

*Research article***Forest planning, rural practices, and woodland cover in an 18th-century Alpine Valley (Val di Fiemme, Italy): A geohistorical and GIS-based approach to the history of environmental resources****Nicola Gabellieri* and Ettore Sarzotti**

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Abstract: The importance of past human activities in determining the extent and composition of current woodland cover has long been recognized. Understanding the environmental dynamics that have characterized vegetation over time, as well as the productive rural practices associated with them, can have significant repercussion on the current and future management of environmental resources. Scholars have identified a significant shift in woodland exploitation regimes in Europe, occurring between the late 18th and early 19th centuries. During this period, several states introduce modern forestry which gradually replaced local agro-silvo-pastoral structures. Geohistorical sources can help reconstruct these previous management systems and provide information on past environments. This paper has two main objectives: to increase knowledge of environmental and landscape dynamics in the Alpine context through a specific case study, and demonstrate the potential of geographic information systems (GIS) software in handling geohistorical sources. The case study of Val di Fiemme (Italy) has been chosen for two reasons: it is an area that has high forest presence and peculiar vegetation cover and the local archive contains a great deal of documentation. Specifically, the documents drafted by an Austrian Commission for forest management in the 18th century have been interpreted as an attempt by the Habsburg Crown to restructure the valley towards a timber economy. Documentation was collected, digitized, and mapped to build a historical GIS, showing woodland ownership status, tree species, and practices in the 18th century. As a result, a socio-ecological system was identified that significantly differs from the current one, revealing a greater diversity of species. The establishment of Habsburg norms represents a watershed in forest management with direct environmental effects that can be seen over the subsequent century. In conclusion, the study demonstrates the potential of using GIS-

based approaches to analyze textual geohistorical sources and extend the analyzed diachrony to periods prior to the geometrical cartographic ones.

Keywords: historical geography; historical GIS; woodlands; Alps; environmental resources; rural practices

Abbreviations

AMCF: Archivio della Magnifica Comunità di Fiemme/Historical Archives of the Magnifica Comunità of Fiemme; ASPT: Archivio Storico della Provincia di Trento/Historical Archives of the Province of Trento; GIS: Geographic Information Systems; FSC: Forest Stewardship Council; PEFC: Programme for the Endorsement of Forest Certification schemes

1. Introduction

The topic of local knowledge and practices relevant to the management of environmental resources, particularly in wooded and grazed areas, has long been the focus of geographical-historical research and other disciplines. Significant attention has been paid first to the history of material culture and later to historical ecology and to reconstructing environmental dynamics in social-ecological systems [1–7].

The need for historical interpretation is seldom recognized in geobotanical research, which often attributes phytogeography and geobotany to natural factors, such as climate or altitude. Studies, such as those conducted by Oliver Rackham in the 1980s, used documentary and field evidence to successfully unveil dynamics of change and permanence in plant cover which cannot be adequately explained solely by climatic factors. These studies underscore the significance of social practices [8–10]. The attention garnered by his work in recent years emphasizes the significant relevance of his proposals [11]. This type of research is of great interest in identifying the legacy these practices have left in current environments and landscapes, often referred to as bio-cultural heritage [12]. Moreover, it sheds light on historical systems of vegetal resource management that can serve as inspiration for current sustainable governance policies [13–16]. Biodiversity is currently recognized as being the result of historical processes to such an extent that scholars suggest discussing biodiversification from a process-based perspective [17]. Recent international scientific and institutional debates have consistently emphasized the need to enhance the interpretive framework on the subject of historical forest processes with new case studies in order to steer contemporary management systems [5]. As pointed out by Bürgi et al., while there exists a well-established model for examining changes in canopy extent, the long-term ecological impacts of past woodland resource utilization practices, such as leaf collection, charcoal production, and grazing, still require assessment through the collection of new and additional topographic-scale data [18]. The concept of practice is at the core of this endeavor. According to the perspective of historical ecology, practice refers to the actions undertaken by social actors on an individual or collective topographic scale, with typically productive aims [4,16–19] ([17, page 3169]). As noticed by Bürgi et al., [18] these action often reflect local knowledge and customary approaches and may differ from the official discourse of agronomic and forestry sciences or legislation of the time [3,19,20]. These practices can affect the ecosystem and may have had positive ecological and resource maintenance effects [21,22]. Many of these customary practices ceased

during the 19th century due to the increasingly regulatory character of the forest authorities' policies and of the gradual abandonment of agro-sylvo-pastoral economies. This is why they are now considered intangible heritage, worthy of being studied and recovered for contemporary management purposes [7,12,14]. The very concept of bio-cultural heritage suggests the importance of examining more closely productive practices and local knowledge, interpreted as “the vital link between culture and nature” [23, page 5]. This concept was coined by UNESCO and the Convention on Biological Diversity (CBD) with the signing of the Florence Convention in 2014 in order to overcome the traditional dichotomy between environment and society, with the belief that biological diversity is also linked to cultural diversity [12,24]. Many studies have focused on identifying biological components and cultural knowledge for the management of environmental resources that are still actively used among indigenous groups [25,26]. A second line of research, which is developing mainly in Europe, focuses on the past and its aim is to identify historical management systems and their effects over time, including those related to the management of wooded meadows/pastures [22,27,28].

Building on this context, the current paper seeks to conduct a study and mapping of practices related to the utilization and management of environmental resources in an alpine valley during the 18th century and to examine their impacts on woodland composition.

The literature consistently points to the 19th century as a period of significant disruption for wooded areas, primarily due to the introduction of new principles of forest science. As highlighted by Akhileshwar Pathak [29], Juha Kotilainen and Teijo Rytteri [30], and Geronimo Barrere de la Torre and Guadalupe de la Torre Villalpando [31], in Asian, European, and American contexts, this era witnessed the construction of state power, with its control over wooded areas being legitimized and intertwined with colonization policies [30,32].

In the Italian peninsula, the 18th century marked a crucial phase in the transition of forest policies, as emphasized by Diego Moreno [33], Renato Sansa [34], and Mauro Agnoletti [35]. While regulations were previously designed to restrict specific wooded areas, which had often been used for specific purposes such as shipbuilding, a shift toward more comprehensive protection policies influenced by Prussian silvicultural theories started to take shape [32,36]. These policies sought to safeguard the environmental resource and expand state authority, particularly in areas such as silviculture, at the cost of the autonomy and of the traditions of local communities. As noted by Diego Moreno [33], this shift was an attempt to move from woodland management based on custom and common uses toward specialization and state or private ownership. This transformation was far from immediate and took place gradually over time. According to Mauro Agnoletti [35], the imperial forestry model became prevalent in the Alpine region from the mid-19th century.

The study of the historical forest cover in various European regions through documentary sources has been largely explored [3,37,38]. Recent studies have above all used zenith geodetic maps produced in the 19th century for military or cadastral purposes. These are easily compatible with Geographic Information Systems (GIS). The focus on georeferenced maps [39–41] has led to a limited use of other types of documentation, such as statistics, which can provide valuable information [37]. Nevertheless, efforts have been made to incorporate textual documentation into GIS analyses for periods lacking cartographic sources [3].

The source presented here allows us to trace the introduction of the woodland management model in the Trentino region (present-day Italy), particularly in the Val di Fiemme territory, during the 18th century under the rule of the Habsburg crown. The case in point revolves around the substantial documentation produced by a forest monitoring Commission that operated in the valley between 1787 and 1788 AD. Val di Fiemme is a highly compelling case study due to its unique

system of collective property management and continuous documentation spanning from the 12th to the 20th century [42].

Trentino (Italy) historiography often refers to the introduction of Habsburg forest governance regulations in the 19th century [36], emphasizing their repercussions in terms of environmental protection and their normalizing influence on local customs. However, the case study we are considering here shows how the transition was gradual, building on a strategy of slow penetration based on compromise. The work of the Commission took the form of mediation between the Habsburg authorities and local representatives, aspiring to find common ground between local practices and imperial policies.

This paper has two main objectives. First, through a detailed examination of historical documents, it seeks to uncover the spreading of local practices and their connections to valley-scale resources before the Napoleonic and Austrian legislation of the 19th century. Second, it aims to explore a methodology that combines the research of textual sources with GIS-based analysis, thus addressing the historical-environmental issues related to the history of alpine landscapes and vegetation coverage. This approach can provide insights into historical woodland cover during periods lacking cartographic sources, making it valuable for historical ecology studies and contemporary resource management, while recognizing the limitations of this documentation. Indeed, historical ecology considers archival documents as important sources of information to be analyzed alongside data produced from field surveys and biostratigraphic analyses [2,8,9,13,16,17].

