Agricultural landscapes rehabilitation suggests ‘ecosystem services’ updating

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Abstract: Improving a rehabilitation of the entire agricultural landscape is an impellent necessity, because it represents the most important possibility for man to recover our Earth: especially after the decrease of ecological efficiency due to the agrarian industrialization and the expanse of urbanization. To strike this goal both ecological and economical criteria are needed, so the concept of “Ecosystem Services” may give a crucial contribution, confirming the renewed role of the farmer in environmental recovery. But these Services are linked with conventional ecology and consequently the “Ecosystem Services” present some limits.

The new discipline of Landscape Bionomics (LB) proposes principles and methods influencing even the “Ecosystem Services” and the measures of their ecological and economical value. After a synthesis of LB and its ability to evaluate the mentioned decrease of ecological efficiency through the concepts of Transformation Deficit (TD), Human Habitat (HH), Standard Habitat per capita (SH), Protective Landscape Apparatus (PRT), Biological Territorial Capacity of Vegetation (BTC), the equivalence of Bionomics Costs/Economics Costs or Bionomic Values/Economic Values is more deeply defined. The values of agrarian and forest lots (referred to 2010-2015 values of Lombardy Italian region), become respectively 113 and 270 €/m^2. These values can change in relation to the bionomic quality of the lot. So, a more fitting measure of environmental damage can help to better defend agrarian landscapes.

Key Words: scientific paradigm, ecology, bionomics, landscape, vegetation science, BTC flux, bionomics cost, economic cost.

1 Introduction

The ‘Gaia Theory’ of Lovelock & Margulis [1] asserts that living organisms and their inorganic surroundings have evolved together as a single living system that greatly affects the physics, chemistry and conditions of Earth’s surface. Some scientists believe that this “Gaia system” self-regulates global temperature, atmospheric content, ocean salinity and other factors in a “spontaneous” manner. Earth’s living system appears to keep conditions on our planet just right for life to persist.

In the past 15-30 years, many of the mechanisms by which Earth self-regulates have been identified [2]. For instance, it has been shown that cloud formation over the open ocean is almost entirely a function of the metabolism of oceanic algae that emit a large sulphur molecule (as a waste gas) that becomes the condensation nuclei for raindrops. Previously, it was thought that cloud formation over the ocean was a purely chemical/physical phenomenon [3].

In the Emerged Lands, forest systems act in a similar way but with stronger effects [3]. The moisture that trees absorb through their roots later evaporates through stomata in their leaves. Vegetation may contribute up to 90 percent to the moisture in the atmosphere derived from land surfaces — far more than earlier estimates. Trees produce flows of water vapour that are more than 10 times greater than that ones deriving from herbaceous vegetation per unit of land area, and still more those produced by wet ground or open water. *Transpiration* “is an active biological process” that is not fully reflected in the physics of climate models [4]. Moreover, trees influence cloud formation by emitting carbon-based chemicals called volatile organic compounds (VOCs) into the atmosphere. Some of those compounds are deposited on tiny airborne particles such as dust, bacteria, pollen and fungal spores. As the particles grow with the deposition of VOCs, they promote condensation and gather the resulting moisture, hastening cloud formation.

The problem is that the regulation capacity of Gaia, first of all depending on forest systems, is today strongly decreased, because of the forest destruction in the last century. The present climate change is not only due to the greenhouse gases but also to forest destruction.

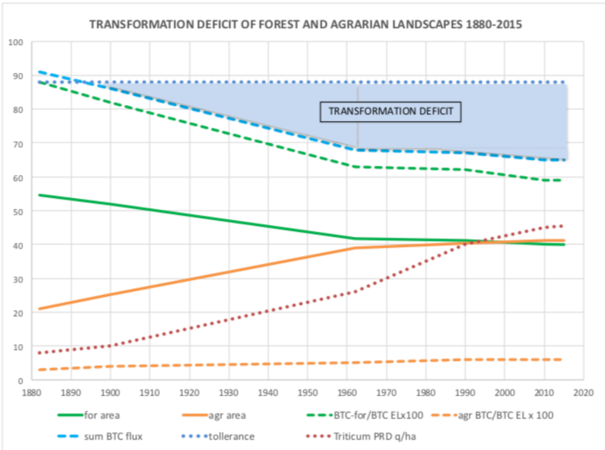

Fig. 1. *The dangerous decrease of forests in the last 130 years (1882-2010) and the increase of agricultural lands, cultivated fields and prairies (yellow). Dotted lines represent the BTC flux as % of the normal state. Note the incredible Transformation Deficit (TD), which needs to be urgently compensated (the light-blue trapezium between the blue sum BTC flux line and the tolerance).*

