

Article

The Landscape Change in the Alps—What Postcards Have to Say about Aesthetic Preference

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Abstract: Land use changes in the Alps over the last few decades have been characterised by a significant increase in forest coverage as a result of the abandonment of marginal agricultural sites. Natural afforestation and species protection laws affected the ecosystem, and therefore the services provided by the mountain environment, including landscape structure and aesthetics, changed. This work assess the changes in the ecosystem services offered by forests since 1954 in a region of the Italian Alps. Some ES were estimated in this work with GIS, and others were taken from the literature or the authors' previous works. Since the 1950s, forest ecosystem services such as growing stock, protection from hydro-geological hazards and carbon storage have increased. Deer and other forest species have risen in number. On the other hand, there has been a depletion of open space for priority habitats and species such as black grouse and capercaillie. Old postcards were used to understand land use change and people's aesthetic preferences. To determine people's preferences for the landscape, we used records of over 300,000 postcards, sold during nearly two decades. The most often chosen postcard portrayed a landscape of the 1970s with a mix of forest and open space, different from the scenario that the buyers could observe. The sales records for over 20 years of postcard business and the dates of the postcards that we obtained in this research allowed us to perform a quantitative analysis of landscape preferences. The main subject of the photo was a good predictor of the number of postcards sold, according to generalised linear models (GLM); and postcards of overly exploited landscapes, dense forest coverage or buildings were significantly less likely to be chosen. Artificially reinstating open areas will boost biodiversity and could recreate a landscape that resembles the historical agro-ecosystem without interfering with the forest's other functions. These findings will help managers and policy makers evaluate cultural ecosystem resources in the face of changing mountain landscapes.

Keywords: forests; historical data; ecosystem services; protection forest; cultural ecosystem services



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1. Introduction

The European alpine environment underwent a dramatic change from the 1950s to present due to socio-economic changes [1,2]. The migration to cities; the abandonment of the traditional agricultural activities; and in some areas, the new nature-oriented silvicultural regime lead to an increase in forest coverage. This forest coverage increase can be considered as a re-naturalisation of the previously heavily exploited environment, at least until about the 1980–1990 [1,3]. This change led to increases in number for mammals and birds species, and improvements in the services provided by the forest, such as protection against landslides and avalanches [4] and carbon sequestration [5]. After the 1990s, the for-

est coverage continued to increase, but the landscape tended to lose its diversity in terms of ecosystem mosaic, becoming more homogeneously covered by trees. The forest started to occupy grass meadows, which are classified as priority habitats by the UE (92/43/EEC) because of their richness in plant and animal species typical of the alpine open areas [6,7]. Despite the public incentives to mow the grasslands in order to keep those habitats free from newborn trees, those measures were not effective everywhere, and the afforestation trend is generally still ongoing [8]. Forests are also growing at higher elevation both due to climate change and due to land abandonment, thereby invading the typical alpine grasslands [9]. Extensive agro-ecosystems, such as traditional mountain cattle breeding, are perceived positively by people because they are linked to historical traditions, familiar economies and traditional values [7].

Schirpke et al., 2016 [10] reported that the demand for pleasant landscapes is an important topic for tourists in the alpine region, and several ecosystem services are linked to the complex structure of habitats that is perceived as a landscape. The importance of the ecosystem services (ES) in the framework of sustainable governance is a well acknowledged concept [11], and several studies have tried taking into account people's values and expectations about forest coverage and composition [12].

ES quantification and mapping are priorities for decision making [13]; however, an estimation of ES at a single point in time is not sufficient to fully inform managers [14]. In order to understand the ecological, social and economic drivers that created the current situation, it is paramount to take into account both time and space in the assessment of ES [1,14,15].

Cultural ecosystem services (CES), such as aesthetic preferences, are difficult to quantify, and there is a lack of an established approach to their assessment. The use of photography surveys of various landscapes and their features has been proposed by [10,13], but an investigation of how the aesthetic value of a landscape changed over time has never been undertaken via photo surveys, but rather derived by biophysical measures and ecological metrics.

Ode and colleagues [16] proposed a framework to evaluate the relationships between visual indicators of landscapes and quantitative landscape metrics. GIS-based metrics derived from photographs and maps have proven to be appropriate tools for the description of some features in landscapes, but the assessment of aesthetics cannot be based on quantitative information only. A combined approach using several data sources is considered to be the most appropriate [16,17]. In a combined study by Frank et al. (2013) [17], visual assessments of photographs were highly correlated with GIS-calculated landscape metrics, such as shape index, Shannon's diversity index and patch density.

Visual choice tests are being used in forestry research, for example, to determine preferences for the presence of trees in rural areas [18] or for different forest management [19].

Ecosystem services' general trends over time and at large scales are crucial for national and EU policy making; nevertheless, local analyses at small scales are equally important in order to account for stakeholder preferences, regional management and traditions, and provide the data for upscaling and comparison with other areas.

The landscape of the past can be appreciated and reconstructed from old postcards, even if some limitations exist due to uncertain dating and even image manipulation to create some effects in the photographs [20]. Nevertheless, some scholars have successfully reconstructed past environments from postcards in natural and urban areas [21,22], and even measured past sea levels [23]. Postcards are primarily icons of touristic destinations, and people choose postcards that evoke positive emotions towards those places and promote the desire to travel to them [24]. Some authors claim that postcards transmit the environmental values of people and nations [25] and that the choice of an image can represent the social function associated with a certain landscape [26].