This work is part of a broader project on the study of woodlands as bio-cultural heritage. It uses a wide range of qualitative and quantitative sources and methods to explore the socio-ecological dynamics that have impacted alpine forested areas. The paper is divided into several sections. The first section introduces the chosen case study, Val di Fiemme, highlighting its unique characteristics from both social and environmental perspectives. It also provides a summary of its history, emphasizing the transitional phase that occurred at the end of the 18th century. The second section focuses on the primary source of the study, the records of the forestry commission. Subsequently, the paper details the method employed for processing the source, which is based on analytical reading and indexing. The indexing process, followed by mapping and analysis within a GIS environment, made it possible to partially reconstruct the socio-ecological system associated with forest cultivation in the 18th century. This approach also revealed the connections with the property system, as explained in the fifth section. The final section presents the conclusions of the study. The critical examination of this documentation and its analysis using geographic information systems, allows two key findings to be highlighted and presented. First, the descriptive operation was a valuable tool for the planning of the valley as a wood resource for the Po Valley market, resulting from a compromise between Habsburg forestry policies and local customs and practices. Second, the census reveals a woodland cover composition that differs from that of today's and is linked to a range of diverse uses and local knowledge, which become evident through the detailed analysis of the documentation produced.

2. Materials and methods

Historical ecology and historical geography share a common perspective that involves thoroughly examining the development of specific landscapes from their historical origins to their present state. This approach seeks to transcend structural processes, which tend to divide the interpretation of biological and social dynamics.

In this respect, the analytical exploration of archival records at a topographic scale provides invaluable research insights. This study employs a methodology that serves a dual purpose: firstly, to

extract topographic information for interpretation in the context of local knowledge and practices; secondly, to offer a semi-quantitative approach aimed at fully revealing geostatistical data possible. The combination of these methodologies makes it possible to historically characterize the spaces described, revealing both synchronic relationships at the valley scale and diachronic dynamics spanning from the past to the present. As pointed out by Barrera de la Torre and de la Torre Villalpando [31, page 113], it is crucial to subject documentation to scrutiny in the context of “micro-sites,” in order to elucidate “the ways through which colonial discourses made sense of forest conservation.”

2.1. The case study

The Fiemme Valley is located in the Trentino-Alto Adige Autonomous Region (Italy), close to the Austrian border (Figure 1) [43]. Geographically, this term is used to define the middle basin of the River Avisio (bordering upstream with the Fassa Valley and downstream with the Cembra Valley), which extends in a southwesterly direction and flows into the River Adige. Administratively speaking, the Fiemme valley is one of the *Comunità di Valle*, intermediate administrative entities between the province and the municipalities, which are used in the autonomous province of Trento. The Val di Fiemme *Comunità territoriale di Valle* covers an area of approximately 300 square kilometers and comprises nine municipalities: Capriana, Castello-Molina di Fiemme, Cavalese, Panchià, Predazzo, Tesero, Valfloriana, Ville di Fiemme, and Ziano. Morphologically, it is an alpine valley with altitudes ranging from 800 meters to 2,842 meters asl in correspondence with the Latemar Group, and has a continental climate typical of the central southern Alpine zone.

Unlike many areas in the Alps, in the Fiemme Valley, forest production and wood processing activities continue to be of great economic importance. The significance of current forestry policies is also underscored by pioneering environmental certifications such as the Forest Stewardship Council (FSC) and the Programme for Endorsement of Forest Certification schemes (PEFC) [44]. In fact, environmental conditions prevented this area from adopting an agriculture-based mixed system, which is typical of lower-elevation valleys in Trentino where cereals, grasses, vines, and mulberry trees were cultivated [45]. Although there were some cereal crops (barley, wheat, oats, and corn), the economy of Fiemme Valley has always revolved around its woodland and pasture resources. In 1673, Michel'Angelo Mariani described the region around Trento by stating, “the heart of the valley is its timber, particularly larch, fir, and spruce trees [...] From these forests, not only is a considerable amount of butter and cheese obtained [...] but its highest peaks also provide pastures for thousands of sheep that come here every year” [46, page 589].

The importance of woodlands for local communities was twofold: on the one hand, they provided essential resources for residents' basic needs, such as firewood and construction timber; on the other, they were high-value commodities, especially coniferous timber, which could be traded in the markets of the Po Valley. As Mariani once again noted, the Avisio stream was used “to transport the large amount of timber from Fiemme out of the Valley to various destinations, including Italy, through the Verona route” [46, page 587]. Equally significant were the grazing areas, consisting of high-altitude grasslands, where alpine transhumance and grazing practices have linked the mountains of Fiemme with the plains of the Adige Valley since the 13th century [47].

The system of ownership and possession that evolved over the centuries was linked to this ecological context and agro-sylvo-pastoral structure. It was centered around a collective resource management body known as the *Magnifica Comunità di Fiemme*. This entity is described as “the most significant example of a rural community in terms of size, authority, and tradition” [48, page 3] in the Italian scenario. Established in 1111 AD following an agreement between representatives of

the valley communities and the Prince-Bishop of Trento, the *Magnifica Comunità* was a form of self-governance that has continued to the present day. Alongside its civil and judicial responsibilities, the *Comunità* was entrusted with the management of common lands, including woodland and pastures, which formed the core of the cultural and economic system underpinning the organization of rural communities [49].

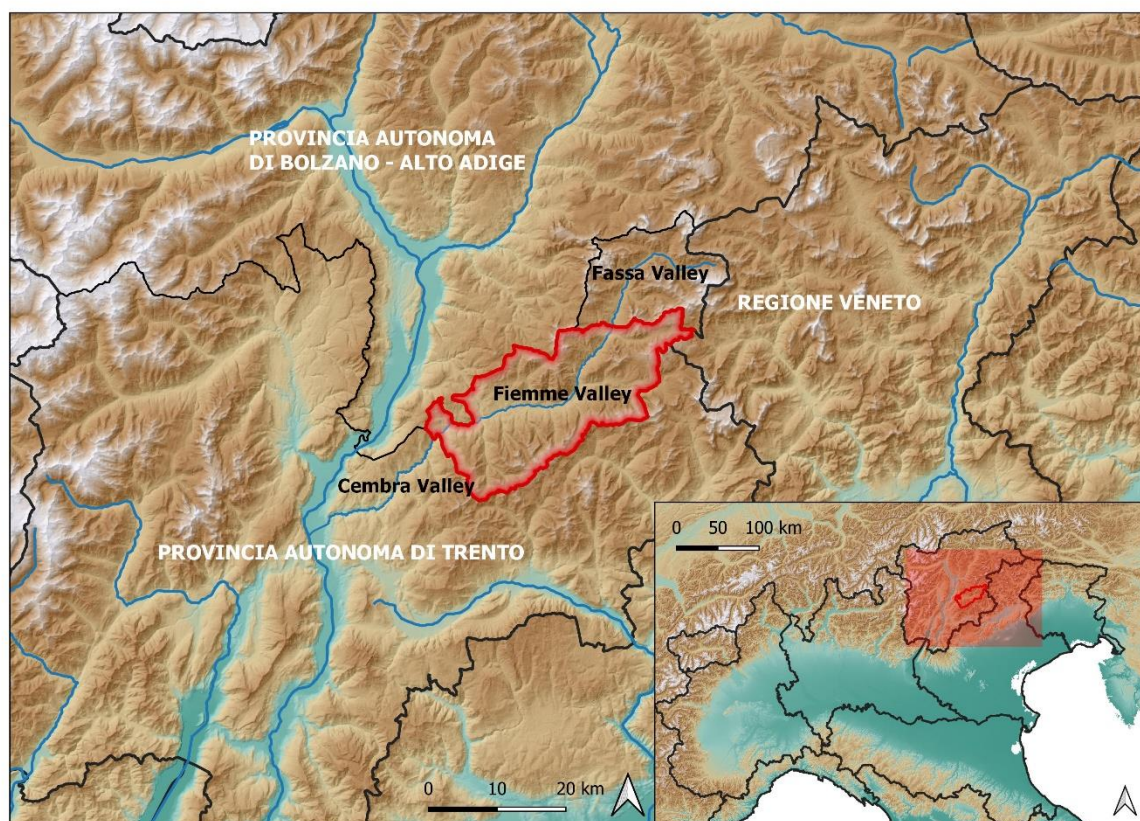


Figure 1. Localization map of the Fiemme valley in the Italian Province of Trento, at the border with the Province of Bolzano/South Tyrol and the Veneto Region.

