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Synergies of planning for forests and planning for Natura 2000: evidences and prospects from northern Italy

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Abstract

Improvements in the management of Natura 2000 sites are essential to achieve the targets set out by the Habitats and Birds Directives of the European Union. A current focus is on the development of management plans, which are fundamental instruments in the implementation of conservation measures. This study explores the viability of using existing forest plans to assist in this purpose. As case study, we consider the regulatory framework of the Veneto Region, northern Italy. We collected quantitative and qualitative data on forest plans at the regional and at three sub-regional spatial scales: local, district, and biogeographical. Forest plans cover about 54% of the terrestrial area of Natura 2000 sites in Veneto, and 75% of Sites of Community Importance in the Alpine biogeographical region. At the local scale of analysis, metrics from forest plans represent a valuable historical record which can be used to interpret the current state and future trends, especially for forests with long management records. These data can be used to assess biodiversity indicators for the monitoring of Natura 2000 forest and non-forest habitats, in compliance with Article 17 of the Habitats Directive. Moreover, the heterogeneous stand conditions which are promoted by some forest management approaches can improve the conservation efforts for some habitats and species. The scale of local forest plans are typically the most appropriate for implementing habitat management strategies. From this study, we conclude that management authorities should take advantage of the wide spatial coverage and distribution of existing forest plans, especially in mountain areas inside and outside the Natura 2000 network, for the successful conservation of European Union habitats and species.

Keywords

Natura 2000, biodiversity conservation, environmental monitoring, forest management, forest planning, conservation status

Introduction

A current focus for protected areas worldwide is the need for improved conservation management of habitats and species (Watson, Dudley, Segan, & Hockings, 2014). In this context, a common goal is to improve the application and use of management planning for the effective protection of habitats (Leverington et al., 2010). To achieve biodiversity goals, planners must consider ecological complexity, economic interests, legal boundaries, and social expectations; making management planning in protected areas a complex task.

For the Natura 2000 network, the flagship European Union (EU) program for protected areas, conservation management is of extreme importance, particularly for habitats and species listed in the Habitats (92/43/EEC) and Birds (2009/147/EC) Directives (Ostermann, 1998). Indeed, the improvement of the management of Natura 2000 sites is essential to achieve the targets set by international agreements (Beresford et al., 2016). The EU biodiversity strategy (COM/2011/0244 final) mentions this need in several different targets, including; "complete the Natura 2000 network and ensure its good management" (action 1) and "integrate biodiversity measures […] in forest management plans" (action 12). Currently, the process of designating Natura 2000 sites is concluded, and the focus is now on appropriate management with an adequate development and implementation of plans (Blicharska, Orlikowska, Roberge, & Grodzinska-Jurczak, 2016; Borrass, 2014; Grodzinska-Jurczak & Cent, 2011; Kati et al., 2015; Křenová & Kindlmann, 2015; Maes et al., 2013). The Habitats Directive, under Article 6(1) (Sobotta, this issue), foresees that "Member States shall establish the necessary conservation measures involving, if need be, appropriate management plans". These management plans can be integrated into other plans if they exist, and the choice of which approach to follow is left to the discretion of the Member States (Dupont et al., 2016). The most common choice is not to use existing instruments, but rather to introduce new instruments outside the existing implementation framework (Bouwma, Liefferink, Apeldoorn, & Arts, 2016). This can lead to overlapping regulatory requirements, which can hinder the adoption of effective and socially responsible policies.

Many planning instruments, such as water protection or forest management plans, are implemented in Natura 2000 sites, which are available tools for site management authorities (Pellegrino, Schirpke, & Marino, 2016). These planning tools are also important because many human activities can impact biodiversity (Tsiafouli et al., 2013). Different types of plans have been analysed in terms of their opportunities, synergies, and conflicts with the Natura 2000 framework; such as river basin management plans (Janauer, Albrecht, & Stratmann, 2015; Stratmann & Albrecht, 2015).
Recently, increased attention has been given to participatory approaches in planning and managing Natura 2000 sites (e.g., Apostolopoulou, Drakou, & Pediaditi, 2012; Dupont et al., 2016; Secco, Favero, Masiero, & Pettenella, 2017), and to stakeholders' perception of such instruments (e.g., Morris et al., 2014; Šorgo, Špur, & Škornik, 2016). However, many Natura 2000 sites still lack management schemes (Borrass, 2014; Popescu et al., 2014).
Regarding forest management planning, Europe has long-historical experience (e.g., Müllerová, Szabó, & Hédl, 2014; Rackham, 1980; Szabó, Müllerová, Suchánková, & Kotačka, 2015). Forest planning typically aims to provide long-term and consistent production and supply of services, by defining the activities and the timing of the activities needed to reach such goal (Baskent & Keles, 2005; Hellrigl, 1986). To this end, forest planning often aims to control stand structure and biodiversity (Barbati, Corona, & Marchetti, 2007). Forest management and planning has local, regional, and national peculiarities and traditions; and occurs at multiple different levels and spatial scales (Cullotta et al., 2015). For example, in certain Italian regions forests are managed at the local level through different types of management plans. Forest monitoring and assessment have been evolving towards the consideration of multipurpose resource surveys, with the development of new inventory and mapping techniques and tools (Corona, 2016; Corona, Chirici, & Marchetti, 2002). Theoretically and practically, in many EU countries, these plans aim for the sustainable use of natural resources. This leads to the opportunity for integrating forest planning tools with other sectors' instruments, such as for nature conservation (Maetzke & Cullotta, 2016).

Natura 2000 management plans have had limited effects on the application of specific forest activities, mainly because management measures have not been clear (Borrass, Sotirov, & Winkel, 2015), or are abstract concepts which are not translated into forestry practices (Borrass, 2014; Cantiani; Geitzenauer, Hogl, & Weiss, 2016). However, legal provisions regarding management under the Habitats Directive must be harmonized with local capacity (Morris et al., 2014). The possibility of integrated conservation approaches within the Natura 2000 forest framework has been highlighted by the European Commission (2015). Therefore, the integration of forest management plans within Natura 2000 may be viable in terms of management and conservation measures under the Habitats Directive requirements. Research is called on to focus on the implementation practices and related results, as well as on the practical and operational approaches used by local administrations and authorities (Borrass, 2014).

We present a case study in Veneto, a northern Italian administrative region, where we focused on forest planning with the aim (a) to stress the informative role that forest plans can have for Natura 2000 management through the identification of possible synergies, and (b) to assess the possibility of meeting the Habitats Directive requirements by identifying the spatial coverage of forest plans in Natura 2000 sites.