The aims of this work were (1) to analyse the states of different ES at time steps comparable to the availability of the historical postcards and (2) to evaluate the aesthetic preferences of the landscape regarding its different appearances over time using said post-

cards. The first aim was attained by collecting data from multiple sources and processing them with GIS when not directly available.

For the second goal, we used postcards to assess the aesthetic value of changes in an alpine landscape over time. The assumption was that people would indicate their preferences when selecting postcards of a landscape, and that by analysing the sales of the various postcards, the aesthetic value of the changing landscape could be measured over time. Data from the postcard market for the past 20 years were utilised to quantify people's preferences for contemporary and previous landscapes. Generalised linear modelling was applied to disentangle the effects of various features in the photographs. Combining all the above results, we examined which ecosystem services are behind a perceived attractive landscape and conceived of management solutions to maximise the benefits.

2. Materials and Methods

2.1. Study Area

This research was carried out in the area of Paneveggio Pale di S. Martino Nature Park (PPSM) in the Italian Dolomites of the Autonomous Province of Trento (PAT) Figure 1. The study area was selected because it is a representative of the forest dynamics that occurred in the Alps [11] and because of the availability of data previously collected by the authors [6], the PPMS and other local authorities. The protected area covers 157.04 km² and the total area considered in this study is 263.6 km². The park was established in 1967 by the Italian law but was operational only from 1990. The main villages of the area are S. Martino di Castrozza and Fiera di Primiero, two popular destinations for both summer and winter tourism.

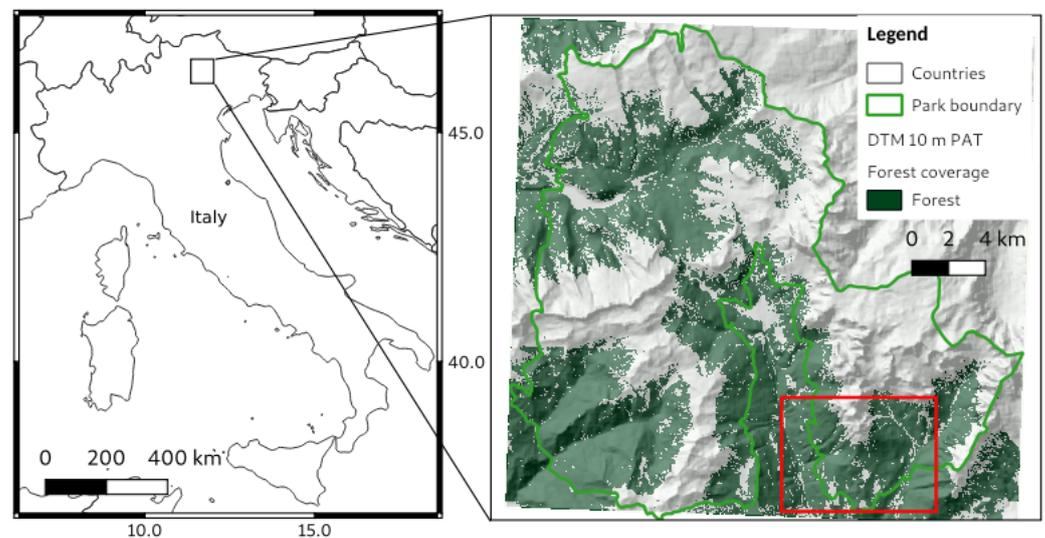


Figure 1. Location of the study area in the Italian Peninsula (**left**) and the enlargement of Paneveggio-Pale di S. Martino Nature Park (**right**). The background is the hill shade calculated from a digital terrain model (DTM; 10 m) and present forest coverage. The red square is approximately the area pictured in the postcards of Fiera di Primiero of Figure 2. The legend refers to both maps.

Currently, about 40% of the Park is strictly protected, whereas in the rest of the area several activities are allowed, including tourism, skiing, logging, agriculture and hunting. Capercaillie hunting has been banned since 1991, but the other game species can be harvested according to national and local laws. The study area is now about 52% covered in forest, mainly spruce and fir. In the park there are four Sites of Community Importance (SCI, defined by the Habitats Directive, 92/43/EEC) protecting endangered alpine habitats. The area hosts typical alpine wildlife and plants. This research covers a time frame of 50 years, from 1950 to 2000, according to the availability of data sources. Since 1950, the region has changed in accordance with the general trend seen in the Alps.

The primary source of income shifted from agriculture and logging to tourism, resulting in increased forest coverage and reduced open space. Since 2014, PAT has been actively opening areas and giving incentives for traditional grass mowing to maintain the alpine meadows [27,28]. PAT restored 61 ha of turf grass meadows through the cutting of the naturally reforested areas. These measures aimed to support rural development and local tourism and at the same time reduce mountain depopulation.

The severe climatic event known as the “Vaia” wind storm destroyed 6.5 km² of forest in the region in 2018 [29], causing deaths and massive timber losses, and affecting the landscape. This sparked a debate about restoring or converting some ruined wooded areas into pastures and meadows. In any case, the storm had no impact on the outcome of our analysis, because all of the postcards examined represent times before 2018.

