

# Assessment of the Ecosystem Services Capacity in Natural Protected Areas for Biodiversity Conservation

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**Abstract.** Recently, in Italy, a legislative proposal has been set to reform the role and the functions of natural protected areas promoting their aggregation (or the abolition) pursuing a better efficiency for their administration and economic saving. The system of natural protected areas is composed of different conservation levels: there are the Natural parks, established in the '80 by national or regional institution for the safeguard of natural elements, the Natura 2000 - Habitat 92/43/CEE promoted by European Union, with conservation measures for maintaining or restoring habitats and species of Communitarian interest, and the local parks of supra-municipal interest (namely PLIS) created by single municipalities or their aggregation aimed at limiting the soil sealing process. The hierarchical level of protection has determined differences in the management of the areas which leads to various approaches and strategies for biodiversity conservation and integrity.

In order to assess strengths and weaknesses of the legislative initiative, the new management framework should be designed, considering the ecosystem characteristics of each natural protected area to define the future opportunities and critics, rather than, in the extreme case, remove the level of protection due to the absence of valuable ecosystem conditions. The paper provides an operative support to better apply the legislative proposal investigating the dynamics that affect all protected areas using the land take process as a major threat to biodiversity conservation in natural zones. The land take process is explored using the Land Use Change analysis (LUCa) as a possible way to determine the impact and the environmental effects of land transitions. LUCa is also useful to determine the loss of protected zones capacity to support Ecosystem Services. Finally, the assessment of the Ecosystem Services Capacity (ESC) index expresses the ability of each LULC to provide ES and, in particular, the Ecological Integrity, Regulating Services and Provisioning Services. The efficacy of the proposal is tested in the Lombardy Region (Northwest of Italy) where the natural protected areas are more than 500 with a territorial extension of 740 thousand hectares that correspond to 31% of the regional surface.

## 1. Introduction

Natural areas are a fundamental source of Ecosystem Service (ES) supply [1] such as carbon sequestration, biodiversity conservation, landscape value and for the regulation of major element cycles. In the last 50 years, humans have altered ecosystems more rapidly and extensively than in any comparable period and wider impacts are expected [2,3]. Most of these impacts are related to Land Use – Land Cover (LULC) changes recognised as one of the main factors in the decline of the global environmental conditions [4] and the major driving force for biodiversity loss [5]. Changes in LULC



are considered as one of the clearest informative indicators on the state and characteristics of the natural resources and environmental systems.

The ES potentially provided by the LULC is acknowledged as a necessary framework for linking human and natural systems in environmental management [6–8] and guiding the spatial planning process towards a more sustainable approach. The implementation of ES assessment may effectively support societal and political choices in the planning process [9] for conservation, protection and management of natural resources.

The conservation of natural resources is strictly linked with the institution of protected area, especially parks, offering a practical and tangible solution to the problem of species loss.

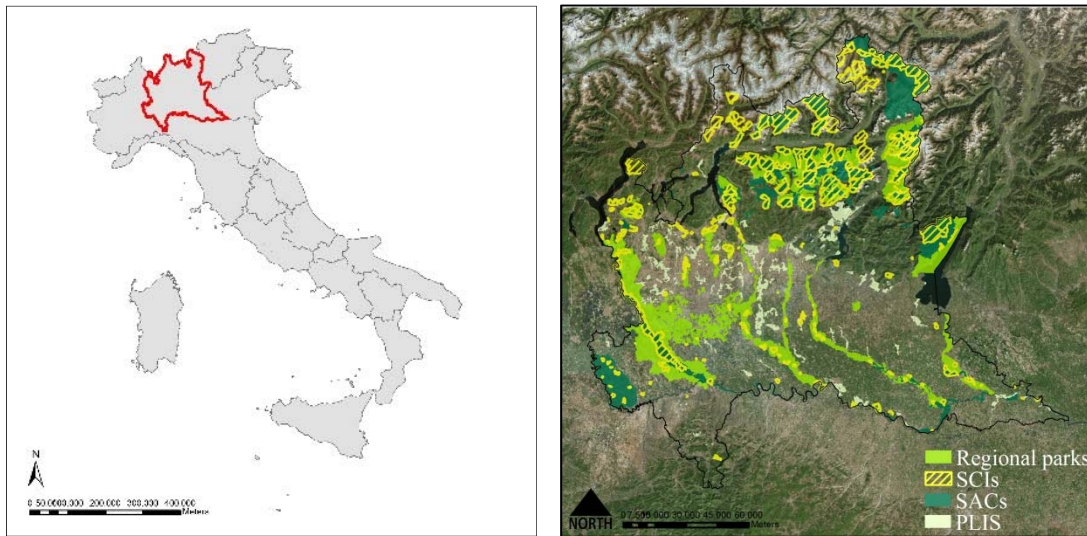
The International Union for Conservation of Nature (IUCN) defines a protected area as “a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values with nature conservation the priority objective”. [10]