In Fig. 1, the period 1882-2010 was considered putting in evidence the increase of crop production (PRD, from 10 to 50 q/ha *Triticum* sp.), the decrease of forest systems (54.3 to 40.3 x 10^6 km^2) and the increase of cropland + grassland systems (36.6 to 40.8 x 10^6 km^2) [5, 6]. These are the most important land systems to which we add the urbanized landscapes, passed from 0.6% to about 3%. So, starting from 2004-05, Agrarian and Urban Landscapes cover more land than Forest Landscapes: 30.3% Vs. 27.05%. More over, in this period population increased from 1.5 billion in 1880 to 7.5 billions in 2017.

Landscape Bionomics [7, 8] discovered a systemic vegetation function evaluating the flux of energy able to maintain the order reached by a complex system like a landscape. This function [Mcal/m^2/year] is named BTC (Biological Territorial Capacity of Vegetation) [25].

Hypothesizing a still sustainable condition when Gaia reached 1.5 billion people (1880) and proportioning BTC flux of both forest and agrarian land systems with Emerged Lands BTC flux, we can see (Fig. 1, brown dotted line) that the sum of these BTC fluxes arrived to 92.12% (1882), value that reinforces the absolute importance of these two land systems. But this sum decreased to 63.67% today, because we have to add to the lost of forest land-cover the lost of forest BTC alteration (as noticed by BTC). At this point, we may put a tolerance limit to 90% and estimate the *Transformation Deficit* (TD) until today. The forest cover loss result -26.19%, while the agrarian cover increase is +11.48%. This corresponds (2010) to a loss of energy flux of about 30% (i.e. 7.64 x 10^{13} Mcal/year). Being the BTC flux of farmland near constant (from 5.30 to 5.96 %), due to industrial agriculture, the huge loss is due to forest decrease and alteration. The area of this large trapezium shows a dramatic TD, urgent to be compensated.

The forest destruction may be reduced. In some continent forests are increasing (i.e. Europe), but their global negative trend would continue and in any case the times for their regrowth is too slow. Moreover the reforestation of desert and urban landscapes needs financial efforts and long times: in any case this action would not be sufficient, being their land cover only 15.8 and 3.0 %. The most available remedial action should be the rehabilitation of Agrarian Landscapes, 27.4 % of land cover, more easy to transform and useful for full agroecology goals.

This view reinforces the role of both agroecology science and farmers actions in environmental recovery and invoke the contribution of the so called Ecosystem Services to drop the consume of agrarian soil, the first victim of urbanization and infrastructure network.

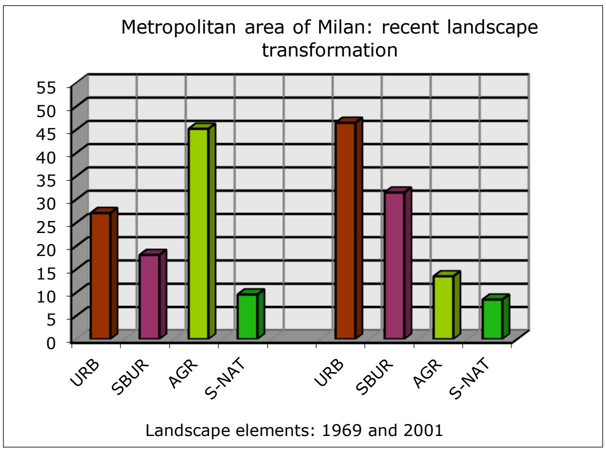

Fig. 2. *In only 32 years the hinterland of Milan changed drastically. This territory composed by the City of Milan and 201 municipalities around it, increased its urban area 172.6 % while agrarian areas decreased 334.8%.*

Figure 2 shows a terrific example of the destruction of agricultural soil in Lombardy (Italy). After the second World War, from 1969 to the beginning of the III Millennium, the territory around Milan, composed by the City of Milan and 201 municipalities (about 2,147.0 km^2) changed drastically. In 1969 the urbanization and the Agricultural landscape units had the same value, 45.2 %. Only 32 years after, the Urban areas reached 78% of this hinterland, while the agrarian areas decreased of 72.2 %.

