoals found in the soil. The area has been subject to colluvial events in more recent times too. The morphology of the "Montarozzi" (residual hill subject to erosion on the entire perimeter) and also the presence of beech-tilted stems highlight how in the recent past and still today the area is affected by slope processes (Figure 2f).

Stop 7—Mirtilleto—In this site, two profiles are selected as sites of potential pedological interest. This stop is related to the Montarozzi one, forming a toposequence of soils along the slope. Depending on the position along the slope, we can observe soils with different peculiarities. The upstream profile has two units with the same characteristics as the profile of the Montarozzi (Figure 4d). The profile downstream has two soil units, both classifiable as paleosols. The most superficial one is a brown exhumed leached paleosol subject to the present-day pedogenesis. It is the same soil unit that we observed buried in the other profiles of the toposequence. The buried paleosol is characterized by a brown leached soil with a very marked degree of development and presumably developed in the Boreal period (ca 9.700–5.520 B.C.). This stop, chosen to highlight how the position along the slope can influence the erosion, and thus the exposure of some portions of soil, stresses how the soil developed in the past, buried, and subsequently exhumed, can again be subject to pedogenetic processes giving life to a polycyclic soil. The two soil profiles taken into consideration in this stop, along with the Montarozzi one, allow for the reconstruction of different phases of stability and instability that have been assigned for the evolution of the slope (Figure 2g,h).

Stop 9—Portolo—The last site of potential pedological interest is selected for its double value (geopedological and geoarcheological). The soil profiles of this area are composed of two different units: the most superficial is related to the present-day pedogenesis and developed from a colluvial deposit, while the buried paleosol is a leached brown soil with a peculiar characteristic at the top, i.e., a very dark-colored organic horizon composed of remains of insects, coprolites (fossilized remains of animal excrement), and micro-charcoals dated between the 13th and 14th centuries A.D., which testify to the use of the area by humans as a shelter for animals (Figure 4e). Furthermore, the organic horizon presents pedological figures related to frost action as evidence of the climatic deterioration that occurred between the two phases of stability. This last detail brings out how much the soil can be considered an archive not only for the phases of stability, but also for those instability phases that affect the area. At this stop, a panel containing a resume of the main topics within the trail and the reconstruction of Mt. Cusna history narrated by the evidence observed is inserted.

In terms of Stop 8, the site is selected mostly for its geoarcheological values. The selected area is called "Prati di Sara" and is one of the most suggestive landscapes of the trail, indicating a relevant aesthetic value as many geomorphosites [8]. In the south-east region, above the treeline, the mountaineers can see the top of Mt. Cusna, while toward the east, after a short climb, one can reach Mt. Bagioletto. The area is surrounded by a centuries-old beech forest that develops around a highland prairie with, in the center, the Caricatore Lake, which collects the water from the surrounding slopes during spring and autumn (Figure 2e). This site has been selected since on the banks of the lake, worked flint artefacts were found, including a flint tip, evidence that in the past, near Caricatore Lake, the Mesolithics hunted the animals that approached this water source.

3.2. Pedosites Selection

Among the site of potential pedological interest chosen for the soil trail, three profiles have been selected as potential pedosites, and thus classified in accordance with the form proposed by Costantini and L'Abate [10] for inclusion into the national database (Table 2).

Table 2. Qualitative evaluation of the two potential pedosites. The criteria are taken from [10], partially modified to better fit our purpose. For more details, see [10].

Criteria	Bagioletto Alto	Mirtilleto	Portolo
Level of interest	Regional interest	Regional interest	Regional interest
Types of scientific interest	Paleoenvironmental evidence; pedological evolution model; educational interest; archeological	Paleoenvironmental evidence; pedological evolution model; educational interest	Paleoenvironmental evidence; pedological evolution model; educational interest; archeological
State of conservation	Medium	Good	Good
Type of risk to lose natural/cultural heritage	Natural: Water- and gravity-related processes	Natural: Water- and gravity-related processes	Natural: Water- and gravity-related processes
Degree of risk of losing natural/cultural heritage	Low	Low	Low
Level of knowledge	Scientific publications	Scientific publications	Scientific publications
Geological age	Holocene	Holocene	Holocene
Protection	Protected	Protected	Protected
Proposed protection or "measures"	Suggested	Suggested	Suggested
Accessibility	Access on foot along the excursionist hiking path	Access on foot along the excursionist hiking path	Access on foot along the excursionist hiking path
Visibility	Improvable	Entirely visible	Entirely visible
Exposure	Natural	Natural	Natural
Observability	Summer, spring, and autumn (without snow)	Summer, spring, and autumn (without snow)	Summer, spring, and autumn (without snow)