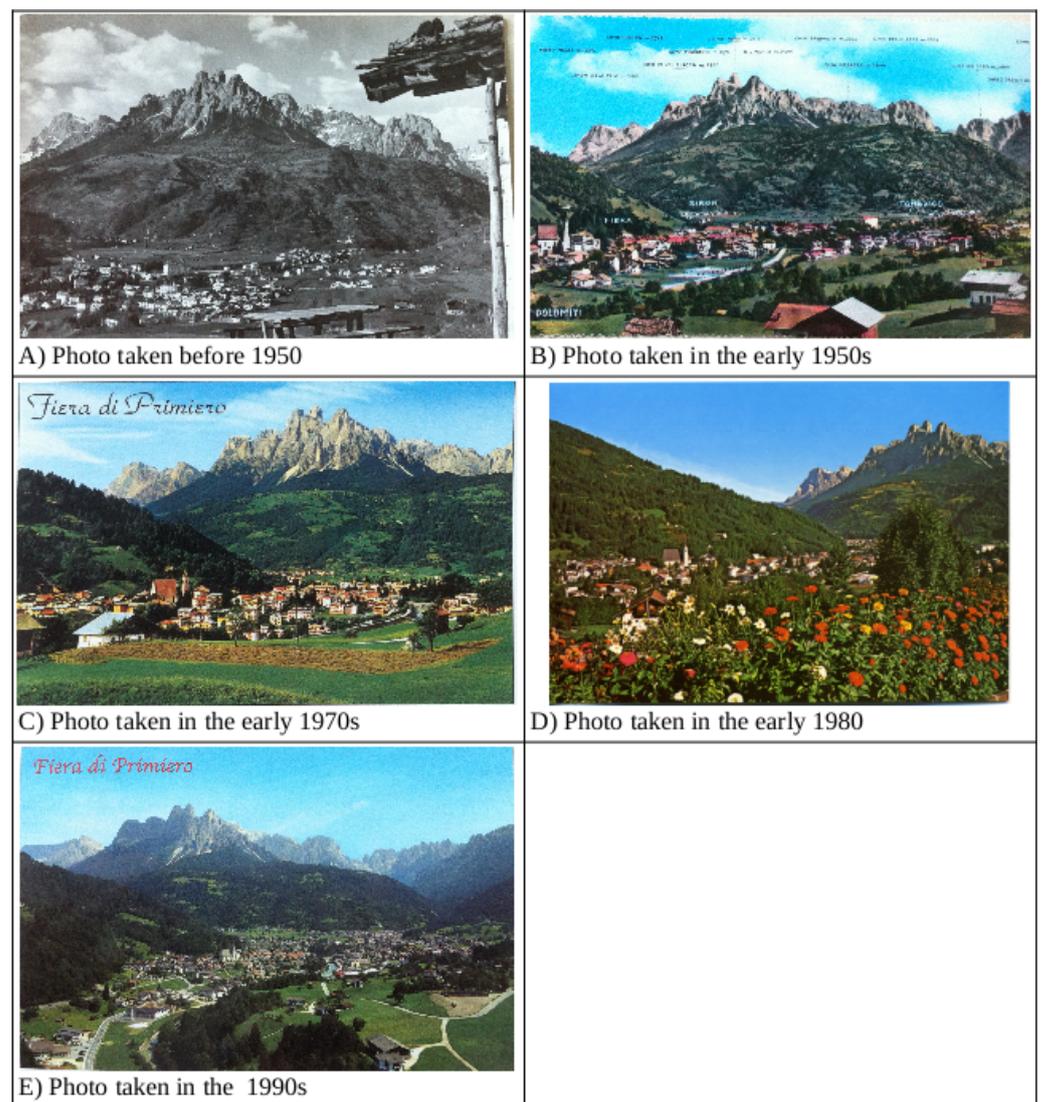


Figure 2. A set of postcards depicting the typical landscape and the Village of Fiera di Primero in the Alps (Italy) over time. Images kindly provided by A. and O. Gilli.

2.2. ES Evaluation

In order to estimate ES over time, a series of maps and data were gathered from different sources. We used to the Common International Classification for Ecosystem Services (CICES), proposed by the European Environment Agency, because it is considered the reference for ecosystem services research [30], even though other functional classifications

have been proposed [31]. Spatial analysis was conducted using the latest versions of GRASS GIS [32] and QGIS [33]. All maps had a resolution of 10 m, projection UTM 32N.

2.2.1. Provisioning ES

Forest

Multi-temporal GIS data about forest coverage and open areas in PPSM from 1860 to present were available from previous studies of the authors in the area [3,34].

Cattle

Number of animals raised as cattle in the area. In the last few decades, bovine breeding decreased while sheep and goat breeding increased due to many factors, including economic convenience and human migration from and to the mountains; a complete description can be found in Zanella et al. [35].

Priority habitats

We measured the extension of the open (non-forest) priority habitats present in the area according to Natura 2000 (European Environmental Agency) over time. We used the map of priority habitat provided by the PAT. The following habitats were considered: “open areas species-rich *Nardus* grasslands (Natura2000 code 6230)”; “Semi-natural dry grasslands (*Festuco-Brometalia*) (6219)”; and “Active raised bogs” (7100) and other bogs. The past extension of these habitats was manually digitised against historical aerial imagery, assuming that they extended where the forest invaded the area around the present priority habitats. This estimation is conservative, as former open areas could have hosted priority habitats but were not presently mapped because they completely turned into forest.

