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EFFECTS OF FOREST EXPANSION AND LAND ABANDONMENT ON ECOSYSTEM SERVICES OF ALPINE ENVIRONMENTS: CASE STUDY IN LEDRO VALLEY (ITALY) FOR THE PERIOD 1859-2011

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ABSTRACT

During the last century, the European Alps have faced intense socio-economic changes, which have led to respective land-use changes with immediate impact on ecosystem services (ESs). The aim of the study is to present the land-use changes and their effects on the economical contribution of ESs in the alpine environment of Ledro Valley, in Northern Italy. Data were collected through historical cartography and photographic material from 1859, 1973 and 2011. The analysis of landscape evolution highlighted the forest expansion, and partially the urban expansion, at the expense of grasslands and croplands due to a transition from a rural to a touristic and handcrafting economy. The land-use changes led to an overall reduction of the economical contribution of ESs, while further analysis on individual services identified advantages and disadvantages caused by the re-naturalization process of forest expansion. The results suggested that the profit maximization of ESs under the pressure of such land-use changes can be achieved by a) a respective profit maximization from services related to recreation activities (tourism) which have an immediate economical impact on local economies and b) the maintenance and sustainable management of the typical rural landscape and grasslands in order to preserve some of their economical benefits.

Keywords: Alpine environment, land-use change, ecosystem services, forest expansion, land abandonment.

1. Introduction

Ecosystems provide a range of services, many of which are of fundamental importance to human well-being, health, livelihoods, and survival. The economical contribution of such services can be evaluated using the reference system of monetary indicators proposed by Costanza *et al.,* (1997, 2014) and de Groot *et al.*, (2012), which is considered an extremely useful tool for the development of landscape management plans. The landscape of Alps is considered one of the most important natural territories of Europe and provides a great number of ecosystem services (ESs): protection from natural hazards, CO_2 storage and accumulation in soil or biomass, provisioning of raw materials and water, genetic diversity and touristic opportunities (Grêt-Regamey *et al.*, 2008). During the second half of 20th century, socio-economic changes caused a modification in the use of Alpine territories towards a greater exploitation or a complete abandonment (Chauchard *et al.*, 2007; Rutherford *et al.*, 2008; Prévosto *et al.*, 2011; Cocca *et al.*, 2012).

These alterations are considered the main causes of variations observed in species diversity, ecosystem functionality, landscape configuration, and economical growth of the local communities (Tasser *et al.*, 2005; 2007).

Many administrative units and scientists demonstrated a growing interest in the development of landscape and urban development plans for the alpine territories (Scolozzi *et al.*, 2010; Fontana *et al.*, 2013; Schirpke *et al.*, 2013; Ferrari and Geneletti, 2014) which are considered among the most interesting places for analyzing the evolution of land-use changes and the interdependence of multiple ecosystem services in terms of their synergies and trade-offs (Bennett *et al.*, 2009; Nelson *et al.*, 2009; Power, 2010; Schirpke *et al.*, 2013).

The aim of the study is to present the land-use changes and their effects on the economical contribution of ESs in the alpine environment of Ledro Valley, in Northern Italy, during the period 1859-2011. The study area and the evolution of its landscape during the 152-years period is representative of the Italian alpine environments and can provide significant information about the economical impact of land-use changes through ESs analysis.

2. Data and methods

2.1. Study area and data

Ledro Valley (45°87’0’’ N, 10°76’0’’ E) is located in the southern area of Alpine chain, in south-western Trentino in Italy (Fig.1). The total coverage of the study area is almost ~200 Km^2 with altitude ranging between 65 m (edge of Garda Lake) and 2253 m (Cima Geometra). The mean annual precipitation is 1300 mm and the mean annual temperature is around 9-10 °C (Cigalotti, 1973). The variety of environmental conditions, in association with the particular geological history (AA.VV., 2012), are among the main reasons of the exceptional natural heritage of Ledro district, which includes 22 botanical endemic species and several priority habitats according to 92/43/EEC. Five Natura 2000 sites are located within its boundaries, which combine 4 SCIs (Sites of Community Importance) and 3 SPAs (Special Protection Areas). From a socio-economic point of view, until the beginning of the second half of XX century, the study area was characterized by an economy mainly based on traditional activities, linked to agriculture and farming. Nowadays, traditional land-use has largely reduced and Ledro Valley is characterized by an economy mostly based on tourism and handcrafting.