Materials and methods

Nature conservation framework

The Natura 2000 network in Italy consists of 2,321 Sites of Community Importance (SCIs), which have been designated under the Habitats Directive, 1,508 of which are Special Areas of Conservation (SACs), and 610 have Special Protection Areas (SPAs) designation under the Birds Directive (2009/147/EC) (MATTM, 2017). A total of 335 sites have both SAC and SPA designations. Natura 2000 sites cover 19% of the terrestrial area of Italy, and 4% of the marine area. Within this area, 131 habitats, 90 species of flora, and 500 animal species (21 mammals, 10 reptiles, 16 amphibians, 25 fishes, 41 invertebrates, and 387 birds) are protected. In addition, a complex network of national and regional protected areas designated under the National Law 1991/394 overlaps with over 50% of the Natura 2000 sites (Marchetti, Cullotta, & Di Marzio, 2005). Most of these areas are managed through environmental plans which aim to protect natural habitats and species, which frequently (at least partially) coincide with the requirements of the Birds and Habitats Directives, both from an ecological and socio-economic perspective.

The heterogeneity of environmental conditions in Veneto has resulted in complex arrangement of protected areas, both in terms of the number and their spatial composition. The Natura 2000 network in the Veneto is composed of 104 SCIs (373,296 ha) and 67 SPAs (359,884 ha); which covers 22.5% of the entire regional area. The SCIs and SPAs can overlap in different ways, being either . partially or totally included or coincident. SCIs are currently under the process of designation as SACs under the Habitats Directive. Approximately 5 % of Veneto is also covered by one national park, five regional parks, twenty natural reserves, and two Ramsar wetlands.

Forest planning framework

Approximately 30% of the forested land in Italy is part of the Natura 2000 network (European Commission, 2013). The forestland has greatly increased in Italy in recent decades, almost doubling its extent in the last fifty years (e.g. Falcucci, Maiorano, & Boitani, 2007). This increased coverage, together with an increased recognition of the multifunctional role of forests, has led to an overlapping of different forms of management and protection in the forest landscapes, frequently associated with a variety of planning instruments covering different spatial scales (Cullotta & Maetzke, 2008, 2009). The current national forest law is the Legislative Decree 227/2001, which reaffirmed the role of regions in drafting and revising forest plans. These plans are the main planning instruments for achieving the goals of both production of commodities and biodiversity conservation. Moreover, the forest law also provides some general silvicultural provisions; for example, clear-cutting and conversion from high forest to coppice are generally banned, and old-tree retention is promoted.

In Veneto, the Regional Law 52/1978 requires the development of two types of forest management plans at the local level: Forest Organization Plans (FOPs, *Piano di Riassetto*) which covers forests under single ownership, and Forest Reorganization Plans (FRPs, *Piano di Riordino*), for multiowner forested landscapes, often involving an entire municipality or other large administrative areas, such as national or regional parks. Public lands are normally planned through FOPs according to the provisions of Article 23 of the Regional Law 52/1978. FOPs must be periodically revised, usually every 10 years. FRPs are created when the development of many individual forest management plans is either technically or economically infeasible, which happens often in the case of fragmented private ownership and at the municipality level. At the district level (Cullotta & Maetzke, 2009), the Territorial Forest Plans (TFP, *Piano Forestale di Indirizzo Territoriale*) are utilized to help in the development of FOPs and FRPs, by providing general guidelines and target objectives. Therefore, FOPs, and to a lesser degree FRPs, are tactical instruments, while TFPs are strategic instruments.

For the purposes of the current study, we considered the planning documents for Veneto, and three sub-regional spatial scales (Fig. 1). These sub-regional scales consist of: (A) an aggregation of the local and the district scales, (B) the Alpine biogeographical region within Veneto, and (C) the entire Veneto. This nested spatial approach allowed for the analysis of quantitative and qualitative data included in FOPs and FRPs (hereafter called forest plans). In addition, this approach enabled an assessment of the availability and spatial cover of forest plans in relation to Natura 2000 sites and other protected areas, with an emphasis given to areas of spatial overlap and structural gaps at the Alpine and the regional scale.

Overview of the scales of analysis

The local and district scale of analysis (A) corresponds to the Val Boite, an alpine valley located in Belluno Province, which contains the Rienza, Ansiei, Cordevole, and Zoldano river basins (Fig. 1). The area of analysis is 410 km^2 (perimeter of 134 km), with forests covering approximately 71% of the area. The most widespread forest categories are larch and Arolla pine, spruce and black pine, spruce-beech forests, and dwarf pine bushes. Approximately 70% of the Boite valley are protected areas. The local scale of analysis focuses on FOPs and FRPs; while the district scale includes the TFP.

The intermediate scale of analysis (B) covers the Alpine biogeographical region, which includes the highest number of Natura 2000 habitat types of the entire Veneto area (Regione Veneto, 2015), represented by 17 forest, 10 natural and semi-natural grasslands, 6 bogs and fens, and a few rocky, shrub, and freshwater habitat types. At this scale we focus on SCIs because Veneto Region has recently established the conservation measures for SCIs under designation as SACs, which should be implemented taking into consideration their synergies with forest plans.

The largest scale of analysis (C) covers the entire Veneto, which has an area of 18,390 km^2; 48% of which lies within the Alpine biogeographical region, and 52% lies within the Continental biogeographical region. Within the Natura 2000 sites, the dominant habitat categories are forests.

Data collection

The local and district scale analysis (A) focused first on the ownership and distribution of forest plans. Emphasis was given to a diachronic analysis (1964-2008) of the structural and growth data summarizing those reported in forest plans for each forest compartment, as well as information on the applied silvicultural systems and treatments recorded in each forest plan (Table 1).

A forest compartment is a land unit, defined by natural or artificial boundaries (e.g., ditches, ridges, roads and paths), characterized by fairly homogeneous vegetation types. A digital database with the collected data was constructed to facilitate data summaries and statistical analyses, as most of the old revisions of plans are only available in hard copies filed in the regional archives. The temporal coverage of these plans varies, as not all of the initial planning documents were developed during the same years. As a result, data were not available for certain time periods for all the area considered. Moreover, stand development stages and silvicultural provisions were not systematically registered, and are only available as descriptions for each land unit. This means that the proportion of each stand development stage and each silvicultural provision must be interpreted as a proportion of occurrences, rather than as a cover proportion. Finally, we collected the number, type, and relative surface of the Natura 2000 habitats included in forest plans. We downloaded the SCI and SPA habitat polygons from a regional database (Regione Veneto, 2016).

At the biogeographical scale (B), a spatial analysis was conducted which focused on the overlapping areas between SCIs and the existing planning instruments for natural resources. At the regional scale (C), an investigation was made of the overall percentage of Natura 2000 sites already covered by forest plans. For the biogeographical (B) and regional (C) scale of analysis, a spatial geo-referenced multi-layered database was developed.

Results

Local and district scale of analysis

Public and private landownership cover 11% of each planned area, while the *Regole* (i.e. village commons, see Table 1) cover 78% of the planned area. Thirteen forest management plans (FOP) and one forest reorganization plan (FRP) fall partially or entirely within the perimeter of the Val Boite. Only 6% of the forest area is outside of the planning area, which corresponds to the Val Tovanella protected area, which has been an 'Oriented Biogenetic Nature Reserve' since 1971 (Sitzia et al., 2012).