Timber

The total forest growing stock almost doubled in Primiero between 1960 and 2015, increasing from 3,336,357 to 6,322,134 m³ [36,37]. The process was fostered by a nature-based silviculture approach implemented by the Trentino Forest Agency to guarantee sustainable forest management [38]. With this approach, both tree density and species diversity increased, thereby leading also to a more productive forest in terms of timber quality and quantity [6]. Nevertheless, wood demand cannot be satisfied from the local wood supply chain and the wood industry must rely on foreign markets.

Wildlife:

We used the data of recreational hunting to assess how the presence of four species changed through time.

Data about recreational hunting in the hunting district of Primiero was kindly provided by the local hunting association (ACT/PAT). According to the hunting plan, 5% of game animals can be killed. Literature shows a good agreement between population size and legally killed animals. Poaching happens but it is not considered. Hence, data from ACT about hunting bags (recreational hunting) can be used as proxies for the populations of various game species (biodiversity indicators). Hunting data during the time span considered in this study have been collected and archived with different methods. The most homogeneous unit of data aggregation is at the “hunt reserve” level. For the purposes of this study, we were interested in a general trend in hunting bags, so we considered the reserve of Primiero, which mostly overlaps with the present boundaries of PPSM and with the landscape pictured in the postcards. Probably, the actual numbers of game animals taken in the whole park area are slightly higher than those reported here, but we chose to be conservative and do not include large areas outside the park. The trends for all the species are consistent with those reported for the neighbouring hunting reserves and for the whole province, so we considered the data robust enough to be used for the purpose of this work.

The species considered in this work:

- Deer (*Cervus elaphus*) were extinct in the area in the 1950 because of habitat loss and over-hunting. In 1963, 7–8 individuals escaped from captivity and repopulated the area; then followed a reintroduction program [39].
- Roe deer (*Capreolus capreolus*) was never extinct in the study area, even if the population was very small in the 1950s. Roe deer ecology requires an alternation of forests and open areas, which are needed by the species for foraging. Competition with deer and open habitats loss led to a decrease in number and in average weight of the gamed individuals.
- Capercaillie (*Tetrao urogallus*) has always been present in the study area for the time span considered in this work. The capercaillie is an icon of alpine conservation, because it requires a series of different habitats to complete its annual life cycle: from open meadows for lek, to mature woodlands in the winter and finally to a thick under-storey during chick breeding. The hunting of this bird was not regulated until 1973; then the number of game capercaillie was assigned by the local government based on counts until 1991, when hunting it was legally banned due to the decline of the population [40]. Despite the ban, the species is still declining in the park area due to habitat changes [9].
- The black grouse (*Tetrao tetrix*) is the only member of its family (tetraonidae) whose hunting is legal in Trentino. The black grouse has similar ecological needs to those of the capercaillie, and the afforestation trend reduced and fragmented its habitat. The species has been considered stable since 1994, thanks to the forest management within the park, with some exceptions in limited areas of the Park, such as the Pan-veggio forests, where it is still declining. The species can be hunted in only one sector of the park, but the bird is now so rare that hunting is limited to one unit per year.

2.2.2. Regulating and Maintenance ES

The study area, being a mountain environment, is prone to avalanches, boulders falling and landslides. The risks of these events were considered constant over time, but the protection provided by forest changed over time according to the extent and location of the trees. The maps of the various levels of risk were provided by the local agencies of “water and energy” and “risk prevention” of PAT as reported in the “General Plan of public water use” (PGUAP) [41]. For each time step, we estimated the areas of forest that overlapped with the areas of moderate and high risk. All hazards were then grouped into a single class called “Protection from hydro geological hazard”, by summing the extent of protection forest in each reference year.

Flood protection

Hydrological risk was ranked into 5 classes, from R0 (no risk) to R4 (very high risk). We considered as protection forests the areas that overlapped with classes of moderate, average, high and very high risk.

Avalanche protection

Avalanche areas were also taken from PGUAP. The area of protection forest was obtained by GIS by overlapping forest extent over time with the risk map provided by the PGUAP [41].

Landslide protection

was similarly calculated from the PGUAP map [41].

Boulder protection

To estimate the amount of forest that provided protection from boulders, we used the vector map of “forest with protective function against boulder falling” (1:10,000) provided by the Forest and wildlife service of PAT. We considered those areas mapped as forests with direct protection in each reference year.

Carbon storage

The carbon stored in the forest was estimated from the forest inventories available from the Forest Service of the Province of Trento [36,42,43]. Biomass estimation and

thus the carbon stock calculation were based on Notarangelo et al. [44]. The total carbon stock used in this work accounted for above and below ground biomass, dead wood, litter and soil.

2.2.3. Cultural ES: Aesthetic Value from Postcards

The postcard industry declined dramatically after 2010; many typographers moved to different businesses or closed in Trentino (Pedrotti personal communications) and in other parts of Europe [45]. The habit of sending postcards used to be very common until 2007–2010, and reasonably captured a representative sample of the population across age [46] and probably income, as postcards used to be cheap. Nowadays people still send postcards, but since the advent of smart phones with cameras, people have shared pictures over social media more often [47]. Postcards buyers still exist; generally they are computer illiterate people or children (Gilli and Pedrotti, personal communications), so postcard buyers after the year 2010 would not be a representative sample of the population. This is known in the marketing sector, as online surveys are more likely to reach the new generations compared to older people with limited access to the Internet [48].