The institution of natural parks in Lombardy (Northwest of Italy) takes place in the 1980s according to the regional programmatic law n. 86 of 1983 namely “General plan of protected areas” with the aim to define protected zones for natural conservation and biodiversity protection among the regional areas.

Five levels of natural protection were created according to the ecological characteristics of the Lombardy region: i) regional parks; ii) natural parks; iii) local parks of supralocal interest (of local design and management - PLIS); iv) regional reserves; and v) natural monuments.

In addition to those, there is the Natura 2000 network composed by Community importance (SCIs) and Special Areas of Conservations (SACs) settled from 1995 in relation to the European Habitats Directive n. 43 of 21 May 1992 to ensure the conservation of a wide range of rare, threatened or endemic animal and plant species and creating a coherent system of areas for biodiversity conservation. Nowadays, almost 50% of SCIs and SACs is included in regional parks, while the rest is mostly located in alpine or pre-alpine region, where the quality of naturalistic functions and biodiversity is generally higher than the valley area.

In Lombardy, there are 22 regional parks with a territorial extension of almost 500 thousand hectares; the SCIs are 192 and spans over 224 thousand hectares; while SACs are 66 with an area of over 297 thousand hectares. Thus, the system of natural protected areas includes an area of more than 1 million hectares that correspond to 43% of the regional surface.



**Figure 1.** Localisation of the Lombardy region in the northern part of Italy (on the left side), Natural protected area in Lombardy region (on the right side)

In Lombardy, the establishment of natural protected areas could be promoted by different institutions (Regional, Provincial and Local administrations). That implies a different regulatory and institutional framework and, as a consequence, a different management approach.

Therefore, despite the common aim of the natural protected areas is mainly the biodiversity conservation and the protection of the habitat quality, some areas have a broader range of finalities and often do not include only areas with high natural quality. This is the case of the PLIS, created by one or more municipalities, with the goal to preserve such areas to LULC changes recognising the diverse type of values: natural, recreation and/or agricultural.

Nowadays, the organisation of the entire system of natural protected areas is not created according to a regional strategy with common policy but, on the contrary, in a fragmented way with considerable consequences on the management of the sites.

The lack of a common policy was partially solved with the institution in 2008 of the Regional Ecological Network (RER) recognised as a priority infrastructure of the Regional Territorial Plan (PTR) that constitutes a guideline for regional and local planning (according to the provisions of the Regional Committee Resolution n. 10962/2009). The RER includes the system of regional and national protected areas and Natura 2000 sites, and identifies areas of priority interests for biodiversity and ecological corridors for wildlife reproduction.

Despite the aim of the RER is to define the main ecological corridors in a large scale, the management of those areas is within precise boundaries, those of the administrative institutions. Consequently, the regional strategy promoted with RER does not match the institutional scale that it manages.

Recently, the necessity to reorganise the regional system of natural protected areas leads to the enactment of a new Law approved by the Regional Council n. 28 of the 17 November 2016 entitled “Reorganisation of the Lombard system of managing and safeguarding protected regional areas, and other ways of protecting the territory”. The aim is to consolidate the conservation and promotion of the natural heritage and landscape considering the design of the RER and promoting the aggregation (or the

abolition) of natural protected areas pursuing a better efficiency for their administration and economic saving.