Val Boite includes one regional park (Dolomiti d'Ampezzo Natural Park), one nature reserve (Val Tovanella Nature Reserve), and five Natura 2000 sites (SCI/SPA IT3230071, SCI/SPA IT3230081, SPA IT3230089, SCI IT3230017, SCI IT3230031) covering 67% of the area. In total, protected areas cover 70% of the Boite valley. Natura 2000 sites completely include the other two national and regional protected areas (ca. 44% of the total protected surface).

Based on the data of the previous decade plans (Zanetti, 1981), in 1981 productive forests covered 9,528 ha, and their growing stock was 1,765,118 m^3 (196 m^3ha^{-1}). Their mean annual growth was 24,712 m^3y^{-1} (2.6 $m^3ha^{-1}y^{-1}$), and the mean harvested volume was 12,014 m^3y^{-1} (1.3 $m^3ha^{-1}y^{-1}$).

Therefore, the harvested volume represented 49% of the annual growth, and 12,700 m^3 were added each year to the reserve growing stock. Productive forests currently cover 8,573 ha, and the total growing stock is 2,358,503 m^3 (286 m^3ha^{-1}). Current annual growth is 33,043 m^3y^{-1} (4 $m^3ha^{-1}y^{-1}$). From 2004 to 2013 annual harvested volume has been approximately 13,200 m^3y^{-1}, which is similar to the volume from 1981s.

The diachronic analysis (Table 2) shows that a timber yield of 412,912 m^3 was harvested between 1964 and 2008, of which 65,602 m^3 was due to wind-throw and land use conversion (mostly to ski slopes), especially during the third of the periods analyzed. Summarizing the timber yield for each of the period considered, moderate values of timber yield are observed (Fig. 2), and no evident time trend in the percentage of harvests due to salvage logging and land conversion (Table 2).
However, the annual fluctuation in yield is quite considerable. This rate of yield was derived for all forests, considering not only production forests but also those with other functions such as wooded pasture, or forests with protective functions.
Even-aged stands are present in 42% of the land units, while uneven-aged stands are in 36%. Two-aged stands are less common, and are present in the 14% of the land units, and approximately 23% of the land units are mature stands (Fig. 3). Poles and adult forests are present in 9% and 12% of the land units, respectively, while both saplings and thickets are present in 6%. Single tree selection is the most widespread final felling technique for uneven-aged stands, while group and irregular shelterwood is the most common final felling adopted for even-aged stands. Spacing and thinning are suggested in 23% of the land units (Fig. 3).

Woodlands can be classified into 12 forest categories and 33 forest types (see Del Favero, 2000), many of which can be directly linked with a specific Natura 2000 habitat (see Appendix, table A1). Forest plans often involve not only woodlands, but also open habitats like meadows, pastures, bogs, and wetlands. For this reason, current forest plans also make provisions for the conservation of a heterogeneous land mosaic within each forest type. For instance, 16% of the planned area consists of meadows and pastures, which correspond to different Natura 2000 open habitat categories (i.e. 6150 "Siliceous alpine and boreal grasslands", 6230 "Species-rich *Nardus grasslands,* on siliceous substrates in mountain areas and sub-mountain areas, in Continental Europe", and 6520 "Mountain hay meadows").

Biogeographical scale of analysis

The total area of SCIs in the Alpine biogeographic region of Veneto is about 234,904 ha, 75% of which is already covered by forest management plans (Fig. 4a and Supplementary Material – S1). 13% of the area is covered by a national park and 7% by regional protected areas. Over 95% of the Dolomiti Bellunesi National Park within the SCI area is covered by forest management plans, while in the two regional parks, the share is about 50%. The entire area (13,872 ha) of SCI IT3210006 "Monti Lessini: Ponte di Veja, Vaio della Marciora" is completely included within the Parco Naturale Regionale della Lessinia, and the 93% of that area is covered by the "Parco Regionale della Lessinia". The SCI IT3230071 "Dolomiti di Ampezzo" (11,362 ha) is completely included in the regional park of Dolomiti di Ampezzo. FOPs cover 38% and FRPs 2% of the SCI area. Moreover, some smaller Natura 2000 sites are not included in regional and national protected areas, but are mostly covered by forest plans. For example, 16% of the SCI IT3230090 "Cima Campo-Monte Celado" (1,812 ha) is covered by FOPs and 72% by FRPs. Furthermore, there are many scattered small areas within some SCIs that represent spatial gaps outside the planning areas, as they are covered neitherby forest plans nor by regional and national protected areas.

Regional scale of analysis

At the regional scale, regional and national protected areas overlap with 19% of the Natura 2000 area. The analysis showed that 192,451 ha inside Natura 2000 sites are covered by forest plans, which corresponds to 46% of the entire Natura 2000 terrestrial area in Veneto. This data includes the Venice lagoon (SPA IT3250046 "Laguna di Venezia), which is obviously not included in forest management plans. With this area removed, the percentage covered by forest plans within Natura 2000 increases to 54% of the area. Moreover 57% of Natura 2000 area is covered by forest plans or regional and national protected areas, or both (Fig. 4b).

Discussion

It is necessary to understand the connections between the various planning frameworks of protected areas for the development of effective forest and natural resource management plans (Mermet & Farcy, 2011). Forest planning must often deal with complex local issues, where there is a need to integrating the particular demands of a given area (e.g. Weintraub & Navon, 1976). Since most forestry practices involve some disturbance to forest ecosystems, forestry will inevitably affect ecosystem functions in both positive and negative ways (Bengtsson, Nilsson, Franc, & Menozzi, 2000).

Diachronic analysis of forest management

In general terms, the data within forest plans represents a fundamental historical memory, which can be used to interpret the current status and future trends for forests with a long management history. Our analyses found that in many cases forest plans can provide information on the main structural characteristics of forests for the previous 30-40 years. This information can be a useful tool for assessing the current conservation status, as well as to retrace or define reference values of past conditions.

As stated by Zanetti (1981) for the Boite valley (i.e. the local and district scale of our analysis), the limited timber harvests observed in the early 1980s are a clear consequence of the wise forest policies adopted by the forest owners. Based on the trend in the current yield levels, the growing stock deficit observed in the plans should have been filled in 35 years. Considering the characteristics of the high forests at that time, Zanetti (1981) projected a 30% increase in timber yield in 30 years, up to 25-30,000 m^3y^{-1}, by applying appropriate continuous silvicultural treatments. Based on the current annual growth and the growing stock volume, the current harvest numbers have failed to meet these predictions. Along with the high portion of mature stands, this indicates that a forest strategy that promotes a large wood biomass reserve cannot be justified on the basis of the needs of growing stock adjustment alone (Bettinger, Boston, Siry, & Grebner, 2009; Recknagel, 1913). Based on this, a strategy of maintaining stands at various development stages with fewer mature land units should be promoted, with an aim towards promoting woodland stability and habitat heterogeneity. Such a strategy would have co-benefits for the habitat quality of some species, such as the hazel grouse (Sitzia, Dainese, Clementi, & Mattedi, 2014).