The three selected profiles (Bagioletto, Stop 5; Mirtilleto, Stop 7; Portolo, Stop 9; Tables 1 and 2), in addition to being well-preserved, with good accessibility and visibility, are the most suitable examples of the paleosols of the area. Although the potential pedosites proposed are leached brown paleosols, each of them has peculiar characteristics that testify the strong relationship between soil evolution, geomorphological context, and human impact.

Bagioletto Alto profile stores the traces of different human occupations during the time related to different phases of slope stability. Moreover, the presence along the profile of the evidence of colluvial deposits narrate the past geomorphic dynamics that affected the area. Furthermore, it is an example of an archeological site studied in the past [38].

Mirtilleto profiles are selected as their evolution was strongly determined by slope dynamics. In addition to the evidence of the occurrence of various colluvial events along the slope, the presence of an exhumed paleosol highlights the current action of the erosion due to running water (Figure 2h). Moreover, the Mirtilleto soil is a good example of polycyclic soil. The profile of the Montarozzi could be connected to this potential pedosite to complete the focus on Mt. Cusna slope evolution, considering the entire toposequence.

Finally, the Portolo profile is proposed for the presence of a dark-colored organic horizon composed of remains of insects, coprolites, and micro-charcoals, which allowed not only for the reconstruction of the human occupation in the area, but also for the micromorphological evidence of frost action in the paleosol.

3.3. Illustrative Panels Design and Evaluation

The first version of the illustrative panels was modified based on the suggestions received from possible users. In Figure 5, an example of a panel before and after the modification is shown, whereas the observations made by students of Natural Sciences B.Sc. (University of Milano) on all panels of the trail are summarized in Table 3.

Table 3. Main observations made by students of Natural Sciences B.Sc. (University of Milano) on all panels of the trail.

Illustrative panel location	The panel is correctly located and allows for better understanding the illustrated topic.
Graphic design	The panels should be better organized and the main suggestions are: - change the background graphic with a basic and light one; - resize the picture and the text; - divide the text in boxes or paragraphs in accordance with the content; - use icons and symbols; - use of colors to establish direct links between the text and timeline; - eliminate the use of arrows as linkage between explanations and soil profile.
Content	The content should be reorganized to facilitate the reading dividing the description of the profile titled "evidence" (on the left side of the panels) and the interpretation of all the evidence (on the right side of the panels).
Text	The text is clear but the language should be simplified and for technical terms, should be useful by inserting a brief explanation enclosed in round brackets. Use of a uniform font is encouraged.
Images	For a better interpretation, the trail map should be replaced with a sketch of the path including elevation and stop names; the timeline should be plotted as a chromatic scale. To better show the evidence within the profile, the soil profile images should be enriched with the descriptive text.
Symbols	The used symbols are almost clear but should be more visible by including them in a circle.

For convenience, the main characteristics of the revised panels will be illustrated.

Each panel has a specific background with a photograph in 80% transparency mode, above which a white local background has been placed (Figures 5 and 6). Text and images have been inserted following the 3-30-3 scheme: The panels headline has to be read within 3 s, the key message supported by images and bold-text within 30 s, and finally, the entire text has to be absorbed within 3 min by the reader [41].