The paper provides a method for the assessment of ES provision based on the LULC composition and its changes that threatens ES [11,12] useful for the reorganisation of the system of natural protected areas based on the Ecosystem Service Capacity (ESC).

Particularly, the paper analyses the flow of LULC changes through a cross-tabulation matrix [13] and the consequent variation of the ESC considering three macro groups of ES: Ecological Integrity, Regulating Services and Provisioning Services [14]. The proposal is focused on Regional parks considering their specific ability in natural conservation and the possibility to act on their institution for pursuing a regional strategy of natural protection.

## **2. Land Use Changes analysis (LUCa) in Regional parks**

The LUCa ranges from 1999 to 2012 using the existing multi-temporal database available for the Lombardy region named Destinazione d'Uso dei Suoli Agricoli e Forestali (DUSAF) developed by ERSAF (Regional Agency for Services to Agriculture and Forestry) with a classification system shared with Corine Land Cover (CLC) [15]. DUSAF is settled at scale of 1:10,000 (minimum mapping unit of 0.16 hectares).

LUCa is defined as a process of transition where, in most cases, natural, semi-natural and rural areas are converted into urban uses (e.g. urban settlements, industrial activities, infrastructures). This process affects biodiversity through the decrease of habitat quality and compromises the ES provision and the related human benefits. [16,17]

The LUCa of the Regional parks was conducted in GIS environment with an interpolation method for data analysis. The Microsoft Excel software has been used for the statistical tabulation of the .dbf file.

The output, a pivot table, is a cross-tabulation matrix of land cover classes that highlights the major changes, and particularly the transitions from agricultural and natural areas into new urban ones. The method allows assessing the balance of LULC transitions regarding gains (increase) and losses (decrease) of a specific class towards a different land use. The flow of changes is a sum of hectares representing the kind of use/cover which has changed from a LULC category to another at the reference time  $T_0 - T_1$ .

There are two typologies of LULC changes: the ones corresponding to the land take process, that is the worst LUCa corresponding to a process of artificialization. The land take process, as defined by European Environment Agency, is the "Change of the amount of agriculture, forest and other semi-natural and natural land taken by urban and other artificial land development. It includes areas sealed by construction and urban infrastructure as well as urban green areas and sport and leisure facilities" [18]. Hence, the land take is the increase of artificial surfaces (such as housing areas; urban green areas; industrial, commercial and transport units; road and rail networks; etc.) over time.

The second typology of LULC changes is called "homologous" because it is not characterised by an irreversible process (e.g. urbanisation) but an exchange within the natural or agricultural classes, (e.g. the transition from grassland to crops) which is reversible by definition.

The LUCa developed in the Regional parks of Lombardy shows three major transitions with an increase of class 1.2 (industrial, commercial and transport units), class 1.4 (artificial, non-agricultural vegetated areas) and 2.3 (Pastures). The LULC threaten by these changes, with a decrease of the surfaces, are the arable land (class 2.1).

Considering the value showed in Table 1, the overall class 1.2 was increased by 23%, equal to 2,374 hectares. Particularly, it should be noted that major changes happened in the class of industrial and commercial zones (+828 ha) and roads and rail network (+488 ha) with an impact on non-irrigated arable land for an amount of hectares equal to 1,571.

The trend is rather evident in the Parco Valle del Ticino (-579 hectares of crops substituted), in the Parco Agricolo Sud Milano (-499 hectares of crops substituted) and, at least, in the Parco Adda Sud (-139 hectares of crops substituted). An important amount of process of anthropization has been caused by new infrastructures built inside the boundaries of natural protected areas in the last years.

**Table 1.** Regional parks. LULC classes: increase and loss

	<b>Percentage variation 1999-2012</b>	<b>Absolute variation (ha) 1999-2012</b>
Class 1.2 (Industrial, commercial and transport units)	+23.8	+2.374,31
Class 1.4 (Artificial, non-agricultural vegetated areas)	+25.4	+1.120,18
Class 2.3 (Pastures)	+62.5	+ 11.679,69
Class 2.1 (Arable land)	-12.7	-17.807,36

Recently in Lombardy, more than 1,600 hectares of natural and agricultural areas were converted into infrastructures (streets, railways and accessory spaces) following the implementation of the regional strategy for the infrastructural development that includes railways and roadways networks (e.g. the new piedmont viability network, the highway system in the eastern part of Milano, the highway connection between the city of Brescia-Bergamo-Milano called BreBeMi, and the new secondary network built for the accessibility of the EXPO 2015 site) [19].