The hypothesis is that the act of buying a postcard can be considered as an experiment where the buyer expresses a preference for the landscape. The same view of the village and the iconic Dolomites as a background, Figure 2, was on sale in various versions, taken from approximately the same viewpoint, for 40 years. The buyer could then choose his/her favourite look of the landscape. Previous research suggested that postcard buyers demand pictures that correspond to their personal tastes, and often attempt to replicate postcard landscapes when taking photographs with their own cameras [49]. On the other hand, postcard producers design postcards in ways that are most likely appreciated by buyers [26]. Therefore, the behavioural hypothesis of this study is that postcard buyers evaluate all available postcards and choose the preferred landscapes based on their tastes. In this way, buyers reveal their preferences for landscape attributes. The choice of a postcard is assumed to be made exclusively based on landscape preferences, with no budget constraints or income effects. In fact, the cost of a postcard is small and constant regardless of the landscape. The intrinsic idea is that if the landscape is valued by buyers, it should explain postcard demand, and the trade-offs between landscape attributes and other determinants of demand can be used to make implicit value changes in landscape characteristics [50].

Valuating ecosystem services is a hard task, since citizens can not buy or sell them on a standard market, and therefore traditional market-based economic models cannot be applied. There is a long tradition of methodologies being developed to tackle this issue under the umbrella of non-market valuation techniques, such as the hedonic method (see Taylor [51] for an overview).

We considered the postcard selection for sale at the “*Ottica Gilli*” in Fiera di Primiero village, the town’s main postcard store. Many of the photographs on display were taken by Mr. Gilli himself, and he was able to provide the dates of the shoots. Both colour and black and white (BW) postcards of various subjects were on sale. Since BW photographs were not easily comparable to the rest of the collection, the analysis focused on the colour postcards only. We assumed that buyers of BW postcards could have particular interests in history and/or photography, and their decisions would thus be motivated by factors other than the appeal of the landscape.

Data about the sale of postcards from the shop *Ottica Gilli* were obtained from the paper and hand-written archives of the companies *Hermes* and *Ghedina*, which supplied the shop by printing photographs taken by Mr Ovidio Gilli on postcards. *Pedrotti’s* printing firm, *Hermes*, had the exclusive right to print postcards in Trento from 1985 until the company’s closure in 2008. *Ghedina* provided BW postcards only. We thus captured the whole period of sales. From 1990 to the present, the shop has been selling the entire series of historical photographs of the same landscape taken by the shop owner and photographer over time Figure 2. All the postcards cost now 50 cents each, and even though the price has

changed in the past, they used to be sold at the same price. Therefore, the choice of postcard has never been affected by price.

When available, we recorded the year of shooting for each picture, and a description of the main subject according to the following classes:

“Landscape”—when the photograph depicted a landscape; “church”—when the photo depicted one or more churches, or details of a church, with none or very little of the landscape in the background; “flowers and animals”—close-ups of flowers or animals with limited to none of the landscape in the background; “hotel”—a picture of the exact building with the name of the hotel on it; “lake”—when the photo depicted a lake in the foreground and a small amount of the landscape; “village”—a photograph of a group of houses, streets, bridges, stores or markets with little to none of the landscape; “Fiera in the 1950, Fiera in the 1970, Fiera in the 1980 and Fiera in the 1990”—same shot of Fiera di Primiero in that given year as in Figure 2; “typical house”—a photo of a typical house or details of it; “alpine hut”—the typical hut used in a mountain pasture for the grazing of cattle during the summer. We then ran a generalised linear model (GLM) with a Poisson link function with the number of postcards sold as the response variable against the main subject of the image. The Poisson error distribution is suitable for count data, as it forces all of the predicted values to be positive.

3. Results

The changes in ES from 1954 to 2006 are summarised in Table 1 and Figure 3. Forest coverage steadily increased in this period, and with it, timber availability (growing stock) and all the regulating services, including carbon storage. In the 1950s the forest occupied about 40% of the study area; it grew on abandoned pastures, marginal agricultural land and natural grasslands, covering about 52% of the area in 2006. The Natura2000 open habitats were reduced from 65.55 to 36.63 ha, with a loss of 44% of rich alpine meadows (Table 1). This was due also to the reduced pressure of grazing cattle, whose number almost halved over the 50 years analysed. Sheep usually graze at higher elevation, above the tree line, on permanent grasslands. Capercaillie and black grouse populations decreased dramatically, and since the 1980s, both species have been threatened. These birds need open areas or mixed habitats to complete their life cycles, and even with the hunting ban they have not been able to recover. The roe deer population increased until the 1990s, and then declined again due to the competition with deer and loss of open areas (Table 1). Figure 3 shows how bundles of ES evolved in the period examined.

We found 51 different colour postcards for sale, each identified by a unique catalogue number by the providers. The total number of postcards provided to Gilli's shop from 1990 to 2007 was 320,400, and the average number of sales per year was 17,800 postcards. Photos of the landscape were the most popular. Over 209,000 of such postcards were sold (including Landscape and Fiera categories from Table 2), followed by 37,900 houses (alpine huts and houses) and 21,000 churches. Among the landscape postcards, 78,000 (24.3%) items depicting Fiera di Primiero village in different years were provided to the shop. The postcards with the shot of the village in the late 1950s accounted for 3000 items; the same view from the 1970s, 55,000 items, the panorama of the 1980s, 11,000 items; and the one from the 1990s, 6000 items.