2.2. Analysis of landscape evolution

The evolution of Ledro landscape was analyzed using cartographic material from 1859 (Hapsburgic cadaster), 1973 and 2011; 1973 (Digital Orthophoto – Autonomous Province of Trento) and 2011 (Digital Orthophoto – Autonomous Province of Trento), covering a total period of 152 years. Land-use mapping (Fig.1) was performed using two GIS software packages: Quantum GIS Brighton (ver.2.6.1.) and Global Mapper v.11 (Global Mapper Software LLC). Nine basic land-uses were identified: 1. Forest (including both coniferous forest and deciduous forests), 2. Pastures, 3. Permanent meadows, 4. Croplands, 5. Inland waters, 6. Sandy river banks, 7. Inland wetlands, 8. Discontinuous urban fabric, 9. Buildings.

Landscape evolution was analyzed according to five elevation zones: 65-600 m, 600-1000 m, 1000-1600 m, 1600-2000 m, 2000-2300 m. The statistically significant changes were tested on the base of comparison of proportions with χ^2 test for *P*-value≤0.01, using StatGraphics Centurion XV (StatPoint Inc.). For each elevation zone, the comparison was performed between the total area of each land-use type of the three years 1859, 1973, 2011 with the overall extension of the remaining ecosystem types (for instance, Forest and Non-forest). The null hypothesis was that the extension of the two classes didn’t change over the years 1859, 1973, 2011. Together with χ^2 test, the analysis of means (ANOM) plot with 99% confidence limits was also used. Based on the ANOM plot, three codes *a*, *b* and *c* were used to denote the location of the proportion values from the three dates: above, inside and below the 99% confidence limits. This procedure was not used to denote statistical differences between the years (e.g. as in the case of LSD test in ANOVA) but to provide some indications about the direction of the most extreme changes, based on the deviation from the grand mean of the ANOM plots.

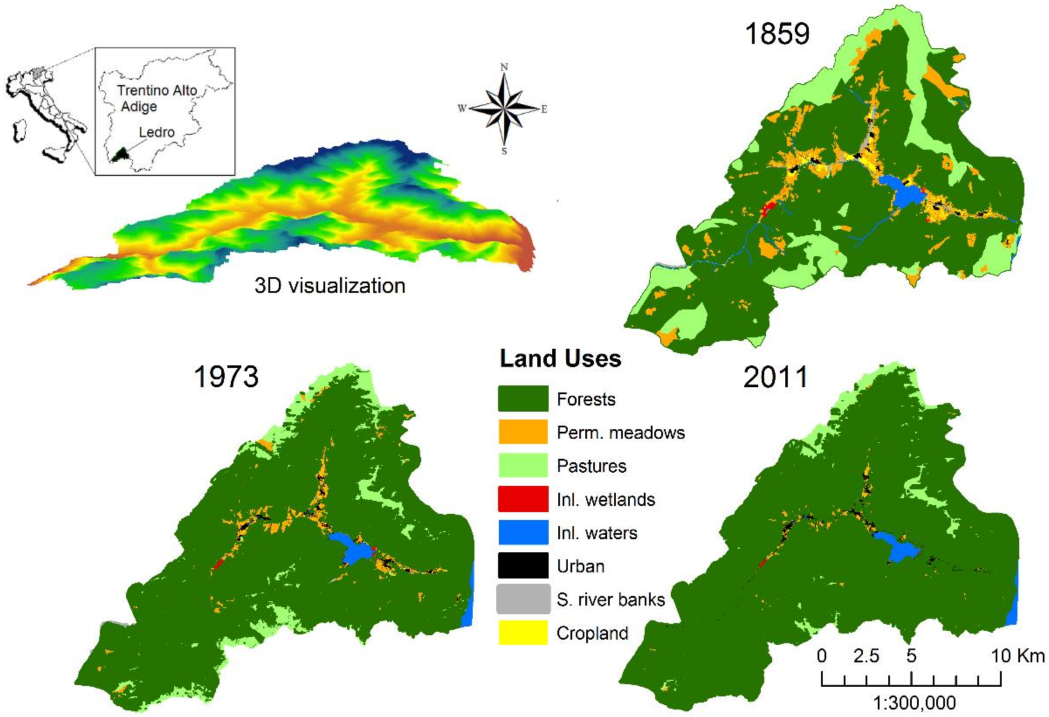

Figure 1. 3D terrain visualization and land-uses of Ledro valley for the years 1859, 1973 and 2011 (“Urban” includes both “Discontinuous urban fabric” and “Buildings”)