The infrastructure development constitutes the major driver of land take process in Regional parks, and represents the higher threat for ES provision because implies the drastic reduction of the bio permeability of topsoil. The transformation of topsoil due to urbanisation causes an alteration in the capacity of soils to provide their functions (naturalistic, productive and protective) and related ES [20,21]

Moreover, the conversion from open lands into new infrastructure generally comprises a surface higher than the impermeable section of the paved road or the rail track, including the areas used for the construction site with a further result of land exploitation and degradation such as compaction, sealing and erosion [22]. Most of the areas used for the construction site often remains isolated between the new infrastructural axis and the existent local viability with a further decrease of important Ecosystem functions.

Moreover, the rate of growth in the period from 1999 to 2012 of LULC class 1.4 (urban green areas) is equal to 25% corresponding to 1,120 ha. Such increase is mainly due to the augment of class 1.4.1.1 (urban Parks and gardens + 503 ha) and 1.4.2.1 (Sports facilities + 406 ha) which leads to the new localisation of urban parks and areas for sports activities in natural protected areas. Despite their important role for recreation opportunities, in many cases, these functions are less compatible with the protection of nature and the conservation of the biodiversity.

The increase of urban green areas determines in many cases the loss of croplands (class 2.1). This process has been registered especially in the Parco Agricolo Sud (-304 ha), in Parco della Valle del Ticino (-205 ha) and in Parco Nord Milano (-103 ha).

The LUCa finally showed an increase of pastures (class 2.3). This dynamic is associated with the urban expansion and especially to the infrastructural development that fragments the productive rural system making them unsuitable for farming practice.

In the period from 1999 to 2012, this process has caused the loss of cropland in favour of pastures (+14,526 ha) and permanent crops (+3,188 ha). Particularly, the Parco Valle del Ticino lost more than 4 thousand hectares of croplands in favour of permanent grassland. Similarly, the Parco Agricolo Sud Milano lost 3,757 ha and the Parco del Mincio 2,442 ha too.

The change from croplands to permanent grasslands confirms the recent national studies of INEA, the Italian National Institute of Economy and Agriculture, which address the loss of croplands to a double dynamic: the abandonment of agricultural fields by farmlands, and the increase of urban areas into the rural agricultural system causing fragmentation of arable surfaces.

### **3. The evaluation of the *Ecosystem Service Capacity* (ESC)**

The regional reorganisation strategy of natural areas should consider the LUCa occurred in the period 1999 to 2012 to better understand the processes that, in the last years, affected the natural resources and related ES in protected areas.

In addition to the LUCa, it has been verified the state of ES and their trends based on changes in LULC and their effects. The additional analysis aims to support the new regional strategy of protected areas reorganisation, considering that the loss of ES can be compensated by specific policies for improving the supply of other ES.

As introduced, the land take is considered a key process to evaluate the ES variations regarding state and trends. Indeed, the land take is often used as a proxy for soil sealing related processes, which leads to interrupt the exchange between the pedosphere and the atmosphere, thus determining changes in the natural functioning of soils.

Soil functions strictly depend on the multi-functionality of Soils and each type performs specific functions.. For example, some soils have a higher capacity to produce fuel or fibre than others, depending on their chemical, physical and pedogenetic characteristics and on the agroclimatic environment, while some soils differ in their capacity to filter water, to store carbon or to provide a habitat for biodiversity.

Therefore, the assessment of the state of the ES into the regional natural parks adopted the methodology recently applied in the study entitled “*Land cover change dynamics and insights into ecosystem services in European stream riparian zones*” [14] which apply a defined ecosystems capacity value to land use classes considering the functions of integrity, regulation and provisioning [23,24].