Despite undergoing a number of changes over time, the *Magnifica Comunità*, maintained a relatively stable structure that was organized across various levels. Heads of households elected representatives from within their towns who served on the *Regola*, in charge of managing *regular* property. The *Regola*, in turn, elected representatives on the *Magnifica Comunità*, which owned the majority of the common lands. The common lands were rotated among the different *Regole*. Therefore, collective properties were divided into *regular* properties (belonging to the *Regole*) and community properties (temporarily entrusted to the *Regole* by the *Magnifica Comunità*).

The rules governing collective resource management were documented in statutes. The statutes were initially drafted in 1480 AD, further refined with the *Quadernollo* of 1533, and ultimately implemented in the *Consuetudini* of 1613. They were divided into four books, with a fifth book added to address woodland regulations [50].

The significant autonomy of the *Magnifica Comunità* began to diminish in the late 18th century. Conflicts with the authority of the Bishop initially arose, followed by clashes with Habsburg and later Napoleonic regulations, which gradually restricted its prerogatives [42].

After World War I, the valley, along with the entire territory of Trento, was annexed to the Kingdom of Italy. In 1927, as a result of legislation on the liquidation of common uses, the *Comunità* was redefined and became a “general shared ownership by condominium” among the eleven municipalities in the Fiemme Valley, with a government-appointed president. In 1950, after the establishment of the Italian Republic, the *Comunità* reclaimed its historic rights to manage state-owned collective property. Today, the *Magnifica Comunità di Fiemme* operates as a collective legal entity that is distinct from the municipal administrations and the *Comunità di Valle*. It represents all the *Vicini* (residents in bloodline) and manages a land estate of approximately 20,000 hectares, which includes forests, pastures, and uncultivated lands.

Currently, conifers make up 99% of the forest stock in the valley [6, page 168], covering about 26,000 hectares, with a strong prevalence of spruce (*Picea abies* (L.) H.Karst., 1881). This species occupies at least 60% of the wooded area, along with larch (*Larix decidua* Mill., 1768) accounting for approximately 20%, and a mixed forest (around 14%) that includes silver fir (*Abies alba* Mill., 1759), mountain pine (*Pinus mugo* Turra, 1764), Swiss pine (*Pinus cembra* L., 1753) and black pine (*Pinus nigra* J.F.Arnold, 1785), alongside some broadleaf trees such as beech (*Fagus sylvatica* L., 1753), chestnut (*Castanea sativa* Mill., 1768) and green alder (*Alnus alnobetula* (Ehrh.) K.Koch) [51, page 146]. The woodland is primarily located between 1,000 and 2,200 meters above sea level, on both the orographic left slope (showing nearly continuous coverage) and the orographic right slope, interspersed with pastures and meadows. In 2018, the Vaia storm, accompanied by a powerful sirocco wind with wind speeds of approximately 200 km/h, caused significant damage to the valley and to the entire Alpine region, resulting in the felling of thousands of hectares of woodlands.

Specific areas of the Val di Fiemme have served as an important laboratory for Italian forestry since the 1960s. Small-scale research conducted by Pietro Piussi has been pioneering in numerous fields, including the study of forest limits, stand regeneration, seed production, and their interactions with anthropogenic activities, specifically analyzing issues and potentials associated with practices such as grazing and logging [52,53]. In many areas, structural diversity has rather been attributed to human disturbances than to natural factors, even within so-called ancient forests [54]. Notably, 19th-century clear-cutting and selective logging, as well as artificial regeneration, appear to be the major causes of the current presence of monospecific stands of spruce [55]. Drawing on this experience, Piussi has frequently criticized the tendency to carelessly adopt Northern European forestry practices, advocating rather the need to conduct localized and historically-informed research [56]. This line of research has continued steadily to the present day. Other recent studies have investigated changes in the forest's altitudinal limits using sources such as aerial photographs from the 1950s and 19th-century cadastral maps [57]. Thus, a comprehensive body of reference literature is available for the area with which to reconstruct the environmental dynamics beyond the time frame addressed in this paper.

2.2. The source: the documentation of the Austrian-Trentino Commission

Val di Fiemme has a distinctive and peculiar history in the broader Italian context. This is mainly due to the long dominion of the German Empire, and subsequently, the Habsburg Crown, which continued until the conclusion of World War I when the region came under the rule of the Kingdom of Italy. Throughout this historical context, Val di Fiemme had been subject to the authority of the Prince-Bishop of Trento since at least the 12th century, and formed the northern border, sharing boundaries with the County of Tyrol and the Episcopal Principality of Brixen.

In the 18th century, the Habsburg dynasty started to develop a strong legislative agenda aimed at redefining and standardizing its diverse components, and aligning them with a more centralized

policy known as *Staatswerdung*. This comprehensive approach extended to the realm of forestry governance, as per the tenets of physiocratic theories and German forestry science [36].

Mauro Nequirito [48] and Mauro Agnoletti [58] have meticulously documented this process in regard to Trentino. In 1763 AD, an administrative body endowed with governing authority, the *Gubernium*, was established in Tyrol. Specific forestry offices (*Waldämter*) were placed under its authority, including the office in Fiemme, also known as the Supreme Office of the Forests. The primary aim was to dismantle the existing system of communal autonomy, achieved through the promulgation of forestry regulations aligned with the principles of *wenüfnige Waldwirtschaft*, denoting a rational approach to silviculture. Numerous directives were issued from Vienna with this purpose, although many were not implemented. In 1768, Maria Theresa enforced the abandonment of communal grazing in favor of expanding cultivated lands, while in 1770, the Tyrolean government issued a directive in support of the partitioning of common lands. Joseph II introduced new regulations in 1781 and 1783 to enhance the protection of forests and strengthened the authority of forestry offices as overseers of woodland resources.

Within this framework, notable documents include a comprehensive survey of the state of the forests in Val di Fiemme, which was undertaken by a collaborative Austrian-Trentino Commission between 1787 and 1788. The significance of these historical events has already been substantiated in the political-institutional history of the Trentino region within the broader Habsburg Empire [42,48]. This period marked the consolidation of Habsburg and Tyrolean authority, following the initial enactment of forestry legislation. The imperial authority sought to legitimize itself as the driving force behind forestry reforms while negotiating governance practices with local communities. The main participants in this endeavor were the Prince-Bishop of Trento and the *Magnifica Comunità di Fiemme*, which represented the self-governing entity of a region in which previous directives had often gone unheeded. The findings of the Commission, currently available in various archival collections [59–62] and offer a comprehensive view of the socio-environmental landscape related to the coniferous forests in 18th-century Val di Fiemme. The survey captures a pivotal moment of transition between longstanding customary practices and the policies that would come to define the 19th century [48] (pp. 56–75).

The Commission took office on August 15th, 1787, in Cavalese, the administrative center of the valley, and was made up of three members: an Austrian contingent led by Giovanni Antonio Wernsbacher, Director of the Tyrol Forestry office, with assistance from the submaster Giuseppe Antonio Untergasser of the local Forestry Office; an episcopal group represented by the legal expert Giuseppe Antonio de Riccabona; and another group representing the local populace, led by Giacomo Antonio Gabrielli, who held the position of *Scario* (the head of the *Magnifica Comunità*).

The appointment of Giuseppe Antonio de Riccabona as the representative of the bishop is an example of the intermingling of public and private interests. The Riccabona family of Cavalese is a prominent example of individuals who held significant administrative roles and at the same time were engaged in timber trade. Giuseppe Antonio, for instance, was a merchant but also an influential politician in the *Magnifica* and the Parliament of Innsbruck [42,63].

In principle, the commission had a dual purpose. First, it aimed to establish a sustainable, enduring resource for commerce which encompassed mapping and describing the woodlands selected for the sale of timber to be transported along the River Avisio and which was subject to the commercial duties of the trading center in Lavis. At the same time, the commission also sought to ensure the preservation of the forests and meet the needs of the inhabitants in the valley.