2.3. Evaluation system of ecosystem services

The economic value of ESs for each land-use was obtained by Costanza *et al.,* (2014) (provided in USD$2007) after modifications from de Groot *et al.,* (2012). Evaluations were updated to euro EU€2015 monetary values using the Inflation calculator (http://www.usinflationcalculator.com/) to convert from USD$2007 to USD$2015 (inflation factor=1.15) and the monetary convertor (www.fxtop.com) to convert from USD$2015 to EU€2015 (conversion factor =0.88). The monetary values of five ecosystem categories were used for the evaluation of ESs: 1. Temperate forests, 2. Grasslands, 3. Croplands, 4. Inland wetlands and 5. Inland waters (Costanza *et al.*, 2014). Their updated monetary values in EU€2015/ha/year are given in Table 1. These ecosystem typologies were used as a proxy for each land-use of Ledro valley. The categories of “Discontinuous urban fabric” and “Buildings” do not provide ESs and for this reason were excluded; the “Pastures” and “Permanent meadows” were considered as “Grasslands” since they provide the same ESs, while the “Sandy river banks” were grouped together with “Inland waters” since their area is covered by water, especially during winter. The overall value of ESs provided by the study area in 1859, 1973 and 2011 was finally estimated by multiplying the area of each land-use with the respective updated values from Table 1.

3. Results

3.1. Land use changes

The coverage of land-use and the land-use changes based on the five different elevation zones for the respective periods are given in Table 2 and the results of χ^2 tests are given in Table 3.

According to Table 2 and 3, significant land-use changes were not observed in the higher elevation zone (2000-2300 m), while the categories of “Inland waters”, “Inland wetlands” and “Buildings” showed no significant changes in all elevation zones during the 152-years period. For the case of “Inland waters”, there was a change in their spatial distribution between the land-use maps of 1859 and 1973, because part of the area covered by streams and part of the small lake Ledro in the center of the study area was lost. This territorial loss of inland waters was counterbalanced by the rise in water level of Garda Lake at the eastern boundaries of the territory, which increased lake’s area as it is evident in Fig.1. This rise occurred in 1950 when the lake was closed by an artificial barrier built on the Mincio in Salionze-Monzambano (Piccolroaz *et al.*, 2013).

Table 1. Monetary values for each ecosystem service per biome, according to de Groot *et al.,* (2012) and Costanza *et al.,* (2014) after conversion to EU€2015/ha/yr

	Ecosystem Services in EU€2015	Ecosystem type				
		Temperate forest	Grasslands	Inl. Wetlands	Inl.waters	Croplands
Provisioning Services	Food production	302.59	1,206.30	963.42	107.27	2,350.88
	Raw materials	183.17	54.65	420.99	-	221.63
	Genetic resources	-	1,228.57	245.92	-	1,054.50
	Water supply	193.29	60.72	970.51	1,829.70	404.80
	Total Prov. Services	679.05	2,550.24	2,600.84	1,936.97	4,031.81
Regulation Services	Gas regulation	-	9.11	-	-	-
	Climate regulation	153.82	40.48	202.40	-	415.93
	Disturbance regulation	-	-	4,651.15	-	-
	Erosion control	5.06†	44.53	3,549.08	-	108.28
	Waste treatment	121.44	75.90	112,681.14	929.02	401.76
	Biological control	237.82	31.37	306.64	-	33.40
	Water regulation	-	3.04	1,810.47	7,604.17	-
	Nutrient cycling	94.12	-	583.92	-	-
	Total Regul. Services	612.26	204.42	123,784.80	8,533.18	959.38
Supporting Services	Soil formation	14.17	2.02	-	-	538.38
	Pollination	-	35.42	-	-	22.26
	Habitat refugia	872.34	1,228.57	12,601.42	-	-
	Total Support. Services	886.51	1,266.01	12,601.42	-	560.65
Cultural Services	Recreation	1,000.87	26.31	2,225.39	2,191.99	82.98
	Other Cultural*	1.01	169.00	643.63	-	-
	Total Cult. Services	1,001.88	195.32	2,869.02	2,191.99	82.98
Total of Ecosystem Services		3,179.70	4,215.99	141,856.09	12,662.14	5,634.82