The overall effect on each ES is calculated in the natural parks. The ESC is the sum of the values associated to the land use typology for the different temporal threshold used for the study. The ESC variation is considered as the difference between the overall ESC value during the observed period.

A preliminary assessment of ESC variation outlines that there is neither drastic reduction, nor increase in the ESC index, even if a slightly decrease trend has been commonly registered to most of the parks, even if the percentage is limited. The dynamic denotes a general tendency to a loss of ES that could be managed considering a future policy of mitigation or compensation for specific ES restoration. The result shows that the conservation strategies adopted were sufficient enough to maintain a balance in the level of the natural value inside the protected zones.

**Table 2.** The capacity of each land use category to support specific ecosystem services.

ART artificial (class 1), AGR agricultural (class 2.1 and 2.2), ASN agriculture and semi-natural (class 2.3), FOR forest (class 3.1), NFV non forest-vegetation 3.2, OTH other (class 3.3), WET wetland (class 4), WMT water marine transitional (class 5)

<i>land Use/land cover type</i>	ART (1)	AGR (2.1/2.2)	ASN (2.3)	FOR (3.1)	NFV (3.2)	OTH (3.3)	WET (4)	WMT (5)
<b>ECOLOGICAL INTEGRITY (EI)</b>								
<i>Abiotic heterogeneity</i>	1	2	3	4	5	3	4	4
<i>Biodiversity</i>	1	2	3	5	5	3	4	4
<i>Biotic waterflows</i>	0	3	3	5	4	1	4	1
<i>Metabolic efficiency</i>	0	3	3	4	4	1	4	4
<i>Exergy capture (radiation)</i>	1	4	4	5	4	0	4	4
<i>Reduction of nutrient loss</i>	0	2	3	5	5	0	4	3
<i>Storage capacity (SOM)</i>	1	3	3	5	4	1	5	3
<i>ESS (EI)</i>	4	19	22	33	31	9	29	23
<b>REGULATING SERVICES (RS)</b>								
<i>Local climate regulation</i>	0	1	2	5	3	1	3	2
<i>Global climate regulation</i>	0	1	2	4	3	1	3	1
<i>Flood protection</i>	0	1	1	4	4	4	4	3
<i>Groundwater recharge</i>	1	2	2	3	3	2	3	3
<i>Air quality regulation</i>	0	1	1	5	4	0	3	1
<i>Erosion regulation</i>	0	1	2	5	4	0	1	0
<i>Nutrient regulation</i>	0	1	1	5	4	0	5	2
<i>Water purification</i>	0	1	1	4	4	0	5	3
<i>Pollination</i>	0	1	3	4	4	0	3	0
<i>ESS (RS)</i>	1	10	15	39	33	8	30	15
<b>PROVISIONING SERVICES (PS)</b>								
<i>Crops</i>	0	5	4	0	0	0	0	0
<i>Livestock</i>	0	4	3	0	3	0	1	0
<i>Fodder</i>	0	4	3	1	1	0	2	0
<i>Capture fisheries</i>	0	0	0	0	0	0	0	4
<i>Aquaculture</i>	0	0	0	0	0	0	0	4
<i>Wild foods</i>	0	0	2	5	3	0	0	1
<i>Timber</i>	0	1	3	5	2	0	0	0
<i>Wood fuel</i>	0	1	4	5	3	0	0	0
<i>Biochemical and medicines</i>	0	1	1	3	3	0	0	0
<i>Freshwater</i>		0	0	0		0	0	2
<i>ESS (PS)</i>		0	16	20		19	15	11