Forest planning is based on data collected at the stand level, and the data recorded can vary significantly depending upon the relevant regulatory framework. This data has been considered, or can be used to assess biodiversity indicators linked to the structure and functions of forests. The conservation status, as defined by Evans and Arvela (2011), can be determined through the evaluation of indicators typically collected in forest plans (e.g., Cantarello & Newton, 2008; Winter et al., 2014), such as stand development stage, tree species composition, regeneration presence and type. Of particular importance for species habitat are deadwood elements (e.g., Russo, Cistrone, & Garonna, 2011). These features are not typically recorded in forest plans, but there are some positive examples (see Winter et al., 2014). Indeed, different types of deadwood (e.g., snag, stump, and logs) have important for varying species (Lassauce, Paillet, Jactel, & Bouget, 2011; Similä, Kouki, & Martikainen, 2003), and their relative amounts can be shaped by silvicultural operations, and ultimately originating from the portion of dead wood generated by wind-throws. The maintenance of different successional stages has important beneficial effects on a broad range of species of conservation interest (e.g., Fartmann, Müller, & Poniatowski, 2013; Merckx et al., 2012).

Our results show that forest plans often take into consideration the balance of successional stages and enable an overview of their total cover in the area to be made. Furthermore, the provision of forest plans promotes the maintenance of certain tree species proportions. This is crucial because overstory composition can influence understory species composition through different mechanisms (Barbier, Gosselin, & Balandier, 2008) and therefore make it possible to shape this characteristic of the forest habitat structure, which in turn has implications on its functions.

Habitat approach in forest planning

Forest management practices which result in heterogeneous conditions at several spatial scales is a essential for many species and habitats of Community interest (e.g., Benes, Cizek, Dovala, & Konvicka, 2006; Bergman & Kindvall, 2004; Jacquin et al., 2005; Russo, Cistrone, & Garonna, 2011; Spitzer et al., 2008; Streitberger, Hermann, Kraus, & Fartmann, 2012). However, low-intensity management and the abandonment of management activities has recently driven landscape homogenization in many alpine areas (Campagnaro, Frate, Carranza, & Sitzia, 2016). Our results highlight that forest plans already cover a variety of non-forest habitats protected under the EU Directives. Therefore, forest plans already include planning for a variety of non-forest habitats, which make them a valuable tool for implementing biodiversity conservation strategies aimed at promoting heterogeneous habitat conditions. Linking forest types with Natura 2000 habitats allow wood production needs and habitat and species conservation requirements to be considered in unison; moreover, the current provisions in forest plans aimed at maintaining different ecosystem functions (landscape attractiveness, biodiversity variability, etc.) allow priorities to be set for non-forest habitats as well.

Distribution of the Natura 2000 network inside existing planned areas

Forest management plans (or equivalent instruments) are usually required by EU Member States' legislation on forest owners. In 2010, management plans (or equivalents) covered around 155 million hectares of European forests, with some countries reporting all forest areas under forest management plans (e.g. Bulgaria, Czech Republic, and Slovak Republic; Forest Europe, 2015). However, within a given country or region, the geographic and regulatory framework may vary significantly due to heterogeneous conditions. Nationally, regionally, and locally protected areas often have different planning tools, while also spatially overlapping with Natura 2000 sites in many Member States (EEA, 2012), which can cause frequent conflicts over provisions within the same area. The spatial coverage of forest plans is an extraordinary opportunity for many Natura 2000 sites. Our study indicates that forest plans could represent a spatially homogeneous instrument for applying coherent habitat and species conservation strategies within Natura 2000 sites.

Conclusions

Integrating biodiversity into forest planning is a challenge, due to the difficulty of adequately defining biodiversity goals and in evaluating management alternatives in relation to biodiversity outcomes (Kangas & Kuusipalo, 1993). Our analysis confirms from both from a scientific and technical point of view the utility of forest plans in managing Natura 2000 sites within silvo-pastoral landscapes. In the Italian Alpine area, the administrative framework (e.g. fragmented ownership), morphology (e.g. physical borders, steep slopes), and existing rules (e.g. clear cut ban) allow for an ecologically appropriate management of forest to be carried. This framework can vary greatly between EU countries, however, and therefore might not guarantee the sustainable management of forest resources in all cases.

Forest plans are in most cases applied at the most appropriate scale for the implementation of habitat management strategies, because the information at the stand level found within forest plans can be linked to habitat patches. This aspect can also support the monitoring of Natura 2000 forest habitats, which Member States are required to perform, according to Article 17 of the Habitats Directive. This approach requires the adoption of some necessary measures, particularly those regarding conservation measures of the habitat of a species as reported in the Habitats Directive (e.g. dead wood quantity and quality for saproxylic species, ponds restoration for amphibians), and updating data on the presence and distribution of species and area of habitats, in compliance with Natura 2000 conservation goals.

For our case study, the results highlighted the critical issue of the low exploitation rate of the forest growing stock according to forest plans previsions, especially in the latter two decades. The long history of management practices have shaped certain habitat types and landscapes fundamental for biodiversity, and these conditions should benefit from the sustainable mobilization of wood, as defined by European Commission (2010). Indeed the abandonment of forest planning activities can have a variety of effects on species communities (Sitzia et al., 2012). However, this should be performed by periodically revising forest plans, registering the amount of harvests, maintaining a constant cooperation with the national statistical agencies and environmental Ministry, and preventing the temptation to develop a bimodal forest landscape pattern (frequent timber harvest, including clearcut, and no timber harvest).

As the successful conservation of habitat types and species frequently depends on the behavior and management of areas outside Natura 2000 sites, the opportunity to utilize the information content of forest plans both inside and outside of Natura 2000 network is a sensible option (Dimitrakopoulos, Memtsas, & Troumbis, 2004). Moreover, the synergetic pursuit of ecological and economic goals should increase the efficiency of conservation instruments, and improve their acceptance by both landowners and other stakeholders (Ianni, Geneletti, & Ciolli, 2015; Winter et al., 2014).

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Figures

Fig. 1. Nested spatial scales of analysis applied in the present study: (A) local and district, (B) biogeographical, (C) regional.

Fig. 2. Total annual timber yield for three different periods in a forest district of Veneto (see Table 2).

Fig. 3. Two examples of maps produced from data collected by forest plans: (a) presence of mature high forests and (b) stand thinning recommendation.

Fig. 4. (a) SCIs area overlap with existing planning tools in the Alpine biogeographical region and, (b) forest management plans overlap with the Natura 2000 sites of Veneto.