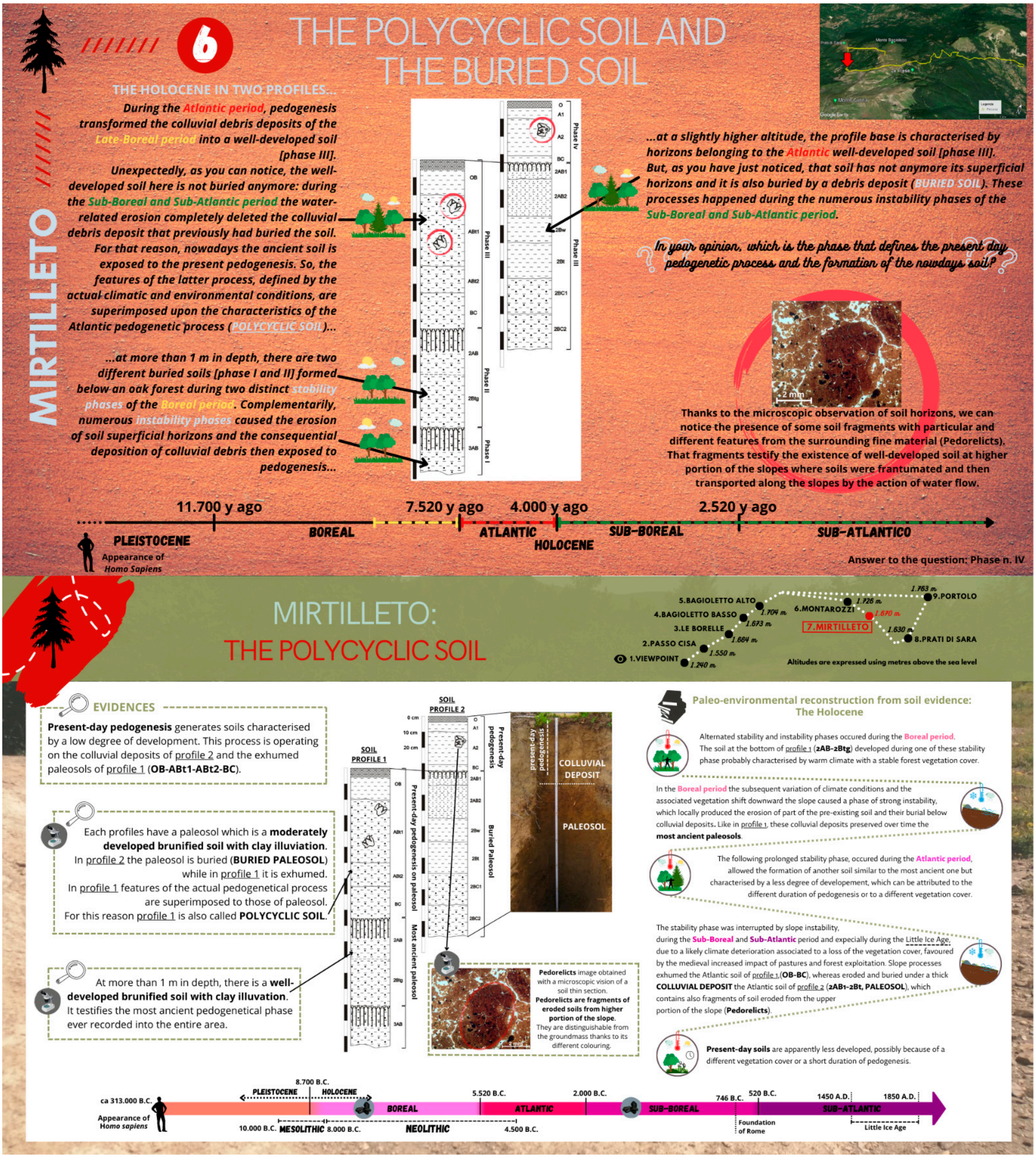

Figure 5. Explicative comparison of the panel referring to Stop 7: Before (at the top) and after all the modifications were carried out following the advice from the evaluation phase of panels (at the bottom). The soil profiles sketches and the pedorelicts photo are modified from Masseroli et al. [36].

Figure 6. Example of a panel about a viewpoint geosite with the tree-shaped symbol of the theme (refers to Stop 3) at the top; example of a panel exposing a potential pedological and archeological interest with its specific symbol, a flint nail (refers to Stop 5) at the bottom. Flint sketch is designed based on the archeological findings described in Cremaschi et al. [38].