As per the preparatory documentation, the commission was tasked with compiling detailed descriptions for each wooded area. These descriptions included several aspects, including ownership, dimensions, capacity, quality and boundaries. Furthermore, the Commission was charged with assessing the current and anticipated state of each woodland, specifying the time for timber harvesting and quantifying the volume of merchantable timber.

The responsibilities of the commissioners extended beyond these assessments. They were also tasked with identifying woods to be reserved for local community use, which included the timber needed for charcoal production, firewood, building activities and other essential requirements. Additionally, the commissioners were expected to designate areas for *roncare* (an obsolete term used to define the cutting and temporary cultivation of a part of the woodland) to sustain the local population. They were to report on any damages resulting from timber cutting and sowing activities within the woods. The identification of transportation routes for timber, with a priority given to the Avisio waterway leading to Lavis, was another crucial duty. Finally, the commissioners were responsible for identifying woods at risk of overcutting, which were to be set aside (*ingazzare*) for future preservation.

The commissioners began their work on August 16th, 1787, performing a number of site visits and descriptions. In some instances, they conducted on-site inspections, while in others, they relied on the assessments of appraisers, who were predominantly representatives of the *Regole* or employees of the Forestry Office.

The declarations had a common template, albeit differently tailored to each area, depending on the recorder and the declarants. The declarations included key elements such as entitlement, date and place of issuance, particulars of the respondents, a description of the plot with details of the toponym, the count of pieces, their intended use, details of ownership and possession, the species present, the delineation of boundaries, and woodland dimensions using units in merchant pieces of timber, or “*pezzi*” and “*tajoni*.”

The Commission concluded its work in the autumn of 1788. The official documents were duplicated and then distributed to various entities, including the local *Magnifica Comunità*, the Forest Office, and the authority of the bishop. As a result, multiple versions of the records can be found in several local archives.

The descriptions in the documents were actually much less detailed than expected. While they consistently provide information about ownership and estimated timber capacity, the same cannot be said about the details of the tree species present or the local uses of the woodlands. Nonetheless, these studies provide us with a valuable analytical snapshot of the prevailing state of the woods well in advance of another comprehensive official historical source, namely the Austrian Land Cadaster, which was created between 1852 and 1861.

It is important to approach this documentation with two important caveats. First, the census covers exclusively “black woods” (i.e., coniferous woodlands subject to forestry regulations and of tangible commercial value). Any reference to the presence of broadleaf or “leaf forests, which sporadically exist and complement the former,” is only briefly mentioned. Secondly, the documents of the Commission do not provide a neutral, purely observational perspective. As will become evident, they adopt a viewpoint deeply imbued with official language and regulatory provisions. By classifying local forests according to the categories provided by forestry legislation, each of which corresponds to different activities that were either permitted or prohibited, the Commission takes on a prescriptive role. It incorporates Austrian regulations and explicitly prohibits activities ‘such as

sawing, clear-cutting, regeneration of thickets beyond the boundaries of one's regular and private meadows, and, grazing, particularly of goats' within state forests [64].

Indeed, the primary focus of the Commission lies in overseeing forest resources that are conducive to commercial exploitation. It clearly discourages alternative uses, which are chastised as being "potential causes of damage to the woods, including practices such as *roncare*, uncontrolled cutting, and the expansion of wood collection activities" [65].

2.3. Georeferencing and analysis of primary sources

The documentation from the 18th-century survey, notable for its unusual systematic approach during that period, underwent processing using QGIS software [66]. A geolocalized dataset was created, enabling the spatialization of the information obtained. Nonetheless, the context in which this documentation was originally generated must be taken into account. As Pathak aptly observes, "colonial documents are ambivalent and present a conjunction of opposing tendencies, appropriation and conservation, coercion and legitimation, and coherence and arbitrariness" [29, page 12]. This insight is also applicable to the extensive body of documents that emerged from the study carried out by the commission. As outlined in the subsequent section, these documents combine both descriptive and prescriptive elements.

As elucidated, Commission's primary objective was to compile a survey of wooded parcels earmarked for potential market inclusion. The descriptive details provided present a tapestry of diverse tree and shrub populations, at various stages of maturity. These populations are the result of management practices undertaken by local communities. However, it is worth noting that these local practices, associated with multiple uses, are not explicitly indicated, as they fell outside the purview of the survey. Indeed when mentioned, the practices are viewed with a very critical eye because potentially detrimental to the resource as they were being used for purposes other than the interests of the State (the insights of Scott [32] concerning the delegitimizing language employed by the State are particularly pertinent in this respect). Consequently, the criticism and allegations made against various local communities for engaging in practices that could harm vegetation cover can be interpreted as indicators of the spreading of these local practices. These traces hint at a complex network of interests that permeates the entire valley.

Analysis of the documentation allowed the enumeration of 122 wooded parcels, situated in an area equivalent to the present-day territory encompassing the Val di Fiemme Community and the municipality of Moena. Each parcel was categorized within a dataset and assigned a distinct and unique code. The extensive textual descriptions were organized into a tabular format, with each entry containing a comprehensive set of inferable information for each woodland. Whenever feasible, a normalization procedure was implemented to enable quantitative analyses: main toponym, secondary toponyms if any, toponyms of neighboring plots, type of plot according to the nomenclature used (forest, forest with open patches, *gazzo*, wooded meadow), ownership, possession (if different from ownership), number of pieces intended for the market, local uses, presence of spruce, presence of larch, presence of fir, presence of pine, presence of Swiss pine, and status.

The parcels were identified and mapped mainly through toponymic references, supplemented with information from adjacent plots. Several of the toponyms employed in the 18th century are still recognizable today, either in slightly altered or identical form, on contemporary provincial technical maps at a 1:10.000 scale [67]. Furthermore, many of these toponyms could be cross-referenced with

the maps generated during the same period by Giuseppe Antonio Untergasser, a commission member and official of the Forestry Office of Cavalese [68,69]. Although detailed information regarding this historical cartography is limited and resides in the Historical Archives of the *Magnifica Comunità*, its chronological alignment and the substantial overlap in place names with the woodland documentation suggest its utility in supporting the work of the commission. Although not strictly zenith and geometric, the cartography provides sufficient detail to enable the incorporation of toponymic references into contemporary cartography at an appropriate scale (Figure 2) [69].



Figure 2. Map with no name and date, attributed to Giuseppe Antonio Untergasser, Forest Officer of Cavalese (around 1788), with localization of place names related to woodlands visited by the commission.

A point vector layer was selected to spatially reference the information from the dataset in GIS. Given the absence of precise data on boundary delineation and on the exact dimensions of woodland plots, experimenting with a number of solutions proposed in the existing literature proved to be unfeasible.

The decision to use a point vector layer stemmed from the intention to address the inherent challenges of the source document while minimizing the risk of overinterpretation. It is well-recognized that historical textual sources have an inherent degree of indeterminateness and ambiguity, especially in relation to their spatial references. Furthermore, these sources frequently lack specific details in terms of the extent and exact boundaries of their features. For these reasons, the point-based data format was considered the most appropriate approach for representing the inherent

indeterminateness of the textual descriptions. It is worth noting that not all scholars and researchers concur with this approach [70,71].

The data classification and mapping process resulted in the creation of a geographically localized historical GIS, containing information on the geographical distribution of 18th-century forested plots at valley scale. To analyze the woodland structure, the available data was processed and the percentage of mentions was calculated for each individual species and/or tree associations described at each site to highlight physiognomic composition. The first issue was identifying the woodland types mentioned in the documents of the commission, which employ a nomenclature that is not inherently straightforward. The terminology used is a fusion of German-speaking, Italian-speaking and Tyrolean dialects. The distinction between “bosco di foglia” (leaf woodland) and “bosco nero” (coniferous, called black woodland) is influenced by definitions in the German-speaking world, such as *schwarzwald* [58]. To address this, the woodlands types were categorized into four groups during the analysis: “woodland” when there is no specific indication, “woodland with open patches” if partially cut for commercial or agricultural purposes, “opened woodland *fratta*” if entirely clear-cut, “protected woodland” (*gazzo*) if over-exploited and the parcel is then subject to restrictions and set aside, and lastly, “wooded meadow or grassland”. The latter term specifically refers to “scattered plants among meadows,” highlighting that the designation of woodland was rather broad and coexisted with grazing activities but was not officially recognized. The interpretation of this data was greatly facilitated by cross-referencing collateral documentation and consulting a wide array of primary and secondary sources. This included documents related to disputes that arose in the years immediately following the survey, particularly for certain areas. At the same time, a comparative analysis with the present state was conducted; this was facilitated by on-site reconnaissance at specific locations, such as those originally surveyed as larch woodlands, and by the use of current vegetation distribution maps produced by the Forestry Service of the Autonomous Province of Trento [72].