**Table 3.** An example of regulation services in Parco Regionale dell'Adamello (1999-2012)

REGULATING SERVICES (RS) 1999-2012 in hectares									total	%
<i>Local climate regulation</i>	-	-29.05	-1,207.2	482.90	2,378.28	-442.90	-	-10.40	1,171.61	0.77%
<i>Global climate regulation</i>	-	-29.05	-1,207.22	386.32	2,378.28	-442.9	-	-5.20	1,080.23	0.82%
<i>Flood protection</i>	-	-29.05	-603.61	386.32	3,171.04	-1,771.6	-	-15.60	1,137.50	0.57%
<i>Groundwater recharge</i>	191.42	-58.10	-1,207.2	289.74	2,378.28	-885.8	-	-15.60	692.72	0.51%
<i>Air quality regulation</i>	-	-29.05	-603.61	482.90	3,171.04	-	-	-5.20	3,016.08	2.2%
<i>Erosion regulation</i>	-	-29.05	-1,207.22	482.90	3,171.04	-	-	-	2,417.67	1.73%
<i>Nutrient regulation</i>	-	-29.05	-603.61	482.90	3,171.04	-	-	-10.40	3,010.88	2.19%
<i>Water purification</i>	-	-29.05	-603.61	386.32	3,171.04	-	-	-15.60	2,909.10	2.45%
<i>Pollination</i>	-	-29.05	-1,810.83	386.32	3,171.04	-	-	-	1,717.48	1.38%
<i>ESS (RS)</i>	191.42	-290.50	-9,054.15	3,766.62	26,161.08	-3,543.20	-	-78.00	17,153.27	1.34%

**Table 4.** Tabulation of ESC variation for protected areas in Lombardy

(EI: Ecological Integrity, RS: Regulating Services, PS: Provisioning Services)

	Tipologia parco	perdita	var EI	var RS	var PS	Var ESC
1	Adamello					0.91%
2	Adda nord					1.05%
3	Adda sud					1.31%
4	Alpi orobie bergamasche					0.85%
5	Alpi orobie valtellinesi					0.33%
6	Alto Garda bresciano	Si	-0.13%	0.64%	-1.05%	-0.01%
7	Campo dei fiori	Si	-0.07%	-0.11%	-0.04%	-0.08%
8	Colli di Bergamo	Si	-0.67%	-0.24%	-1.44%	-0.69%
9	Mincio					3.85%
10	Serio	Si	-0.16%	1.10%	-1.22%	-0.14%
11	Pineta appiano gentile	Si	-0.50%	-0.40%	-0.63%	-0.49%
12	Groane					1.84%
13	Oglio nord					0.01%
14	Oglio sud					1.58%
15	Montevecchia e della valle del Curone	Si	-1.08%	-1.01%	-2.07%	-1.29%
16	Monte barro					3.80%
17	Stelvio					0.01%
18	Spina verde Como	Si	-0.97%	-1.18%	-1.04%	-1.07%
19	Sud Milano	Si	-0.85%	1.42%	-0.77%	-0.28%
20	Valle del Lambro	Si	-2.42%	-2.86%	-2.68%	-2.63%
21	Valle del Ticino	Si	-0.51%	0.58%	-0.86%	-0.27%
22	SIC (valore complessivo per tutti i Siti)					0.27%
23	ZPS (valore complessivo per tutte le Zone)					0.78%

Moreover, a recent study highlighted that protected areas suffer of an increase in the land take process occurring at their margins, which may represent a serious threat to the integrity of species populations and habitats preserved within the protected areas and may interrupt ecological continuity/connectivity [16,25]. Therefore, starting from the ESC trend, it was decided to consider a buffer zone external to the area with the aim to test and verify the edge-effect, here intended as the analysis of how park-proximity generates an acceleration in the real estate marked for new hosting sites located at the boundaries of protected areas [16].

The assessment of ESC in each single natural park is listed below.

*Alto Garda Bresciano*: the overall ESC value is slightly decreasing (-0.01%), nevertheless a higher decrease is registered for provisioning services (-1.05%), where differences are due to the loss of cropland production (-17.42%), livestock (-12.62%) and fodder (-5.08%). At the same time, it is noticed a consistent increase in the provisioning service of fresh water (+30.77%) which indicates a process of

re-naturalization that guarantee a better capacity of the soil to buffer and filter water streams and their nutrients.

*Colli di Bergamo:* the overall value of ESC is decreasing of -0.67%, which is mainly due to the lowering value of the provisioning services (-1.44%). Analogously to the Alto Garda Bresciano, the higher decreases are linked to the reduction of crops production capacity (-6.79%), provisioning for livestock (-4.71%) and fodder (-4.39%).