*† In Costanza et al., (2014) the erosion control of temperate forests is 0 while in de Groot et al., (2012) is equal to 5 USD$2007 (~5.06 EU€2015). We chose the second case since temp. forests contribute economically to the reduction of erosion. *Aesthetics information, inspiration for culture and arts, spiritual experience, cognitive development (de Groot et al., 2012).*

From the remaining land-uses, the categories of “Forest” and “Discontinuous urban fabric” showed a statistically significant increase of their coverage while the categories “Pastures”, “Permanent meadows”, “Arable land” and “Sandy river banks” a statistically significant decrease during the 152-years period (Table 3).

The coverage of forests increased from 65.7% of the total area in 1859, to 75.2% in 1973 and to 82.6% in 2011 (3301 ha gained in 152-years period). For the elevation zones between 65-1600 m, the increase of forest mostly happened before 1973 while for the elevation zone 1600-2000 m mostly happened after 1973. Forest expansion in these elevation zones mainly reduced the summarized coverage of both “Pastures” and “Permanent meadows” from 30.4% of the total area in 1859, to 22.4% in 1973 and to 14.6% in 2011 (3088 ha lost in 152-years period).

In the two lower elevation zones (65-600 and 600-1000 m), which correspond to the valley floor, it was found a large reduction of both “Croplands” and “Sandy river banks” mainly due to the increase of “Discontinuous urban fabric” but also by some expansion of “Pastures” and “Permanent meadows”. The reduction of “Croplands” mostly happened before 1973 and its coverage in 2011 was only 20.8 ha (0.11% of the total area) with an overall loss of 94.8% since 1859 (380 ha lost in 152-years period). The “Sandy river banks” gradually decreased reaching 4.4 ha (0.02% of the total area) with an overall loss of 86% since 1859 (27 ha lost in 152-years period). The “Discontinuous urban fabric” mainly increased in the zone of 600-1000 m from 0.21% of the total area in 1859, to 0.72% in 1973 and to 1.19% in 2011 (191 ha gained in 152-years period).

Table 2. Coverage of land-uses and land-use changes for five different elevation zones of the Ledro valley for the years 1859, 1973 and 2011

LAND-USE 1859 [ha]

Altitude [m a.s.l.]	Forest	Pastures	Permanent meadow	Crop land	Inland waters	S.R. Banks	Inland wetlands	Discontinuous urban fabric	Buildings	Total [ha]	Total [%]
2000 - 2300	11.98	131.1	-	-	-	-	-	-	-	143	0.74%
1600 - 2000	705.3	1664.4	69.77	-	-	-	-	-	0.24	2440	12.53%
1000 - 1600	7545.05	1599.43	802.18	2.01	2.19	-	-	-	1.79	9953	51.13%
600 - 1000	4109.66	207.69	1106.39	346.79	253.722	22.18	10.99	35.03	7.33	6100	31.34%
65 - 600	407.17	233.04	106.85	51.99	15.82	9.08	-	6.17	0.89	831	4.27%
Total [ha]	12779.16	3835.66	2085.19	400.79	271.732	31.26	10.99	41.2	10.25	19466	100%
Total [%]	65.65%	19.70%	10.71%	2.06%	1.40%	0.16%	0.06%	0.21%	0.05%	100%	

LAND-USE 1973 [ha]