3. Results and discussion

3.1. Properties and possessions

Mention has already been made of the broad variety of jurisdictions that affected the valley. This heterogeneity can also be seen in the ownership of forest resources. The descriptions of the Commission consistently include information about ownership and possession. Woodlands within the valley show a wide array of different rights, stemming from collective, feudal, state, and private origins (Figure 3).

A significant portion of the wooded sites (40) are under the ownership of the *Magnifica Comunità di Fiemme*. These properties, as per the *Consuetudini* of 1613, were assigned in a rotating fashion every four years to various *Regole*, catering to local needs. They are distributed across the entire territory, situated at higher elevations and often at some distance from inhabited areas, predominantly on the orographic left slope of the Avisio. Other notable woodland owners within the valley include some of the *Regole*, such as Moena (17), Predazzo (9), Tesero, and Varena (5). Figure 3 illustrates the distribution of 18th-century woodland properties superimposed on the current municipal boundaries. It is evident that the geographical arrangement of the 18th-century system is aligned with the contemporary administrative divisions (with the exception of Ziano) [73]. This observation suggests not only a substantial spatial continuity but also emphasize the central role of communal properties in shaping and supporting the administrative structure.

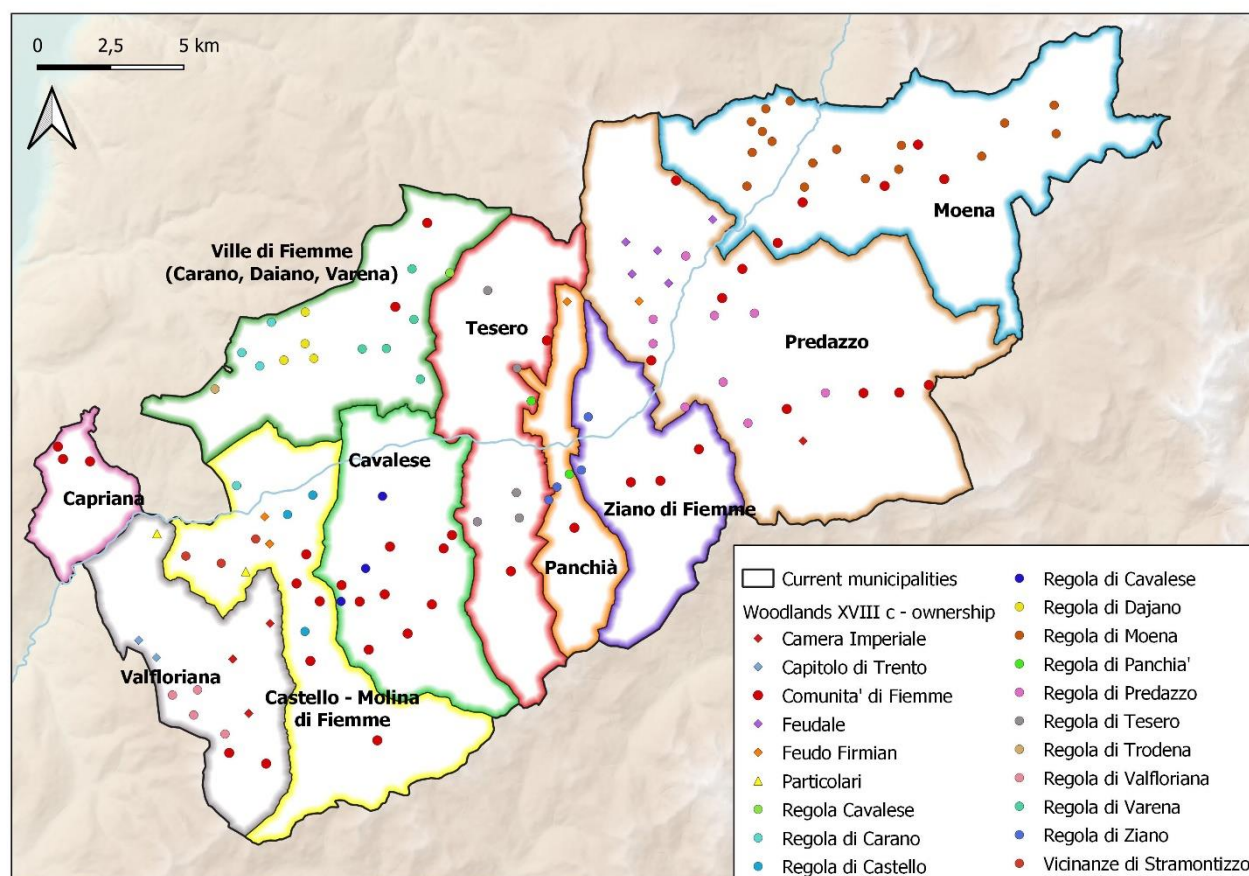


Figure 3. Localization of 18th-century woodlands in the Fiemme Valley with ownerships. Borders refer to current municipalities.

Of a different nature are other rights exercised over woodland of various origins. Those of feudal lineage include the Firmian properties (4), which are situated close to Predazzo and Molina, and the *Regola Feudale di Predazzo* (5) (the feudal *Regola* of Predazzo differed from the *Regola* of Predazzo and stemmed from an agreement forged in 1608 by local families to exclusively retain certain properties and remove them from the jurisdiction and control of the *Magnifica*). Instead, the properties of the House of Austria (4) and the Bishopric of Trent (2), located to the southwest on the border with Val di Cembra and to the northeast on the border with Paneveggio (a large Habsburg property not included in the survey), are of state-owned nature. Woodlands classified as private, or *particolari*, are notably limited in number. Only two such instances are identified, emphasizing the low significance of this category in relation to forest resources. These woodlands are positioned in the southwest and comprise the “Bosco dei masi” and the “Bosco delle Vicinanze”. Both are limited in size and comprise mainly spruce and larch. They appear to have multiple ownership, involving local tenants and notables [74].

A prevalent practice, showing at least 36 instances, is the concession of possession, which involves temporary usage rights being granted to other parties. This practice is particularly prominent in the woodlands owned by the *Magnifica Comunità*, with eleven sites permanently granted to the *Regole* of Castello, Cavalese, Predazzo, and Trodena, in addition to their direct ownership. Furthermore, two woods are granted to the *Regola* of Forno, located outside the *Magnifica*, for purposes of common interest, specifically for the maintenance of bridges over the Avisio. Possession

of both the woods owned by the bishop are granted to the Community of Valfloriana. Additionally, a considerable number of wooded meadows in Predazzo, whether held feudally or owned by the *Regola*, are made available for use by unspecified private individuals, most likely the tenants of agro-pastoral farms.

3.2. Local uses and practices

With regard to local practices, usages and productions, not all visits result in specific descriptions. Given the primary interest of the commission in wood production for the Italian market, its focus lies on quantifying timber and transportable wood along the Avisio. To facilitate trade, the commissioners actively engage in defining transportation routes, with particular recommendation for the construction of *stue*, which are systems of canals and dams [75]. These infrastructure improvements allow timber to be transported on smaller waterways up to the Avisio, thus streamlining the process [6] (pp. 144–152). Alternative transport methods, albeit less advised, involve the use of mountain passes. In general, the woodlands located in the southern part of the Valley, which are owned by the Habsburgs, feudal entities, or the *Magnifica Comunità*, are exclusively allocated for the market, representing 52 woodlands (42.6 percent of the total sites).