Each panel has a title and a subtitle, respectively, the name of the place where the stop is located and the topic of the panel. In the upper left portion, the symbol of the topic (i.e., environmental and/or geoarcheological evidence) is inserted: A stylized representation of a typical flint for stops that focus attention on the imprint left by human activity and a tree for those that allow for the reconstruction of climatic and environmental changes that occurred during the Quaternary (Figures 5 and 6).

In the upper right portion, the trace of the path has been placed to identify the position of the stop (highlighted) within the path.

In the lower portion of the panels, a colored timeline has been inserted; each time period is depicted with the same color, both in the timeline and along the text.

In the middle of the panels, an image about the main theme is inserted (i.e., soil profile for panels in sites of potential pedological interest; picture of landforms for panels located in the viewpoint), which is enriched with the necessary descriptive text.

The texts are contained in boxes and written using a Sans Serif font, which is widely accessible to people affected by visual disability, in order that it guarantees inclusivity of the soil trail [41]. Technical terms are followed by a brief explanation enclosed in round brackets.

The text on the left describes the geopedological, geomorphological, or geoarcheological evidence and the human traces found in soil, whereas the text on the right refers to the interpretation of the evidence articulated as a story. The environmental conditions reconstructed based on the evidence observed in the soil are summarized and presented through symbols. Moreover, a symbol is used to identify the different topics and types of evidence shown. The magnifying glass identifies the boxes dedicated to the description of the evidence, the book identifies the narration of the paleoenvironmental reconstruction, while the microscope refers to the micromorphological evidence. To stimulate curiosity, soil thin section images and drawings of archeological findings have also been included. The charcoals, vase, and nail sketches identify the presence of the different types of human traces (Figures 5 and 6).

In order to spread the thematic trail and increase its usability, panels are planned to be made available in digital version (e.g., website of the protected area, specific applications for planning excursions) in both Italian and English languages through the link of Google MyMaps, and for now, the installation of the panels along the path is not foreseen.

4. Discussion and Conclusions

The Mt. Cusna geotrail project aspires to fit in an original way in the geotrails panorama since it aims at the reconstruction of the history of the area, from the Pleistocene until today, through the analysis of the soil profiles (Figure 7). The design of a geotrail rarely focuses on soil as a principal element of an entire itinerary. Indeed, there are few examples of soil trails in the literature, e.g., [8,22].