The main subject of the photo was a good predictor of the number of postcards sold, according to GLM (Table 3). Except for the presence of a village without the landscape, all the categories yielded highly significant results. Fiera in 1970 had the most significant coefficient, indicating that the amount of items sold was high for that group. On the contrary, negative estimates were given to postcards depicting Fiera in the 1950s and 1990s, indicating that postcards with those images were bought the least. Portraits of nature, including the categories “landscape” and “flowers and animals” were expected to have sold better than the ones with buildings (houses, hotels or huts).

Table 1. Ecosystem services provided by the forest over time in the area of Paneveggio Nature Park (Italy). Priority habitats include natural and semi-natural grasslands according to Natura2000. * Hunting data for roe deer, capercaillie and black grouse have been recorded since 1965, so for those species we used the data of 1965. ** Growing stock available since 1960.

Service	Source	1954	1973	1983	1994	2006
Provisioning						
Forest cover %	[3]	41.7	41.8	45.09	47.87	52.01
Natura2000 (ha)	This work	65.55	52.52	49.83	38.24	36.63
Growing stock (m ³)	[36,42,43]	3,336,357 **	4,371,132	5,416,336	5,976,859	6,159,652
Cattle (N)	[3]	2120	1999	1736	1744	1381
Sheep (N)	[3]	734	637	108	3028	2655
Roe deer(N)	ACT data	42 *	105	140	301	63
Deer (N)	ACT data	0	0	0	24	159
Capercaillie (N)	ACT data	3 *	2	1	0	0
Black grouse (N)	ACT data	10 *	5	4	5	1
Regulating						
Protection from Slides (km ²)	This work	34.9	34.8	38.9	39.3	46.0
Protection from avalanches (km ²)	This work	5.6	5.6	5.8	5.8	7.6
Protection from flooding (km ²)	This work	210.2	209.4	210.4	216.6	231.8
Protection from Boulders (km ²)	This work	6.6	7.1	7.7	8.0	8.8
Total carbon stock (m ³)	This work	1,757,881	2,303,071	2,853,756	3,149,078	3,245,386
Cultural						
Aesthetic value (Postcards sold)	This work					

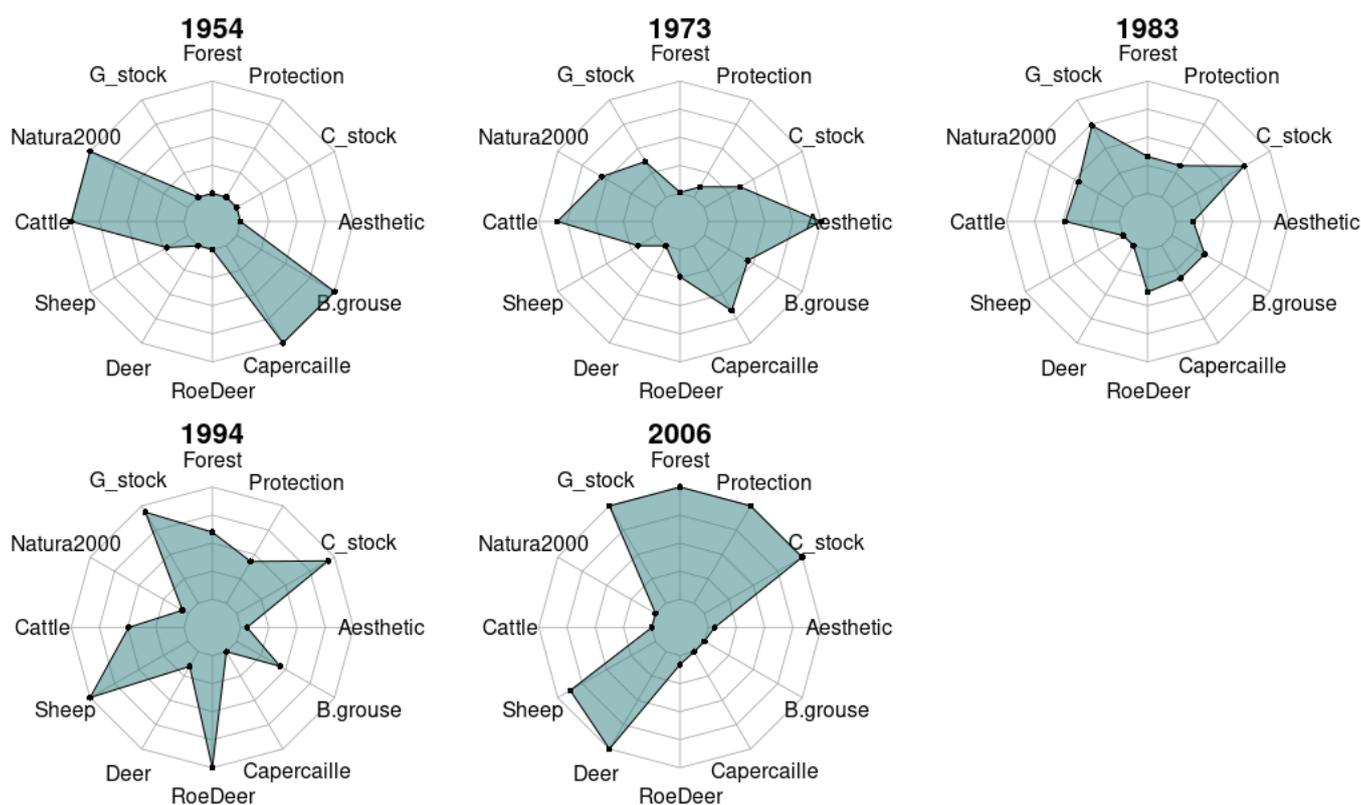


Figure 3. Ecosystem services change in the area of Paneveggio-Pale di S. Martino Nature Park (Italy) over time. Data of Table 1 have been re-scaled to 0–100 interval to facilitate comparisons. G_stock stands for growing stock, C_Stock for total carbon stock and Aesthetic for aesthetic value.