All the woodland are destined to timber trade but some also have other uses. These uses are mentioned only incidentally (as in the case of *Regole* woodlands in particular) and chiefly as justifications for not placing specific plots on the market (Figure 4). Only few woodlands are entirely allocated to meeting the needs of local communities, at times with a general label such as “wood for construction and maintenance” (21, representing 17.2 percent) or “firewood” (16, representing 13.1 percent). In terms of usage, fir wood is primarily employed for construction purposes, while pine and stone pine are used for firewood, charcoal production, and kilns supply.

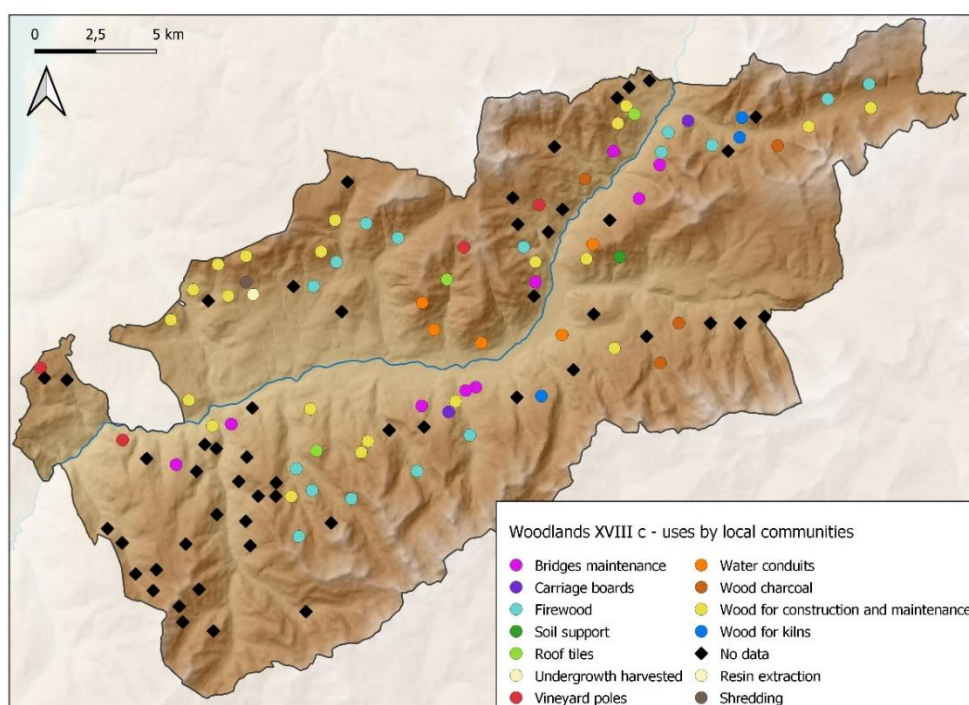


Figure 4. Local uses of the different 18th-century woodlands located in the Fiemme Valley.

On some occasions, specific purposes are defined. For instance, there are nine woodlands, including one explicitly named “del Ponte” (of the bridge) near Predazzo, reserved for repairing bridges subject to seasonal damage due to the torrential nature of Alpine streams [76]. Other frequently mentioned productions encompass the construction of water conduits (5, primarily using pine), wood charcoal production (4, located in the north of the valley and involving spruce and larch), kilns supply (3), roof tiles repairs (3), and the supply of poles for vineyards in the nearby Cembra valley and Lavis plain (4, predominantly consisting of larch)—the latter representing a non-local use that highlights the close integration with agricultural activities. In a specific case, the “Bosco di Fontana” above Predazzo is designated to support the soil of a particularly landslide-prone terrain.

Furthermore, it is noteworthy that the inhabitants of the village of Daiano face severe criticism for two practices deemed harmful to the well-being of the woodland and explicitly prohibited by Habsburg regulations. These practices entail the extraction of resin from larch trees, which is intended for trade and used for medical purposes, as well as the shredding of pine trees and collection of their leaves for use as sheep bedding.

The commission adopts a rather reticent stance on the multifaceted use of resources, particularly the coexistence of cultivation or grazing activities. Notably, it provides specific information only for the Cermis communal woodland, which is described as being “occupied by a shepherd with three huts for sheep” [77]. This reticence is evident even in areas like Capriana, where previous research has indicated the presence and significance of these activities [22]. The studies conducted by the commission mention these activities only in peripheral and border areas, and its remarks are often accusing and targeted at neighboring communities engaged in dairy farming and in depleting the resources of the forest, as seen in the case of Forno or Anterivo. The documents refer to the presence of *fratte*, or open spaces within the forest used for sowing, temporary cultivation, or mowing, primarily for “*roncare* for the livelihood of the many people” [65]. *Ronco*, the process of creating cleared patches in the woodlands, is achieved through clear-cutting or controlled fire and is strongly recommended for deciduous woodlands but not for conifers. The use of fire, however, is never explicitly mentioned in the studies by the commission, except when attributed to neighboring communities. This reason for this is that while it was condemned by the Austrian forest regulations, it was permitted under the Fiemme regime. As a result, it was practiced, but official records typically attributed such practices to others.

In the case of forests that were overexploited by local communities or logging companies, the approach was to *ingazzare*, or set aside plots for several years, prohibiting access to them [48] (pp. 56–76).

The recommendations of the commission, on the other hand, advocate for an increase in the utilization of broadleaf trees for local needs while reserving conifers for trade, as exemplified in the case of the Bosco di Runcadin. In this instance, the commission suggests that “in case fires or other misfortunes oblige neighbors to use more wood for repairs and maintenance [...] the *Regolano* should privilege white wood [broadleaf woodland] at the bottom of the mountain for the neighbors own use” [74]. Other uses are sporadically referred to in the attached documentation, particularly in the context of disputes. This is the case of the conflict that arose between the *Magnifica* and the Feudal *Regola* of Predazzo regarding compensation for the provision of “firewood” and “charcoal wood” for both local inhabitants and commercial enterprises. The Feudal *Regola* asserts the right to collect “the small piece of wood [...] abandoned in the woodland”. [74] Another document is a public proclamation against the practice of removing wood for “crafting poles, hedges, and firewood” [65].

In summary, this document provides insights into a system of woodland resource management that represents a compromise between the principles of forestry science and local practices and knowledge. While certain local practices do surface, they are often unofficially documented.

3.3. Woodland coverage extent and composition

Reconstructing the exact extent of woodland cover based on this documentation is not feasible. This limitation arises from the fact that the capacity of each individual plot is estimated in terms of merchantable pieces of timber and not of its surface area; the density of vegetation is not taken into account either. Figure 5 is based on this measurement unit and illustrates the point elements corresponding to woodlands of sizes directly proportional to their timber production. Nevertheless, it is evident that the majority of wooded areas were located on the southern side of the valley. Conversely, the northern side, which is exposed to the sun and thus more suitable for agricultural crops or meadows, contained smaller wooded areas, except at higher altitudes. Notably, there was a relative scarcity of woods in the northeastern end of the valley, which today is completely forested. One plausible explanation for this scarcity is the strategic importance of these areas, such as Bellamonte, which served as a grazing reserve for transhumant livestock during the summer. This pastoral use most likely deterred the widespread planting of coniferous trees in that region. It is once again emphasized that deciduous woodlands are entirely absent from the census, which suggests their existence at lower altitudes, “at the foot of the mountains” [74].