*Serio:* Also in this protected area the provisioning services are decreasing their value. The overall value of provisioning services is losing the 1.22% of initial value. Specifically, the potential crop production is decreasing by 3.15%, the provisioning for livestock decreased by 2.55% and fodder too decreased its initial value of 2.70%.

*Montevecchia e Valle del Curone:* all the ecosystem groups (ecological integrity, regulation and provisioning) slightly decreases respectively of -1.08%, -1.01% and 2.07%. Particularly, the pollination services (regulation services) decreasing by 2.75%, while the freshwater provision increase with a rate of change equal to 39.13%.

*Parco Sud Milano:* the Parco Agricolo Sud Milano is an agricultural park in the metropolitan area of Milano where the productive vocations must be maintained. It is also a greenbelt park for the densely built-up area of Milan and its establishment has historically conditioned the development of the city along North axes and corridors, rather than other areas. Moreover, the park is subjected to a high pressure of the real estate market which found in the undeveloped agricultural land a suitable location for new residences. The overall ESC indicator decrease of 0.28%, by a decrease of the ecological integrity of 0.85%, and an increase of regulation services of 1.42% and provisioning services decrease of 0.77%. Particularly, the crops production decrease of 5.08%, livestock decreases of 5.40% and fodder decreases of 5.51%. Moreover, the metabolic efficiency (EI) decrease of 2.76%, but for other important services, the ecosystem capacity marked a slightly increase: climate regulation, erosion regulation, pollination, timber production.

*Valle del Lambro:* this protected area marked a decrease of ESC equal to 2.63%. Particularly, ecological integrity, regulation and provisioning decrease respectively of 2.42%, 2.86% and 2.68%. The category of provisioning is affected by a decrease of crop production of 4.68%, livestock of 4.55% and fodder of 5.00%. Also for regulative services the decrease affects flooding regulation of 3.74%, air quality decreases of 3.95% and nutrient regulation decrease to of 3.90%. All the services mentioned above are of crucial importance for the well-being of the citizens in the metropolitan area of Milan.

*Valle del Ticino:* this area represents one of the greatest green corridors for the metropolitan region of Milan, the ESC decreases of 0.27%. The decrease is due to the change in ecological integrity services (-0.27%), in regulation services (+0.58%) and provisioning services (-0.86%). Services of crop production and livestock are the ones which are affected by the highest decrease, and also the flooding regulation is subjected to a decrease in an area where regulative services are crucial for their buffering effect in the metropolitan area.

#### 4. Results and discussions

Protected areas in Lombardy are a proxy of the overall ecological quality in the Region regarding ES provision. The land take phenomena affected also protected areas, especially by the new infrastructural process, relocalisation of urban green areas (urban park and sport facilities areas) and industrial and commercial development areas.

Certainly, the land take process is a fraction of the overall LUCa and sometimes other kinds of land use changes (the agricultural abandonment, the shifts from agricultural to natural or seminatural and vice versa) generate an ecosystemic downgrade even if an impermeabilization process does not occurs. Moreover, the increase of natural areas does not imply an increase of biodiversity because, as demonstrated by the in-depth ES analysis, when pastures in alpine valleys are substituted with a new regenerating forest, this new and young forest is not enough mature and sometimes invasive; meanwhile when seminatural areas substitute agricultural land in plain flat areas the transition is often due to abandonment too.

The association of the traditional quantitative LUCa with qualitative information on ecosystem capacity of the soils to provide many ES (ESC indicator) has been used as a methodology to support the decision-making mechanism leading the new regional reform for protected areas in Lombardy.

The quantitative/qualitative analysis shows that, to some extent, the preservation of the natural value on protected areas in Lombardy has been provided even when land use changes happened. The mismatch between the land use changes and their effects on ES capacity is a key issue for the future management of these areas, because the natural preservation of protected zones should be pursued both avoiding the land take phenomena on protected zones rather than promoting interventions to increase the natural value of protected sites.