Fig.1

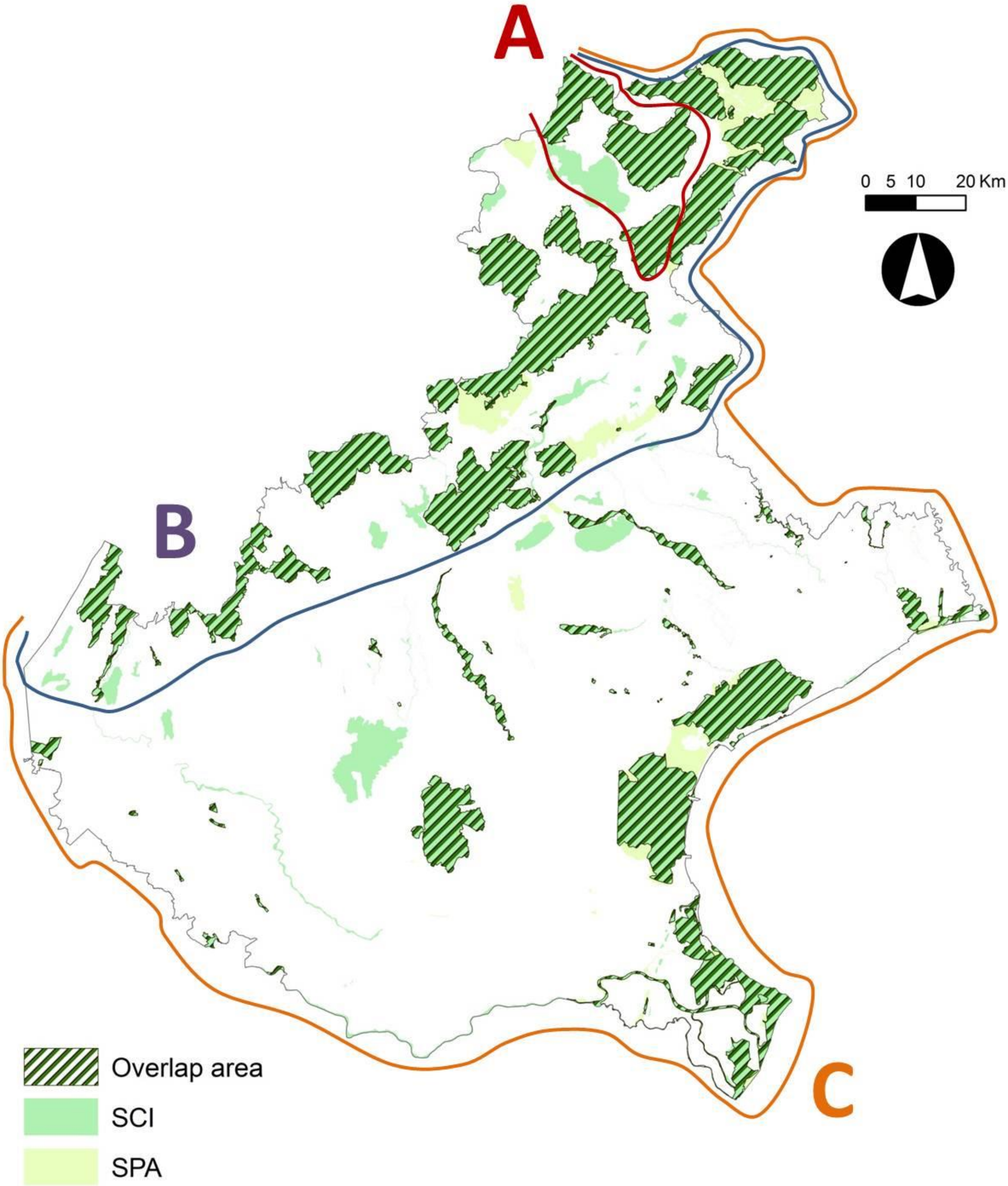


Fig.2

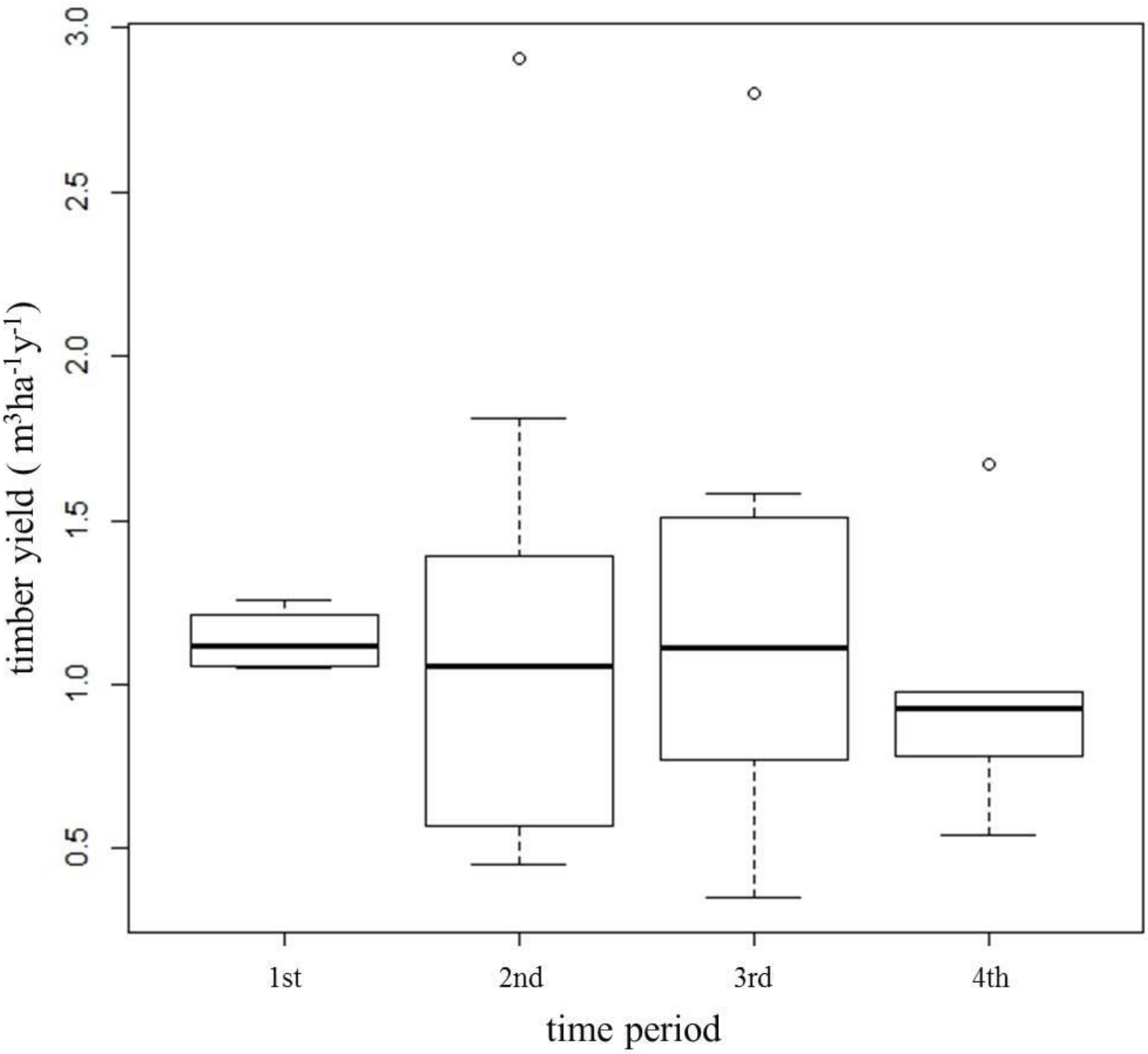

3.0
2.5
2.0
1.5
1.0
0.5
timber yield (m3ha-1y-1)
1st
2nd
3rd
4th
time period

Fig.3(A)