Table 2. Number of postcards printed for each category from 1990 to 2008.

Postcard Main Subject	Printed Items	Percent
Church	21,000	6.5
Fiera in 1950	3000	0.9
Fiera in 1970	55,000	17.2
Fiera in 1980	11,000	3.4
Fiera in 1990	6000	1.9
Flowers and animals	7000	2.2
Hotel	6000	1.9
Lake	15,500	4.8
Alpine house	8000	2.5
Landscape	114,000	35.5
Village	17,000	5.3
Alpine hut	29,500	9.2

Table 3. Results of GLM model: the response variable was the number of postcards sold modelled against the main subject of the picture. Significance level of at $p \alpha < 0.05$.

Postcard Main Subject	Estimate	Std. Error	p-Value
(Intercept)	8.343	0.007	<0.01
Fiera in 1950	−0.336	0.019	<0.01
Fiera in 1970	0.679	0.008	<0.01
Fiera in 1980	0.269	0.012	<0.01
Fiera in 1990	−0.336	0.015	<0.01
Flowers and animals	0.511	0.014	<0.01
Hotel	−0.336	0.015	<0.01
Lake	0.207	0.010	<0.01
Alpine house	−0.049	0.013	<0.01
Landscape	0.502	0.008	<0.01
Village	0.012	0.010	0.25
Alpine hut	−0.130	0.009	<0.01

4. Discussion

4.1. Ecosystem Services over Time

Since 1954, forest reclaimed a large number of the open areas of PPSM and its surroundings [3]. Many studies highlighted the irreplaceable role played by agro-ecosystems in the preservation of biodiversity and the enhancement of the multi-functionality of the forest through the historical balance between open and wooded areas in the Alps in general [2,52,53] and in Trentino in particular [7,34,35]. The progressive afforestation led to increases in many ES, including protection from hydro-geological hazards, wood production and forest diversity. Thicker forest coverage together with biodiversity improvements contributed to enhancing both soil quality and quantity over time, leading to a significant improvement of forest resilience to major disturbances, such as fires, storms and pests. The amount of active soil is directly connected with the capability of a forest environment to restore its previous state after a catastrophic event.

On the other hand, from 1954 there was a the reduction of priority habitats and species typical of open areas. Many bird species of agro-ecosystem have been reported to be threatened by such changes [54], including the capercaillie, black grouse but also the corncrake (*Crex crex*) [55] a priority species for European Union.

The greater aesthetic value was given to the landscape of the 1970s, a moment in the history when none of the other ES considered were at their maxima. On top of that, deer were absent and the roe deer population was still low (Figure 3). The perceived beauty of the landscape is linked to open areas, which are also host priority habitats and birds. The loss of priority habitats since 1950 is of about 30 ha (Table 1), in an area of more than 200 km². Removing a well selected amount of forest from a small portion of the study area would likely restore open areas and provide a habitat for birds, without reducing

significantly the protection and carbon storage provided by the trees. Our results could guide specific interventions to create a different scenario from the one depicted in Figure 3 that maximises the provisions of the various ES.

The abandonment of traditional agriculture and the loss of biodiversity triggered a discussion at local political level about the possible recovery of some open areas [56,57]. In 2000, the PAT started to give subsidies to farmers for mowing grassland to prevent forest re-invasion and conserve these habitats. From 2014 to 2018, the Forest Department cut 61 ha of newly formed woods in order to restore turf grass meadows in the district of Primiero [28], that way investing public money to recreate a balance between open (pastures and meadows) and wooded areas of the traditional alpine landscape [1]. These interventions aimed to restore lost habitat without affecting the forests functions and the ES they provide, which increased over the last decades. A diverse and multi-functional landscape is considered the key factor to making the environment more resilient and to promote societal and economic sustainability.

These restoration measures, even if they cost, are likely to be accepted by the taxpayer because they tend to recreate a landscape that is perceived as more beautiful and closer to traditional local identity than a compact forest. Aesthetic value only should not guide decision making; the aim of interventions should be sustainable maintenance of ES over time. Historical analysis can be useful to simulate the effects of different management options on ES to create a sustainable scenario.

4.2. Aesthetic Preferences Assessed through Postcards

We evaluated the aesthetic preferences regarding the landscape using over 320,000 postcards from nearly 20 year of business. Other studies assessing the cultural value of landscapes were based on interviews or questionnaires administered to 50–500 people [58]—sometimes more [10,13] but usually fewer than 1000—whereas using postcards allowed us to collect landscape preferences for a sample size of a thousand times greater. However, using postcards does not allow for a socio-demographic analysis, because this information could not be retrieved from postcard selling. Potential limits of this approach are that the same picture could be purchased multiple times by the same person, and the same person could buy different postcards at the same time. Another limit of using postcard sales is that data gathering, contacting providers and screening the photographic material can be time consuming.