It should be noted that:

- the average value of ESC is little positive (0.42%), thus by an ecosystem analysis perspective the region has acted with a mixed framework of protection/restoration which maintained an equal balance inside protected zones;
- where the decrease is associated with land take dynamics (Capo dei Fiori, Colli di Bergamo, Serio, Pineta Appiano Gentile, Montevicchia e Valle del Curone, Spina Verde Como, Sud Milano, Valle del Lambro and Valle del Ticino) a re-enforcement of the management system of the park needs to be considered;
- the land take happened in the most relevant protected areas of the metropolitan city of Milan threatened by the urbanisation pressure. In these areas, the most frequent typology of authorization concerns the request for new streets, which includes connections, extensions or enlargement of the existing network; rather than requests of requalification for rural buildings by specific executive projects (PAC or PII);
- in the surrounding areas the land take process happened with high intensity.

The registered land take is the result of the conversion for new infrastructures or new residential zones. In the first case (the construction of new streets), the authorization concerns viability of provincial or regional management that always obtain a favourable authorization by the park authority (which is regional too), while the municipal requests concern more the authorization for new parking areas, or junctions, which often are rejected because are not allowed by the park legislation.

In the case of PAC or PII, the largest part of authorization requests comes from the owners of rural settlements which are dismissed or abandoned and with degraded state of conservation. The procedure concludes with a favourable technical authorization when the project takes into account the historical value of the building, and also consider the traditional rural character of the surrounding areas and their landscape. Sometimes, the authority expressed a favourable opinion if the project considers mitigations or compensations for natural re-balance of the original condition.

## 5. Conclusions

In Lombardy region, relevant protected areas are affected by land take process and also by a decrease in their overall ESC. These two processes sometimes are correlated, while in other cases not. Thus the traditional quantitative LUCa which is essential to know the intensity of the land take process needs to be integrated into a qualitative assessment of each transition as using ES assessment. The integration between quantitative and qualitative analysis make the proposed method more effective, giving better knowledge for the decision making process.

The institutions required to reorganise the system for managing and safeguarding protected areas in Lombardy require a tool that support decision-making process considering the specific territorial dynamics of the natural protected areas. Otherwise, the reorganisation is considered just focusing on institutional economization.

The recent Law (n.28/2016) of Lombardy region for the reorganisation of the system of managing and safeguarding protected regional areas needs an operative support to orient the decisions on possible aggregation (or the abolition) of natural protected areas for biodiversity conservation.

The paper provides a method that combines quantitative analysis based on LULC changes in the period 1999-2012 with a qualitative investigation on the ES provision of Regional parks. The methodology proposed highlights dynamics complex that includes different phenomenon: land take process, LULC changes “homologous”, and trends in ES provision.

The proposed methodology is considered as a starting point for the comprehension of the dynamics that occur in regional parks regarding pressures, ES threats, and management. A reorganisation of the system of natural protected area must include a detailed analysis for the assessment of the causes that have threats nature and biodiversity.

The approach provided by the authors allows the understanding of these dynamics. Additionally, the analysis needs to be completed with a documental study on the most frequent typology of authorization, regarding building permits, of new infrastructures and new urban areas in protected areas provided by Park Authority. This analysis allows highlighting the management approaches adopted by the different authorities for achieving a better conservation of the natural quality. This analysis is important in deciding how to combine or separate various authorities in the govern of natural protected areas. In fact, the authorization of new urban transformations inside natural protected areas need to be considered in a regional strategy to insure a real management of nature.

Considering the low capacity of authority to deny permissions in protected areas where the urbanisation pressure is high, and also the edge-effect which leads to an increase of the land take dynamic outside the boundaries of protected zones, two key points seems to be crucial for further discussion. The reorganisation of parks should join different authorities with a central new authority with a higher political power. By the way, the authority should be less affected by the “local” real-estate market pressures and a higher rate of denying for non-adequate transformations should be achieved in future.

Secondly, even though the formal number of parks will diminish, it should be better considering an extension of a “medium-protected zone” in the future; thus to limit the land take edge-effect. As an example, the construction of a regional green infrastructure to connect the existent protected zones preserving the urban and periurban areas will guarantee higher ecological values also outside the traditional protected sites.

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