This depredation was mainly due to the difference between the price of an agrarian lot (3-9 €/m^2) compared with an urbanized one, 250-1500 €/m^2 in actual values. Even with minor virulence, this fact is far to be arrested today. The evident underestimation of agrarian lots denounces a lack of information on their ecological services. As underlined by Herman Daly [9]: "the exchange values *per se* can not be the economic measure of everything, because the value of everything is concreting linked to its role in natural complex systems". The impellent necessity to recover the agricultural landscapes gives a stronger importance to this Daly's observation remembering that our survive depends on this kind of linkage: exchange value and role in landscape complex systems.

To reach this goal, the "Ecosystem Services" have to be upgraded, because they are linked with conventional ecology which is at least partially reductionist, consequently the "Ecosystem Services" (ES) present some limits. The aim of the present study is i) to face the ES issue framed in the new discipline of Bionomic; ii) to give a possible new assessment of ES by applying the bionomic methodology in a real case study, i.e. Italian Region of Lombardy and Metropolitan Area of Milan.

2 Theory and methods

2.1 Scientific Paradigms and Biological Limits

The old Scientific Paradigm is mainly reductionist, anchored to the concept of process reversibility, to the Darwinian struggle for existence, to Newtonian physics, to the division among knowledge, etc. The Theoretic References (i.e. Paradigm) is near the opposite: it's mainly holistic, able to admit process irreversibility, to give more importance to symbiosis and cooperation, to quantum mechanics, to information theory, to trans-disciplinarity, etc.

Note that while Physics started to change the scientific paradigm at the beginning of past century, after the works of Planck and Einstein on Quantum Mechanics (1901) and General Relativity (1905), Biology has been remaining blocked until the end of the XX century, due to the ambiguous concept of ecosystem [10, 11], the DNA as Central Dogma [12] and the dominion of Neo-Darwinism [13]. This delay to follow the new paradigm brought biology towards many limits, from micro to macro scale.

For instance, the ambiguity of the concept of *ecosystem* [10,11, 14] emerges recognising:

(a) the disruption between the biotic Vs. functional view and

(b) the ignorance of the scale-dependence of real systems

The main reason depends on a wrong interpretation of the term "system", intended as <u>linear</u> (not complex), as shown in the concept of *deterministic succession*. In other cases the term ecosystem is simply confused with the term "ecological system".

At the light of the new Scientific Paradigm, not only many limits of traditional general ecology emerge, but even the necessity of new scientific disciplines able to upgrade ecology in studying complex systems as Landscape Bionomics is.

2.2 Landscape Bionomics

The new discipline of Bionomics derived from pioneer studies of Ingegnoli [14, 15] and discussions together with Forman and Naveh [16, 17, 18], within which the landscape was recognized as living entity in "Biological-Integrated Landscape Ecology" [7] recently re-named as "Landscape Bionomics" [5, 19]. The attempt to understand the behaviour of a landscape elaborating its thematic components meta-data (i.e. species, soils, human activities, hydrology, geomorphology, etc.), even with the help of GIS mapping and statistic controls, is without hope. The Principle of Emergent Properties demonstrated the necessity of a top-down criterion of observation to enlighten and preserve the new acquired systemic properties.

Bionomics transforms many principles of traditional Ecology, recognizing that Life on Earth is hierarchically organized in complex systems, acting as living entities well farther populations and communities. When related to the territory we talk about Landscape Bionomics, defining Landscape as the *Level of biological organization integrating complex systems of plants, animals and humans in a living Entity recognizable in a territory as characterized by suitable emerging properties in a determined spatial configuration.*

Bionomics underlines the difference between what really exists (the Living Entities) and the different approaches to the study of the environment (viewpoints). The real environment is constituted of *six* levels. In fact, it is necessary to consider two hierarchic levels in the middle "biological spectrum" [5, 19]: (1) the ecobiota, composed of the community, the ecosystem and the microchore i.e. the spatial contiguity characters, *sensu* Zonneveld [20], which we Ingegnoli named ecocoenotope, and (2) the landscape, formed by a system of interacting ecocoenotopes (the "green row" in Tab. 1, *at the end of this paper*).