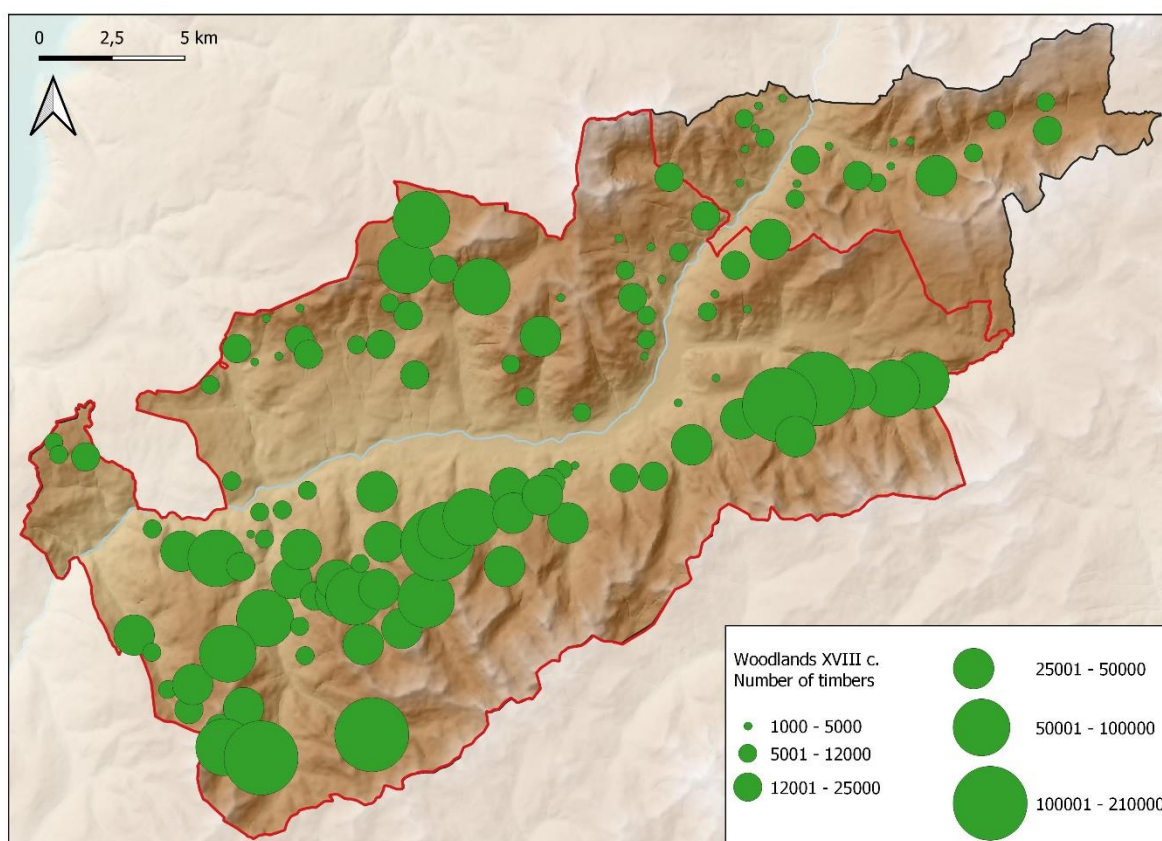


Figure 5. Size of the 18th-century woodlands located in the Fiemme Valley in proportion of their timber production.

Figure 6 shows the distribution of different kind of woodlands as reported in the sources and explained in the methodological section. Wooded meadows appear to be mainly situated on the sunnier northern slope and are predominantly planted with larch trees, while dense coverage of spruces was predominant on the southern slope. Unfortunately, not all descriptions provide specific information about the type of trees present, with 62 out of 122 descriptions primarily located in the northern slope lacking such details. The most frequently mentioned species is larch, found in at least 45 plots, followed by spruce (42). In contrast, Swiss pine (9), mountain pine (8), and fir (6) are mentioned much less frequently. The selection of these species is already indicative of their distribution in the alpine environment and also of their commercial value and local requirements. Each species appears to serve predominant uses, as outlined in the previous section, and has its own (although incomplete) geographical distribution, only partially in line with the present-day scenario (see Figure 7) [72]. Spruce seems to be mainly located in the north, often together with larch, whereas today it is mainly found in the southern slope. Pine woodlands seem to have dropped in size, while *Pinus cembra* is documented at lower altitudes than today, frequently in association with spruce and larch. The most significant disparity, however, is seen in the distribution of larch, which was found either in isolation (only in 14 mentions out of 45) or in conjunction with other species along the entire northern slope at various elevations, whereas it currently accounts for only 20 percent of the canopy.

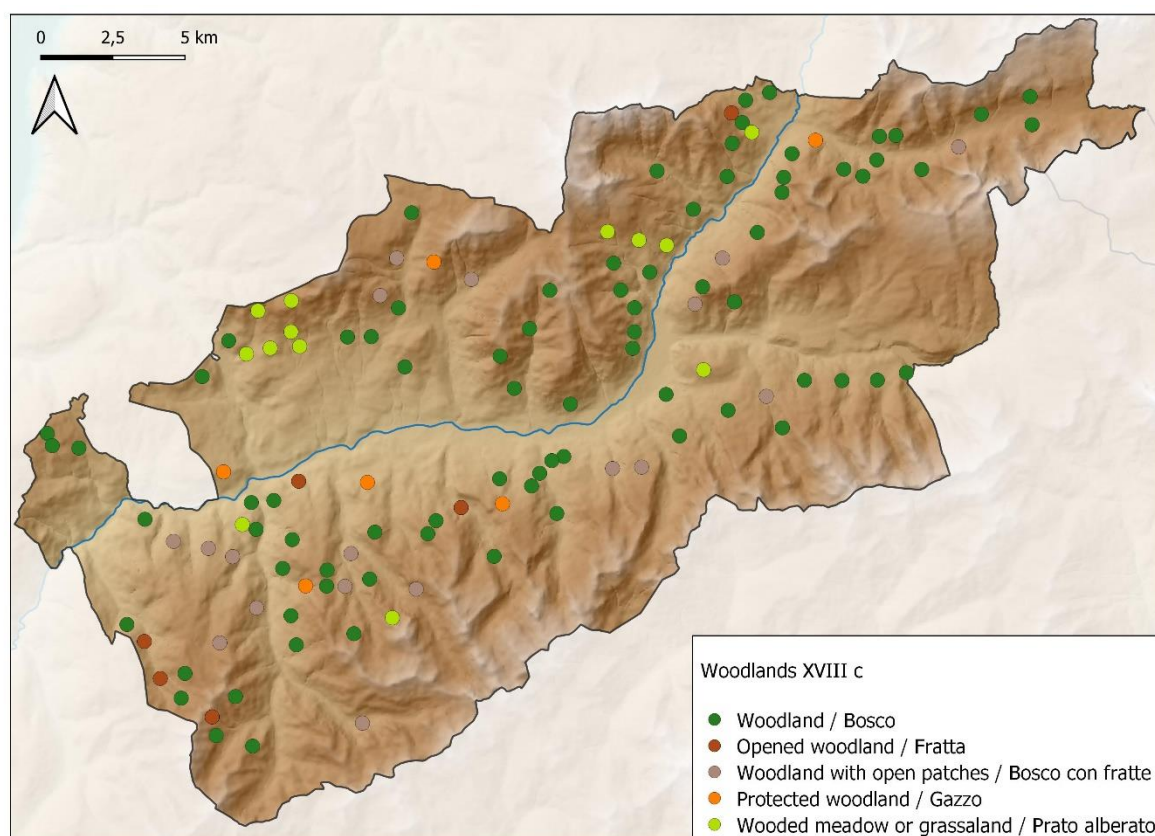


Figure 6. Spatial distribution of the different types of 18th-century woodlands in the Fiemme Valley.