Altitude [m a.s.l.]	Forest	Pastures	Permanent meadow	Crop land	Inland waters	S.R. Banks	Inland wetlands	Discontinuous urban fabric	Buildings	Total [ha]	Total [%]
2000 - 2300	2.57	140.5	-	-	-	-	-	-	-	143	0.74%
1600 - 2000	603.15	1749.4	76.56	-	-	-	-	-	0.12	2440	12.53%
1000 - 1600	8696.6	881.8	378.9	0	1.9	-	-	-	4.6	9953	51.13%
600 - 1000	4670.04	22.5	970.7	34.48	242	9.37	12.08	126.6	11.8	6100	31.33%
65 - 600	658.73	44.3	87.31	11.48	12.37	1.63	-	14.4	1.01	831	4.27%
Total [ha]	14631.09	2838.55	1513.47	45.96	256.27	11	12.08	141	17.53	19466	100%
Total [%]	75.16%	14.58%	7.77%	0.24%	1.32%	0.06%	0.06%	0.72%	0.09%	100%	
% Change from 1859	14.49%	-26.00%	-27.42%	-88.53%	-5.69%	-64.81%	9.92%	242.23%	71.02%		

LAND-USE 2011 [ha]

Altitude [m a.s.l.]	Forest	Pastures	Permanent meadow	Crop land	Inland waters	S.R. Banks	Inland wetlands	Discontinuous urban fabric	Buildings	Total [ha]	Total [%]
2000 - 2300	9.39	133.69	-	-	-	-	-	-	-	143	0.74%
1600 - 2000	1312.3	1104.79	21.56	-	0.21	-	-	-	0.85	2440	12.53%
1000 - 1600	9244.02	480.15	219.29	0.05	4.45	-	-	-	4.69	9953	51.13%
600 - 1000	4821.72	26.68	756.62	11.7	239.22	4.37	9.1	212.91	17.31	6100	31.34%
65 - 600	692.72	32.38	58.03	9.03	18.4	0	-	18.79	1.66	831	4.27%
Total [ha]	16080.15	1777.69	1055.5	20.78	262.28	4.37	9.1	231.7	24.51	19466	100%
Total [%]	82.61%	9.13%	5.42%	0.11%	1.35%	0.02%	0.05%	1.19%	0.13%	100%	
%Change from 1859	25.83%	-53.65%	-49.38%	-94.82%	-3.48%	-86.02%	-17.20%	462.38%	139.12%		
%Change from 1973	9.90%	-37.37%	-30.26%	-54.79%	2.35%	-60.27%	-24.67%	64.33%	39.82%		

Table 3. Comparative analysis of land use changes for five different elevation zones of the Ledro valley between the years 1859, 1973 and 2011 using the χ^2 test and codes of the respective proportions of each date obtained by the means plot with 99% confidence limits

	Forest					Pastures					Permanent meadow				
Altitude [m a.s.l.]	**χ^2 (df=2)**	**P-value**	**1859**	**1973**	**2011**	**χ^2 (df=2)**	**P-value**	**1859**	**1973**	**2011**	**χ^2 (df=2)**	**P-value**	**1859**	**1973**	**2011**
2000 - 2300	6.27	0.0435	b	b	b	6.34	0.042	b	b	b	-	-	-	-	-
1600 - 2000	524.3	<0.001	c	c	a	425.3	<0.001	a	a	c	32.9	<0.001	b	a	c
1000 - 1600	1209.2	<0.001	c	a	a	723.1	<0.001	a	c	c	407.9	<0.001	a	c	c
600 - 1000	241.78	<0.001	c	a	a	264.8	<0.001	a	c	c	77.9	<0.001	a	b	c
65 - 600	281.8	<0.001	c	a	a	280.3	<0.001	a	c	c	15.98	<0.001	a	b	c
	Arable land					**Inland waters**					**Banks**				
Altitude [m a.s.l.]	**χ^2 (df=2)**	**P-value**	**1859**	**1973**	**2011**	**χ^2 (df=2)**	**P-value**	**1859**	**1973**	**2011**	**χ^2 (df=2)**	**P-value**	**1859**	**1973**	**2011**
2000 - 2300	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1600 - 2000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1000 - 1600	3.83	0.148	b	b	b	1.37	0.504	b	b	b	-	-	-	-	-
600 - 1000	546.9	<0.001	a	c	c	0.55	0.78	b	b	b	14.1	<0.001	a	b	c
65 - 600	49.6	<0.001	a	c	c	1.2	0.55	b	b	b	13.2	0.002	a	b	c
	Inland wetlands					**Discontinuous urban fabric**					**Buildings**				
Altitude [m a.s.l.]	**χ^2 (df=2)**	**P-value**	**1859**	**1973**	**2011**	**χ^2 (df=2))**	**P-value**	**1859**	**1973**	**2011**	**χ^2 (df=2)**	**P-value**	**1859**	**1973**	**2011**
2000 - 2300	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1600 - 2000	-	-	-	-	-	-	-	-	-	-	0.76	0.69	b	b	b
1000 - 1600	-	-	-	-	-	-	-	-	-	-	1.47	0.48	b	b	b
600 - 1000	0.42	0.81	b	b	b	129.4	<0.001	c	b	a	4.12	0.13	b	b	b
65 - 600	-	-	-	-	-	6.4	0.041	b	b	b	0.29	0.87	b	b	b