Nevertheless, we deem that our results are reliable because of the large sample size and because the habit of sending postcards reasonably captured a good sample of the population. In addition, we were able to obtain publishers records for over 20 years and the dates of the images, precious information that was not always available in other studies based on postcards [25], and allowed us to have a quantitative approach.

The selling of postcards clearly showed that landscape pictures were the most chosen (35%) to represent a holiday in the study area, followed by the view of Fiera di Primiero in the 1970s (17.2%), which was also highly significant in the GLM analysis.

Nearly a quarter of the postcards sold in the shop depicted the village of Fiera di Primiero and the Dolomites, making this view the icon of the area. The photo of Fiera included various natural and cultural elements, the village, the forest, the open areas and the dolomites in a single image, conveying an idea of balance between people and the environment.

The great majority of people chose the postcard of Fiera taken in the 1970s, even if it was different from the landscape they could observe in reality. The least preferred image was the one taken in the 1950s, wherein the exploitation of the forest was most evident, followed by the most recent one, where forest covered nearly all of the sides of the mountains. The preferred image portrayed an intermediate situation between wilderness and exploitation that conveyed the idea of a traditional agro-ecosystem where forest and grassland were balanced. In this 1970 postcard, the mountains around Fiera di Primiero presented several meadows encased in a flourishing forest (Figure 2), giving the idea of

a place where people lived and worked, compared to the present perceived wilderness and abandonment.

The preferred postcard represents the 1970s forest landscape. This period was neither the best in terms of ecosystem services nor a stable situation. It was rather a period of transformation from an overexploited environment into a more healthy and resilient forest that still continued to show the facets of traditional anthropic activities. It also represented a turning point in which the local agro-forest economy began its transformation into a more tourism-oriented reality that brought a significant economic growth. In the 1970s the impact of tourism was still relatively sustainable in terms of numbers of tourists and the impacts of infrastructure.

Our results are in agreement with the findings of Schleyer et al. [59], who reported that local stakeholders perceive the loss of the historical landscape as the main threat to tourism. This fact also supports the idea that postcards for sale in tourist destinations could reveal relations among actors in the tourist industry and other stakeholders [60]. According to the questionnaire administered to local stakeholders in 2019 [59], it appears that the combination of natural and agricultural areas is seen as key to creating a landscape that can revive the tourism in the Primiero region.

In any case, focusing on biodiversity enhancement appears to be the true win–win option for achieving a long-term balanced equilibrium [61] that does not deplete natural resources or discourage the local population's activities. It must be obvious that this biodiversity must be investigated through the lens of landscape ecology. Concentrating local funding and activities on real problems that are also considered aesthetically positive, such as Natura2000 areas and grouse leks, may help to focus on more achievable goals. If this principle of biodiversity maximisation is embraced by the local community, it could promote sustainable local growth and it may help to reach more resilient communities and also reduce wildlife conflicts. These activities are often seen as practical and easily incorporated into local planning. A complex landscape can meet all of the objectives, and a small number of well-targeted initiatives may make substantial differences while not interfering with ongoing positive ES trends (e.g., carbon stock) and enhancing the aesthetic value of the alpine environment.

5. Conclusions

Aesthetic preferences for a mountain landscape in the Alps were quantified from postcard sales over a 20-year period, thanks to the ability to retrieve valuable information on the dates of photography, which was not always available in previous postcard studies [25]. This is both a strength of our study and its biggest limitation in terms of reproducibility.

We do believe, however, that assessing landscape preference from photographs may be applied to online photographs. The number of photographs circulating on the Internet is large, both on official tourism sites and on social media, particularly Instagram, which is image-based and employs tags. The number of likes or shares of an image could be used to assess the preference for a specific landscape, with the added benefit that social media allow users to gather (some) socio-demographic information that postcards do not.

People's preferences for the landscape at given times gave a measure of its aesthetic value; however, there is much more behind the image of that landscape: cultural perspectives, traditions [62] and different levels of various ES that the environment provides. The individual who chose a specific image may just be aware of some of the ES or may be completely unaware of them.

In other words, a preference for the landscape at a given time reflects certain levels of ES that can be approximated by the "market share" of the postcard. Some of the services could be appreciated directly in the postcards, for instance, forest coverage, whereas others, such as wildlife presence, cannot be directly perceived from them, but can be measured and used in a hedonic model to test whether or not they do affect buying behaviour. Therefore, by restoring a beautiful landscape, a particular policy changes the quality of many of the ecosystem services associated with it. By identifying such ES measures, measuring them

and using them to explain postcard demand, preferences for different ES can be elicited. These preferences are useful to inform managers who choose among alternative restoration policies and the non-market benefits associated with them.. Our results suggest that in the Alps a complex landscape can meet sustainability goals and be perceived as pleasant at the same time.

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Abbreviations

The following abbreviations are used in this manuscript:

ACT	Associazione Cacciatori Trentini (Trento hunting association)
BW	Black and White
CES	Cultural Ecosystem Services
ES	Ecosystems Services
GLM	Generalised Linear Models
PAT	Provincia Autonoma di Trento (Autonomous Province of Trento)
PGUAP	Piano Generale di Utilizzazione delle Acque Pubbliche (General Plan of public water use)
PPSM	Paneveggio Pale di S. Martino Nature Park
RES	Recreational Ecosystems Services

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