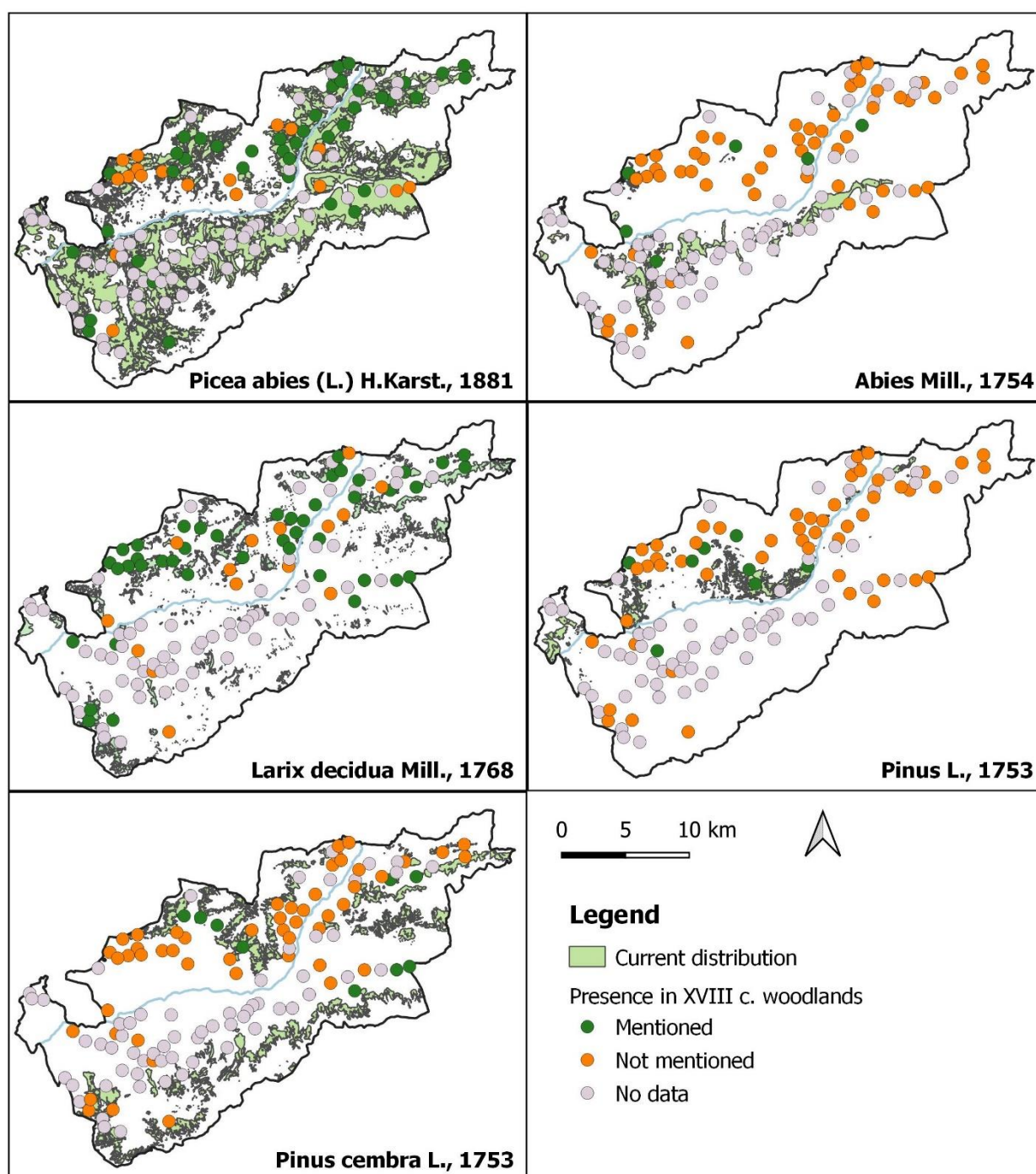


Figure 7. Spatial distribution of the main different tree species of 18th-century woodlands in the Fiemme Valley compared with current distribution.

Frequently, the documentation also contains information about rotational growth and cutting cycles, a feature of coppice management. These details are crucial in estimating the timber available for trade in the coming years. Rotational cycles encompass a range of timeframes, and the stages of growth and maturity suitable for cutting vary between 20 and 180 years, with no significant variations observed across different species. Essentially, the monitoring activity of the commission transitions into a programmatic approach, culminating in the formulation of a forest management plan. This plan, similar to those studied by Berretti et al. [54], includes guidelines for the cutting

process, which could be selective—by choice, or by fraction—and at times entail the complete clearing of an entire woodland sector.

4. Conclusions

This work has focused on a specific historical period and event, relating to a commission for the mapping of forest resources in the late 18th century in an Alpine valley, Val di Fiemme. This documentation has led to two significant outcomes: one concerning the history of environmental resource management; the other concerning the sources for the history of wooded landscapes.

The primary aim of this paper has been to address the topic of 17th to 18th-century forest legislation, often interpreted as an attempt to safeguard forest resources. In some areas, the spread of administrative regulations in wooded areas “was a reaction to the increasing utilization of forest resources” [30] (p. 438). This paper argues that Val di Fiemme legislation sought to make an inventory of the resources in order to remove them from the control and uses of local communities and direct them toward the productive market under Habsburg control. This attempt was only partially successful, given the numerous conflicts that continued to persist throughout the subsequent century [42].

This census operation has indeed been construed as ostensibly neutral, serving instead as a transitional phase from a system of woodland management grounded on customary and community-based rationales to one administered by the central state. The latter was driven by conservative and productive principles aligned with the forest regime that gained ascendancy across the German-speaking world during the 18th and 19th centuries. This model, promoted by Habsburg legislation, sought to curtail the supplementary uses of the woods, prioritizing specialization in the production of high-quality timber for the market. Its gradual enactment, exemplified by these events, underscores the intricate center-periphery dynamics that were negotiated within the Ancien Régime to regulate resource utilization.

In fact, it has been possible to identify the emergence of a “colonial” discourse concerning the rational management of forest resources in this peripheral Alpine area of the Habsburg Empire, similar to that documented in extra-European colonial contexts [29,31]. This discourse frames forest legislation and resource monitoring within a broader context with evidence of the strengthening of a central power over that of marginal communities.

At the same time, the notion of a univocal destination for coniferous woodlands is contradicted if we analytically explore the contents in the study. A patchwork of local uses, including community requirements, grazing, and charcoal production, are all clearly linked to the collective ownership and possession structure of the lands of the valley. At the same time, these practices directly influence the extent of woodland areas and the composition of their species.

As noted by Bergès and Dupouey [39], the diachronic depth of the majority of historical ecology research does not go beyond two centuries due to the lack of quantitative data and georeferenced maps for earlier periods. This gap has prompted various requests to retrieve pre-19th-century data, which may be just as relevant as more recent data for understanding the current state of ecosystems. Forest and ecological history studies in the Fiemme Valley have indeed so far only been applied to the 19th century [56,57]. Transforming archival documents into systematically organized datasets within a GIS environment is regarded as a useful strategy for making documentation valuable to landscape ecologists [3,15,40,56,78]. In this context, the use of GIS software and the construction of a geodataset have enabled a systematic spatial interpretation of 18th century textual data—specifically, the data contained in the commission’s study—that would otherwise be

challenging to analyze. Nevertheless, when interpreting this data, both the indeterminateness and gaps in the collected documentation and data need to be considered.

The compiled dataset provides clear evidence of changes in terms of composition, rather than extent, of the forest cover in the valley. The 18th-century woodland geography helps explain the current distribution of certain current forest formations, which are difficult to interpret within the framework of structural ecology but prove to be remnants and legacies of the past socio-ecological system. Furthermore, there has been a shift in the distribution and occurrence of some tree species that have now greatly diminished, such as *Larix decidua*. Local scale studies have already highlighted how this species was closely associated with activities such as grazing and mowing, resulting in landscape forms characterized by wooded meadows, due to its unique biological and ecological characteristics [22]. These studies have also documented its gradual decline owing to its limited competitive ability against species such as *Picea abies* [79,80]. The dialectic between spruce and larch continues to be of interest in the current context. For instance, it is worth considering how, in the aftermath of the devastation caused by the Vaia storm, larch shows lower vulnerability to wind compared to the now more prevalent red fir, as a result of its deep root system and reduced deciduous leaf canopy. With this data, it is possible to confirm these two dynamics at the scale of an entire valley and over an almost three-century timeframe, suggesting a much richer variety of species in the 18th century than today. One of the outcomes of this study, namely the dataset, opens up new perspectives for comparison with subsequent sources. This broader comparison, beyond what was experimentally achieved here, aims to identify evolutionary dynamics and date crucial landscape elements of current biodiversity, such as alpine meadows/pastures and mixed forests, within a range of at least three centuries. Indeed, the paper suggests that human influences throughout the 19th century altered the 18th-century forested landscape, which was very different from the current one in terms of composition, extent, and structure.

In conclusion, Val di Fiemme forest cover presents itself today as a geo-historical artifact. Its distribution, characteristics, and dynamics are still largely influenced by current human management practices or past dynamics. These processes have been conditioned by social practices and the utilization and management of environmental resources over at least the past three centuries. Intertwining the identification of species with that of rural practices also leads to developing hypotheses of mutual relationships between the two, which will be explored in subsequent analyses. In particular, some open larch forest systems can be considered bio-cultural heritage, based on their correlation with grazing activities or turpentine extraction, despite being restricted by forestry regulations. This opposition may be the cause of the gradual shift and reduction in the range of this species during the 19th and 20th centuries. The historical understanding of ecological dynamics can also provide valuable insights into the current management of forested areas, and historical geography can contribute its expertise to the study of past woodland cover and biodiversity diversification processes.

Use of AI tools declaration

The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

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Conflict of Interest

The authors declare no conflicts of interest in this paper.

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