† a: is for values above, b: is for values inside and c: is for values below the 99% confidence limits in the ANOM plot of the proportion values of 1859, 1973, 2011 for a land use in the same elevation zone.

3.2. Ecosystem services evaluation

The results obtained from landscape analysis (Table 2) were combined with the updated values of services (Table 1) in order to assess the economical contribution of Ledro valley ESs during the 152-years period. Table 4 shows the total sum in millions €/year (M€/yr) of the provided ESs for each ecosystem type during 1859, 1973 and 2011 while Table 5 shows the total sum in M€/year of a specific ES from all the existing ecosystem types during the respective years.

According to Table 4, it is observed that the overall value of ESs has been decreased about 5.39 M€/yr from 73.25 M€/yr in 1859 to 67.86 M€/yr in 2011 (total reduction -7.4% during the 152-years period). This reduction is attributed to the expansion of forest mainly at the expense of grasslands but also of croplands, which both have greater contribution in the expensive Provisional services in comparison to forests (Table 1).

Considering the ES groups, it was observed that Provisional and Supporting services were reduced, while Regulation and Cultural services were increased (Table 5), with the intensity of their changes following the ranking scheme: Provisional (-27.8%) > Cultural (+17.6%) > Supporting (-6.3%) > Regulation services (+3.5%).

Even though Provisional services showed the greater reduction/change among the rest ES groups, it was observed that this change was regulated by the respective reduction of “Food Production” and “Genetic Resources” since “Raw Materials” and “Water Supply” contribution was increased. In the case of Regulation services group, it was observed that “Climate Regulation”, “Biological Control” and “Nutrient Cycling” were increased while all the rest ESs were reduced, leading to a final positive change for this group of services. In the case of Supporting services, all the ESs were negatively affected and especially the “Habitat refugia”. The case of Cultural services group is of special interest since the “Recreation” contribution significantly increased, mitigating the reduction of the overall ESs. Finally, analysis was performed on the annual rates of change r_c for each ES but also for each ES group between the periods of 1859-1973 and 1973-2011 (Fig. 2). The results showed that the r_c values were higher during the period 1973-2011 for all ES groups (Fig.2a) but also for each individual ES except “Water Regulation” and “Soil Formation” (Fig.2b). These two ESs showed higher r_c values during 1859-1973 due to the expansion of forest at the expense of pastures, which was found to be higher before 1973 in the elevation zones between 65-1600 m (Table 3).