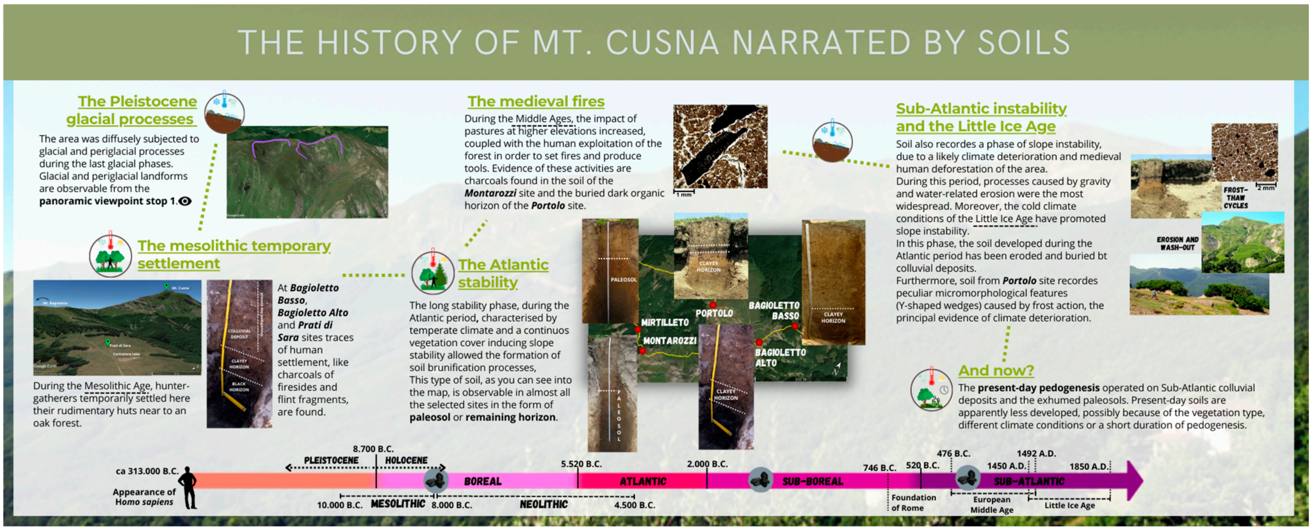

Figure 7. The history of Mt. Cusna resumed in the last panel of the trail. In the middle of the panel, the photographs of all the studied profiles are inserted. The soil thin sections photos are modified from Mariani et al. [39].

In literature, geotrails are always created starting from an accurate analysis of the geographical, geological, and geomorphological characteristics. Moreover, they may include sites of high scientific relevance (i.e., geosites). The peculiarity of the Mt. Cusna geosite and surrounding area is the presence of a wide range and constantly updated data of different disciplines. The presence of abundant literature focused on pedology, geomorphology, archeology, climatic and vegetation characterization, and specific laboratory analyses, such as radiocarbon dating, anthracological, and dendrochronological studies, e.g., [26,29–31,36] allowed for the creation of an innovative trail able to enhance the soil as a paleoenvironmental archive and as a meeting point for different disciplines.

The area, in addition to being the object of study in numerous scientific publications, is the site of yearly-based fieldtrip for academic students. This allows for a continuous collection of data and observations related not only to the soil, but also to the landscape, making it a type of open-air laboratory.

In our study case, soil diversity is very relevant, based on a broader concept that takes into account not only surface soils, but also buried ones, which are usually not considered in pedodiversity studies. In fact, the different paleosols of the area are the main characters of the trail (Figures 4 and 7). Moreover, soil is considered as an archive of both paleoenvironmental information and human traces. For this reason, interpretative panels are divided into two groups using a specific symbology: stylized representations of a flint for the panels highlighting human traces, and of a tree for all the other panels.

In particular, the different stability phases characterizing the area are recorded in paleosols and, by combining them with geomorphological data, they allow for the reconstruction of instability phases affecting the area, such as, for example, the various colluvial events that occurred along the NW slope of Mt. Cusna (Stops 6 and 7, Table 1), and the development of a polycyclic soil (Stop 7, Table 1). In some cases, soil also provides direct information on the climatic conditions that determined the instability phases, as in the case of the "Portolo" site (Stop 9, Table 1), where pedofeatures linked to the action of frost were found.

Furthermore, a strong point of the Mt. Cusna trail is that it combines geopedological heritage features, mainly soils, with the archeological evidence that soils themselves preserve and testify the presence of past human settlements. A similar approach was applied by Prieto et al. [23], combining the enhancement of the geoheritage (selected geosites include those of geological, geomorphological, and pedological interest) to archeological themes as pre-Hispanic lithic remains and to local customs and traditions, inserting stops that allow for the discovery of local workers, such as ceramic producers or stop.

The presence of well-preserved and developed paleosols and their close relationship with the history of the area has also allowed us to propose some of the studied soils as possible pedosites. The three selected profiles (Bagioletto, Stop 5; Mirtilleto, Stop 7; Portolo, Stop 9; Tables 1 and 2) are the most suitable examples of the paleosols diversity of the area and allow for the narration of the strong relationship between soil evolution, geomorphological context, and human impact.

Given the importance of the area from a geoarcheological viewpoint, the geosite could also be defined as a geocultural site (i.e., sites where "the geological features interact with cultural elements (historical or archeological vestiges, cultural or religious monuments, etc.)"), in which the geoheritage value joins the cultural value (sensu [15]).

The creation of the geotrails will allow for the promotion of geotourism in the Mt. Cusna area, which is already protected and extensively studied over the last 30 years but never sufficiently enhanced from a tourist viewpoint. Indeed, no geotrails have yet been implemented in Mt. Cusna area.