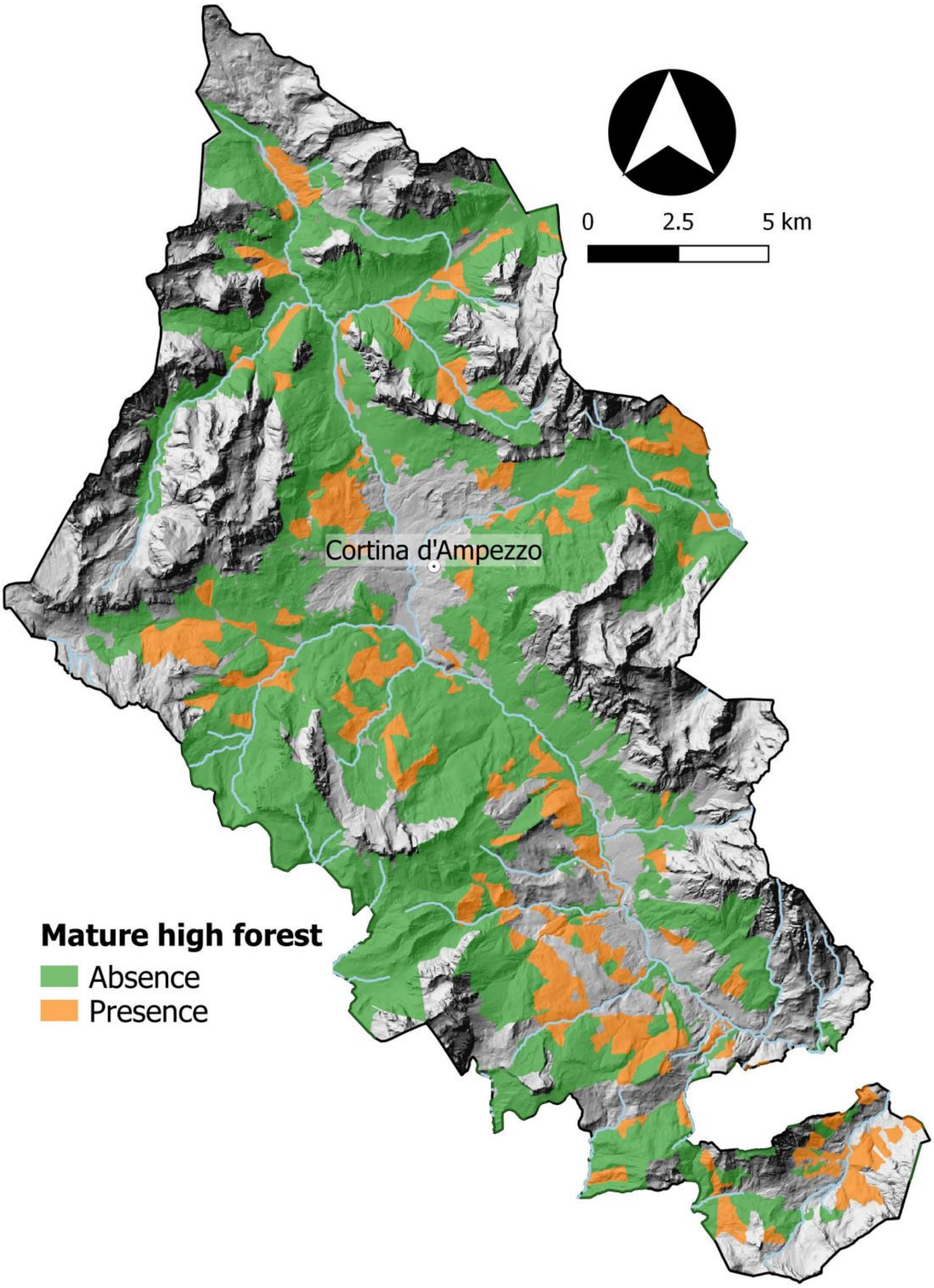
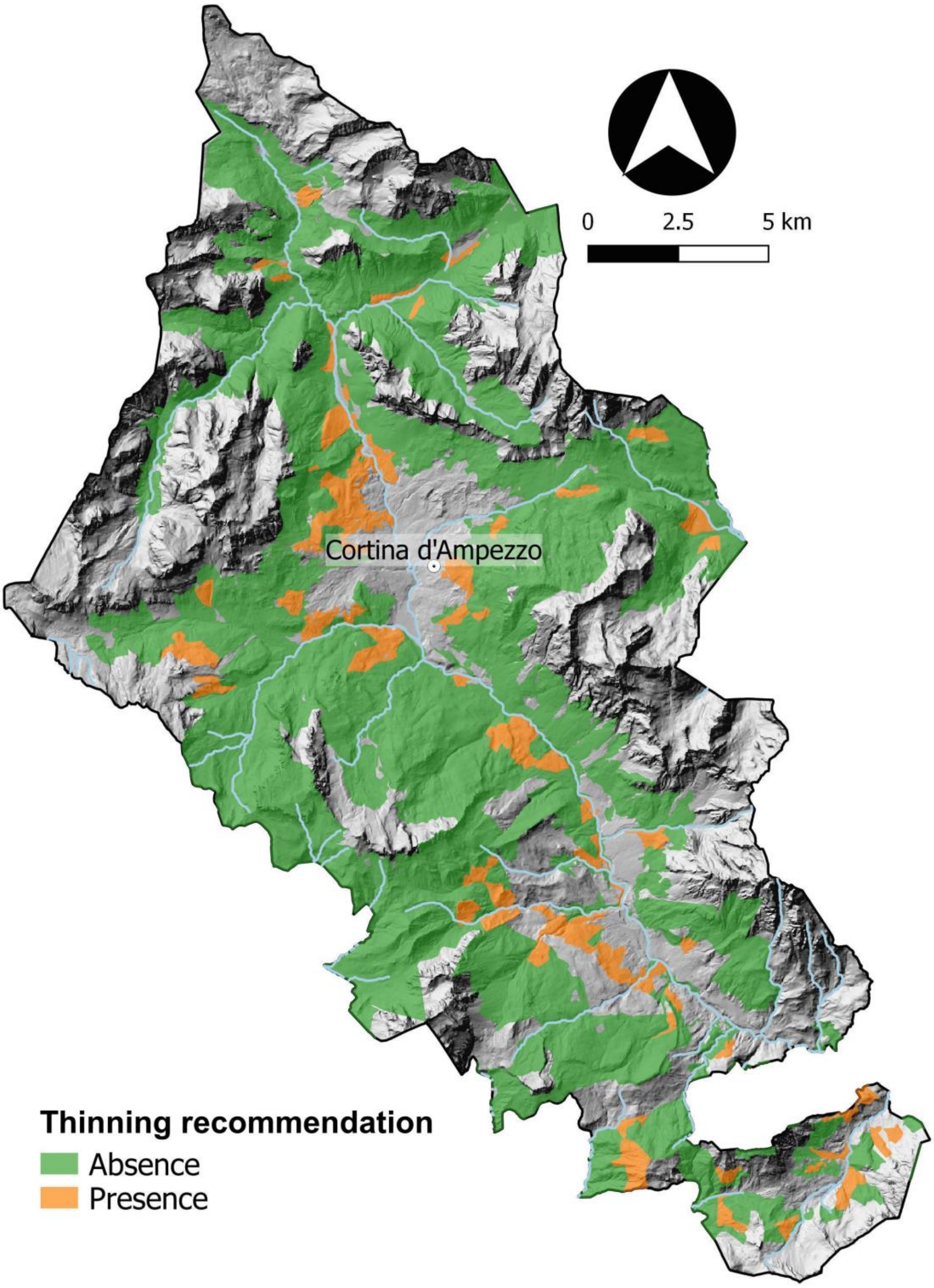