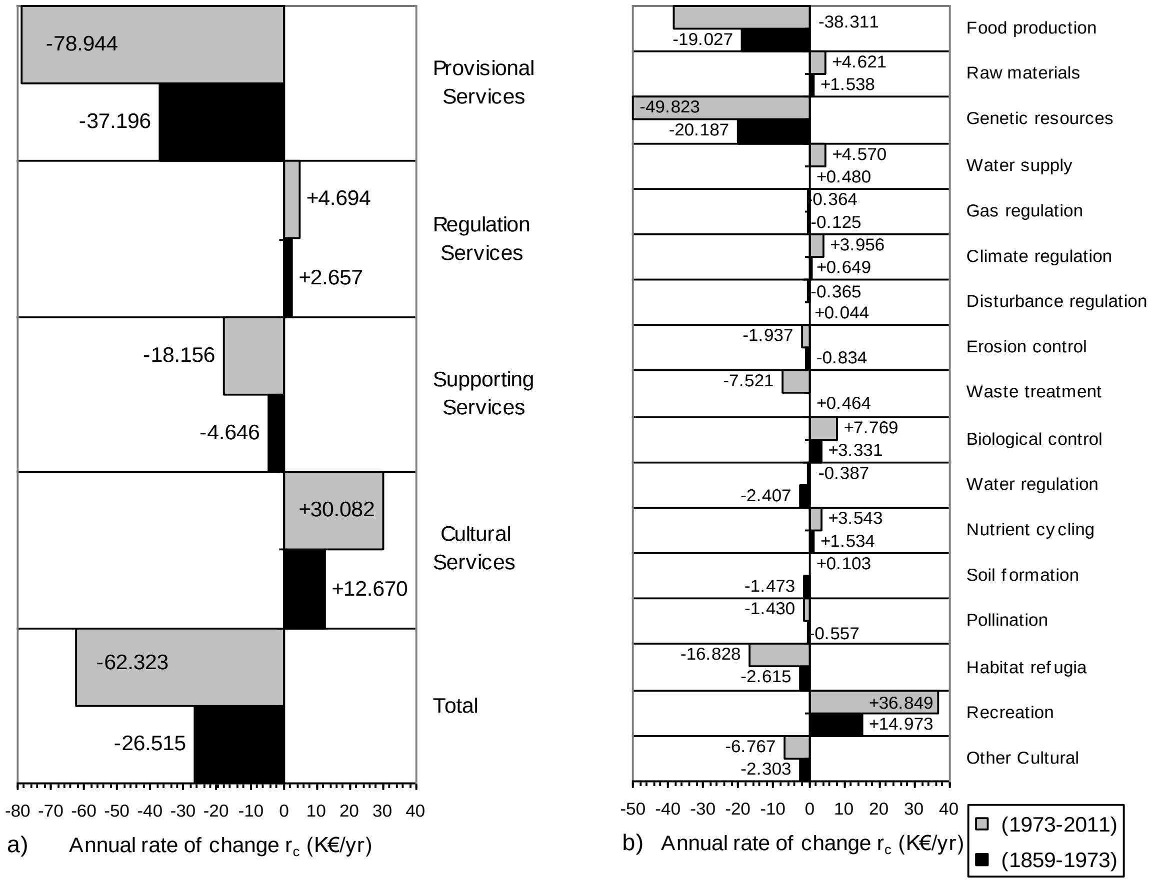

Figure 2. Annual rate of change r_c a) for each ES group and b) for each individual ES during the periods 1859-1973 and 1973-2011

4. Discussion

The absence of significant changes in the landscape above 2000 m and the significant changes below this elevation during the 152-years period suggest that the observed landscape evolution in Ledro valley is mainly associated to human activities rather than climate changes (Vittoz *et al.*, 2009). The general trends verify the findings of other authors from similar study areas in Alpine and Mediterranean environments

(Gehrig-Fasel *et al.*, 2007; Gellrich *et al.*, 2007; Cramer *et al.*, 2008; Tasser *et al.*, 2005,2007; Geri *et al.*, 2010; Schirpke *et al.*, 2013), which have experienced a conversion from a rural and subsistence economy, to an economy based on handcrafting and tourism. Regarding the urbanization phenomenon, the number of inhabitants in Ledro Valley increased from 4708 inhabitants in 1834 to 5523 in 2014, even though other mountainous areas face an increasing depopulation process (Lehringer *et al.*, 2003), which enhances the phenomenon of land abandonment and consequently forest expansion.

Table 4. The total sum in M€/yr of the provided ecosystems services for each ecosystem type during 1857, 1973 and 2011 and gain/loss (G/L) in M€/yr between the respective dates

Date	Ecosystem type					
	Forest	**Grasslands†**	**Inl. wetlands**	**Inl. Waters‡**	**Croplands**	**Total**
1859	40.634	24.962	1.559	3.837	2.258	73.250
1973	46.523	18.348	1.714	3.384	0.259	70.227
2011	51.130	11.945	1.291	3.376	0.117	67.859
G/L (1859-1973)	5.889	-6.614	0.155	-0.452	-1.999	-3.023
G/L (1973-2011)	4.608	-6.403	-0.423	-0.008	-0.142	-2.368
G/L (1859-2011)	10.496	-13.018	-0.268	-0.460	-2.141	-5.391

†Includes "Pastures" and "Permanent Meadows", ‡Includes "Inland waters" and "Sandy river banks"