In contrast to the other geotrails created within protected areas of considerable extensions, such as the UNESCO Global Geopark of Mixteca Alta [23] or geotrails that connect different geosites scattered throughout the territory in Greece [43], this trail extends over a very limited area, thus carrying out a highly localized valorization action. For this reason, the trail requires less time for the enjoyment of the entire experience, and thus interests a greater audience and may potentially attract people who are generally not fascinated by these topics.

However, it must be taken into consideration that the thematic trails on soil can also have critical issues. Soil is a dynamic entity, which is the result of the interaction of various forming factors, also at the human time-scale. Therefore, it may change its characteristics over time, for example, as a result of slope processes, soil could be subject to erosion and/or burial (i.e., formation of buried soils), whereas due to an environmental change (e.g., change in vegetation cover, climate deterioration), the new pedogenetic processes can superimpose on the previous ones (e.g., polycyclic soils). This must be considered in terms of both protection and valorization.

In this case, the management of these critical issues can be facilitated by the fact that the area is already included in a park, and thus already subject to protection from human impact and subject to natural processes monitoring.

In regard to valorization, we try to propose a trail taking into account the peculiarities of the soil (e.g., visibility, continuous evolution of the profile, tight relation with environmental conditions, horizons with both paleoenvironmental and geoarcheological evidence). Soil profiles require a constant maintenance to allow visitors to appreciate, on the field, what is exposed in the illustrative material. In our study case, this may not be strictly necessary as most profiles are naturally exposed, mainly due to running water erosion. Moreover, Conway [22], in one of the few examples of trails focused on soil, "encourage viewing soil of natural exposures without digging or disturbing the sites to minimize any impact on the environment" [22]. Furthermore, for each site of potential pedological interest, panels have soil photos to show the clean profile and its characteristics. Finally, the support and involvement of professional guides, specifically trained on the topic (by researchers and thanks to the huge available literature), could bring to the general public attention to the soil-related thematic. The professional guides may organize specific tours on demand along the trail, checking for soil profile conditions, and eventually cleansing them during the visit.

Furthermore, given that the soil is still an undervalued topic in geotourism, the Mt Cusna trail aims to combine geopedological evidence with geomorphological and geoarcheological ones, in order to be more captivating and reach a larger public. In addition, Conway [22] tried to engage the public through their other interests (e.g., nature, birds, and archeology) to raise awareness about the soil importance and the link between the soil and their interest.

Since didactic-educational tools are fundamental for the transmission of information of each tourist trail [41], in our study case, the valorization of the area is indeed based on the creation of different interpretive panels in each site of interest along the trail in digital format, which guarantees the modification over time of the information, and thus a continuous possible update of the contents and graphics. Moreover, the digital version can be viewed beforehand by the interested visitor and the rapid sharing of the file and link allows for an effective communication of the itinerary through the appropriate channels. The usefulness of utilizing digital technology in the enhancement of geoheritage has already been highlighted by similar studies. For example, Perotti et al. [24] have elaborated a virtual itinerary in the Sesia-Val Grande UNESCO Global Geopark (Piedmont, Italy), by combining GIS technologies with Internet functionalities, which can be used through a special application downloadable on mobile devices or by accessing the website. Similarly, Lewis [44] combines tradition and technological innovation for a geotrail, which connects different geological sites in Southern Australia, through the creation of guidebooks, panels, and guided tours along with the use of a website and an application. From an economic viewpoint, the combined use of open-source programs, such as Google Earth, Google My Maps, and Canva, guaranteed the implementation of the project without any construction costs.

The panels created in this project are planned for the total independence of the visitor; the information is simplified and condensed to the greatest extent possible to make it comprehensible to the general public without trivializing the scientific information displaced. The use of the same symbols and icons in all panels and the inclusion of photos makes understanding more immediate and the practice of "storytelling" improves amusement [41].

The formative evaluation (sensu [41]) of the trail panels also allowed for gathering feedback and making adjustments to better attain trail objectives as well as better finalize the design and texts of the panels. The advice resulting from the evaluation proved to be essential for the improvement of the trail panels planning.

In conclusion, the Mt. Cusna trail could contribute to both raising the visibility of soil, which is often little known in touristic contexts, and increasing awareness of the scientific and cultural value of the Mt. Cusna area that is already recognized as a geosite of regional interest.

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