0
2.5
5 km
Cortina d'Ampezzo
Mature high forest
Absence
Presence

Fig. 3(B)



0
2.5
5 km
Cortina d'Ampezzo
Thinning recommendation
Absence
Presence

Fig.4(A)

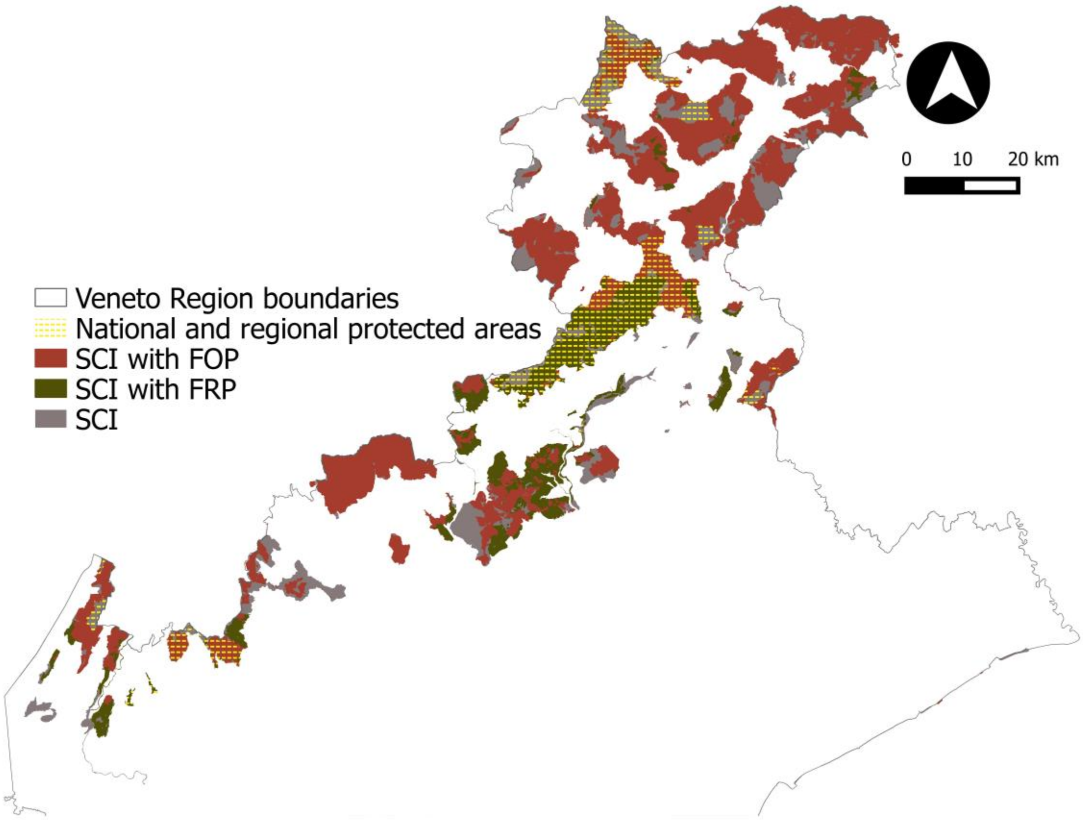

Veneto Region boundaries
National and regional protected areas
SCI with FOP
SCI with FRP
SCI
0
10
20 km

Fig.4(B)

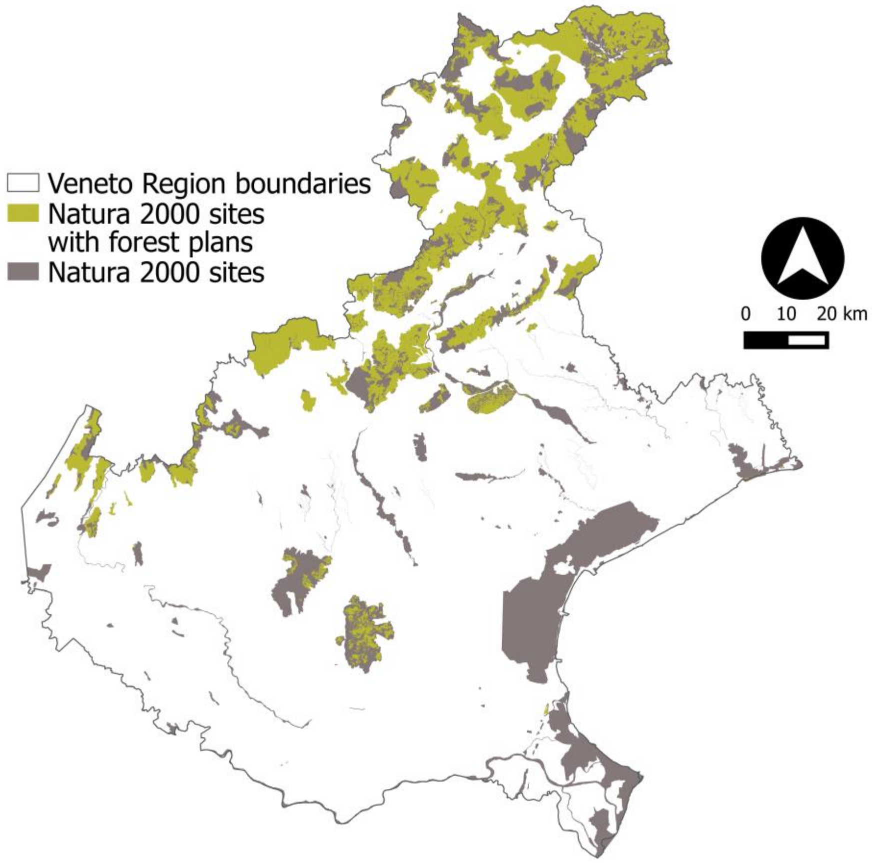

Veneto Region boundaries
Natura 2000 sites with forest plans
Natura 2000 sites
0 10 20 km

Table 1. Data collected and scale of analysis considered.