Table 5. The total sum in M€/year of a specific ecosystem service from all the existing ecosystem types during 1857, 1973 and 2011 and gain/loss (G/L) in M€/yr between the respective dates

Ecosystem Services in M€/yr		Date			G/L		
		1859	1973	2011	(1859-1973)	(1973-2011)	(1859-2011)
Provisioning Services	Food production	11.994	9.825	8.370	-2.169	-1.456	-3.625
	Raw materials	2.758	2.933	3.109	0.175	0.176	0.351
	Genetic resources	7.700	5.398	3.505	-2.301	-1.893	-4.195
	Water supply	3.557	3.612	3.785	0.055	0.174	0.228
	Total Prov. Services	**26.009**	**21.768**	**18.769**	**-4.240**	**-3.000**	**-7.240**
Regulation Services	Gas regulation	0.054	0.040	0.026	-0.014	-0.014	-0.028
	Climate regulation	2.374	2.448	2.599	0.074	0.150	0.224
	Disturbance regulation	0.051	0.056	0.042	0.005	-0.014	-0.009
	Erosion control	0.411	0.316	0.242	-0.095	-0.074	-0.169
	Waste treatment	3.682	3.735	3.449	0.053	-0.286	-0.233
	Biological control	3.242	3.621	3.917	0.380	0.295	0.675
	Water regulation	2.342	2.067	2.053	-0.274	-0.015	-0.289
	Nutrient cycling	1.209	1.384	1.519	0.175	0.135	0.310
	Total Regul. Services	**13.365**	**13.668**	**13.846**	**0.303**	**0.178**	**0.481**
Supporting Services	Soil formation	0.409	0.241	0.245	-0.168	0.004	-0.164
	Pollination	0.219	0.155	0.101	-0.063	-0.054	-0.118
	Habitat refugia	18.560	18.262	17.623	-0.298	-0.639	-0.938
	Total Support. Services	**19.188**	**18.658**	**17.968**	**-0.530**	**-0.690**	**-1.220**
Cultural Services	Recreation	13.668	15.375	16.775	1.707	1.400	3.107
	Other Cultural	1.021	0.758	0.501	-0.263	-0.257	-0.520
	Total Cult. Services	**14.689**	**16.133**	**17.276**	**1.444**	**1.143**	**2.588**
Total of Ecosystem Services		**73.250**	**70.227**	**67.859**	**-3.023**	**-2.368**	**-5.391**

As concerns the changes in the provided ESs, it was found that the observed landscape evolution decreased their overall economic contribution through a non-counterbalanced decrease of some ESs versus others, which showed an increase of lower intensity. From an economical point of view, the re-naturalization of the environment according to the given values of ESs (Table 1) reduces the economic profit. This trend is strongly associated to the management strategies of the local economies and can be easily reversed if decision-makers and local stakeholders make serious efforts to maximize the final profit from specific ES favored by the forest expansion, which have direct economical contribution to the society (e.g. recreation activities through tourism). Such efforts could be the key to achieve both sustainable economical growth and environmental management (Marini *et al.*, 2011).

From an ecological point of view, it was also observed that the re-naturalization of the environment had negative effects on some services, which play significant role on the ecological and environmental quality of the environment (e.g. Habitat refugia availability, and genetic resources etc). These effects have been considered as a consequence of the gradual abandonment of traditional practices, showing the need to incorporate intervention strategies in landscape planning for the maintenance and management of the typical rural landscape and grasslands.

5. Conclusions

This study revealed the changes that occurred in the alpine landscape of Ledro valley for a 152-years period (1859-2011) and their effects on the provided ESs of the territory. The analysis of landscape evolution highlighted the forest expansion, and partially the urban expansion, at the expense of grasslands and croplands due to a transition from a rural economy to a touristic and handcrafting economy. The observed land-use changes led to an overall reduction of the ESs economical contribution while the detailed analysis of each ES changes allowed to identify advantages and disadvantages caused by the re-naturalization process of forest expansion. The results suggest that the maximization of ESs under the pressure of such land-use changes can be achieved by a respective maximization of the profits from services related to recreation activities (tourism), which have an immediate economical impact on local economies, together with the maintenance and sustainable management of the typical rural landscape and grasslands in order not to loose some of their benefits to the ecological quality of the landscape.

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