Indicator			Categories		Type of data	Scale of analysis
Forestry	Stand vertical structure (**)		Even-aged stands		Quantitative (e.g. % on the total area)	A
			Uneven-aged stands			
			Two-aged stands			
	Volumetric data		Total timber harvest		Quantitative (m^3 ha^{-1})	
			Harvest due to windthrows and land use conversion			
	Stand development stage (**)		Seedling		Qualitative	
			Sapling		Quantitative (e.g. % on the total area)	
			Thicket			
			Pole			
			Adult			
			Mature			
	Silviculture (**)	Final felling	Selection system	Group	Qualitative	
				Single tree		
			Shelterwood system	Strip		
				Uniform		
				Group		
			Salvage logging			
		Intermediate felling	Spacing			
			Thinning			
Vegetation	Forest categories and types		Forest categories and types refer to Del Favero (2000)		Qualitative and quantitative (e.g. % on the total area)	A
	Natura 2000 habitat		Natura 2000 habitat refers to Biondi et al. (2010)			A
Administrative level	Properties		Private		Quantitative (% on the total area)	A, B
			Public			
			Regole (*)			
	Forest plans		Forest Reorganization Plan (FRP)			A, B, C
			Forest Management Plan (FOP)			A, B, C
			Territorial Forest Plan (TFP)			A
	Protected areas		Natura 2000 sites			A, B, C
			Parks and reserves			A, B

(*) The "Regole" are similar to village commons, a political institution and center of decision-making power widespread in Veneto mountainous areas, acting as managers of local natural resources (Favero, Gatto, Deutsch, & Pettenella, 2016). Such institution can be defined as a sort of mixed system between public and private properties (Olivotto, 2010).

(**) Collected as presence/absence data at land unit level, based on the availability of the information in each forest plan.

Table 2. Period of validity, forest land area and harvest for the different time periods considered in each forest plan. Comune (Italian) = municipality (English); frazione (Italian) = a type of sub-municipal administrative division. VD = length (years) of validity of the plans.

Plan validity	**Time period**	**Forest plan (*)**	**VD (**)**	**Forest land [ha]**	**Total timber harvest [m³] (TY)**	**Harvest due to windthrows and land use conversion [m³] (WLC)**	**WLC/TY [%]**
1964-1973	1st	Comune di Cibiana	10	555	5,823	1,406	24
1964-1973		Comune/Regole di San Vito di Cadore	10	1,812	22,846	3,721	16
1964-1973		Frazione di Valle	10	566	6,014	1,057	18
1966-1975		Regola di Vodo	10	347	4,052	734	18
1978-1987	2nd	Comune di Borca	10	868	15,676	3,245	21
1974-1983		Comune di Cibiana	10	560	6,165	977	16
1976-1986		Comune di Cortina d'Ampezzo	11	1,023	5,050	2,410	48
1975-1984		Comune di Vodo	10	1,853	18,678	4,039	22
1974-1983		Comune/Regole di San Vito di Cadore	10	1,941	17,386	4,510	26
1974-1983		Frazione di Valle	10	566	7,879	1,085	14
1971-1980		Frazione di Venas	10	250	7,288	1,796	25
1975-1984		Regola di Cancia	10	220	1,264	664	53
1976-1985		Regola di Vodo	10	347	4,529	1,057	23
1976-1990		Regole d'Ampezzo	15	10,837	91,513	8,804	10
1988-1997	3rd	Comune di Borca	10	868	13,126	3,210	24
1984-1993		Comune di Cibiana	10	560	6,242	363	6
1987-1996		Comune di Cortina d'Ampezzo	10	1,009	4,466	2,440	55
1985-1994		Comune di Vodo	10	1,853	18,261	3,836	21
1984-1993		Comune/Regole di San Vito di Cadore	10	1,941	15,030	740	5
1984-1995		Frazione di Valle	12	566	7,751	2,747	35
1981-1990		Frazione di Venas	10	250	7,013	1,207	17
1985-1997		Regola di Cancia	13	220	1,011	607	60
1986-1995		Regola di Vodo	10	347	5,483	915	17
1994-2003	4th	Comune di Cibiana	10	523	4,070	263	6
1997-2008		Comune di Cortina d'Ampezzo	12	996	826	630	76
1995-2004		Comune di Vodo	10	1,839	18,064	2,111	12
1994-2003		Comune/Regole di San Vito di Cadore	10	1,948.19	18,173	3,771	21
1996-2005		Regola di Vodo	10	322.15	5,370	150	3
1991-2002		Regole d'Ampezzo	12	11,324.97	73,863	7,106	10
TOTAL				**46,317**	**412,912**	**65,602**	**16**

Appendix

Table A1. Natura 2000 forest habitat types and relative surface

Forest category	**Forest type**	**Natura 2000 habitat**	**Surface [ha]**
Silver fir forests	Silver fir forest of carbonate soils	9130	534
	Silver fir forest of silicate soils	9410	13
	Silver fir forest of mesic soils with beech	9130	11
	Typical silver fir forest of mesic soils	9130/9410	387
Maple-ash and maple-lime forests	Maple-ash forest with grey alder	9180*	10
	Typical maple-ash forest	9180*	109
Alder forests	Alder forest with common and/or grey alder	91E0*	131
	Alder forest with green alder	4060/4080	126
Shrubland	-	-	7
Beech forests	High mountain beech forest	9130/91K0	16
	Typical mountain beech forest	9130/91K0	93
Plantations	Conifer plantations	-	52
Larch, larch-Arolla pine and Arolla pine forests	Rocky larch forest	9420	126
	Typical larch forest	9420	4,199
	Larch-Arolla pine forest with spruce	9410/9420	1,917
	Larch-Arolla pine forest with green alder	9420	185
	Typical larch-Arolla pine forest	9420	2,101
Dwarf pine forests	Macrothermic dwarf pine forest	4060/4070*	0.4
	Mesothermic dwarf pine forest	4060/4070*	2,637
	Microthermic dwarf pine forest	4070*	5,916
Spruce forests	Spruce with ash and/or maple	-	166
	High mountain spruce forest of carbonate soils	9410	3,778
	Sub-alpine spruce forest of carbonate soils	9410	1,001
	Sub-alpine spruce forest of silicate and mesic soils	9410	42
	Secondary mountain spruce forest	-	1,621
Spruce-beech forests	Spruce-beech forest of mesic soils	9130	1,662
	Spruce-beech forest of xeric soils	9150	311
Scots pine forests	Inner alpine Scots pine forest	-	505
	Intermediate alpine Scots pine forest with spruce	9410	740
	Typical intermediate alpine Scots pine forest	-	811
	Rocky Scots pine forest	-	182
Riparian forest	White willow riparian forest	91E0*	5