After the definition of Landscape Bionomics, we expose in synthesis the concepts useful to evaluate the mentioned decrease of ecological efficiency and to elaborate Eco-Bionomics Services. These concepts are related with structural and/or functional aspects. They are: Ecotissue (Ets), Landscape Apparatus (LAp), Human Habitat (HH), Standard Habitat per capita (SH), Carrying Capacity (SH/SH*), Biological Territorial Capacity of Vegetation (BTC), Transformation Deficit (TD).

(a) The concept of **Ecotissue** (**Ets**) describes the complex multidimensional structure of a landscape, through the integration (not simply the overlapping!) of a basic mosaic (possibly the vegetation one) and a hierarchic succession of correlated mosaics and attributes.

(b) The **Landscape Apparatuses** (**LAps**), functional systems of ecocoenotopes forming *specific configurations within the ecotissue*, form the physiological structure of the LU. The LAps in temperate zones are normally 15-16, the most important being:

1. **HGL** hydro-geologic, (emerging geotopes or elements dominated by geomorphic processes)
2. **RNT** resistant (elements with high metastability, e.g. forests)
3. **RSL** resilient (elements with high recover capacity, e.g. prairies or shrub lands)
4. **PRT** protective (elements which protect and compensate other elements or parts of the mosaic)
5. **PRD** productive (elements with high production of biomass, e.g agriculture)
6. **SBS** subsidiary (systems of human energetic, transport and work resources)
7. **RSD** residential (systems of human residence and its dependent functions)

(c) The **Human Habitat (HH)** is the surface evaluation (% of LU) of the human ability to affect and limit the self-regulation capability of natural systems. Ecologically speaking, the HH cannot be the entire territorial (geographical) surface: it is limited to the human ecotopes and landscape units (e.g. urban, industrial and rural areas) and to the semi-human ones (e.g. semi-agricultural, plantations, ponds, managed woods) and it's usually measured within the different LAps.. The NH are the natural ecotopes and landscape units, with dominance of natural components and biological processes, capable of normal self-regulation.

(d) The vital space per capita [m^2/inhab] has been redefined as **Standard Habitat per capita** (**SH**). It is available for an organism (man or animal), divisible in all its components, biological and relational. SH is the inverse of the ecological (i.e. non-geographic) density of population, measurable in m^2/organism and intended as the set of portions of the landscape apparatuses within the examined landscape unit (LU) indispensable for an organism to survive [7].

Note that, even for the same species, SH may change in function of the bioclimatic belt and the landscape type. In the case of human populations, we will have a SH_{HH}, that is a SH referred to the human habitat (HH):

$$SH_{HH} = (HGL+PRD+RES+SBS+PRT) / \text{N° of people} \quad [m^2/\text{inhabitant}]$$

(e) The **Carrying Capacity** (σ) is the ratio **SH/SH*** [where SH* is the *minimum theoretical standard habitat per capita,* which can be calculated both for human and animal population], that is the measure of the *autotrophy* or *heterotrophy* of a landscape unit (LU).

Tab. 2. Theoretical minimum standard habitat/capite

Climatic Belts	Kcal/inhab°	SH* x 1000m²	Agricultural surface/capita
Arctic	3,500	2,500	1670
Boreal	3,100	1,850	1250
Cold-Temperate	2,850	1,480	1050
Warm-Temperate	2,750	1,360	980
Sub-Tropical	2,550	1,250	870
Tropical	2,350	1,020	730

° Minimum edible Kcal/day per capita
Data from Ingegnoli [5] (partially updated)

In Tab. 2, the *minimum theoretical standard habitat per capita* SH*, in relationship to human population and the main climatic belts of the biosphere, is presented. The magnitudes have been estimated in function of: (a) the minimum edible Kcal/day per capita [1/2 (male + female diet)], (b) the productive capacity (PRD) of the minimum field available to satisfy this energy for one year, taking into account the production of major agricultural crops [21, 23, 24], (c) an appropriate safety factor for current disturbances, (d) the need for natural and/or semi-natural protective vegetation for the cultivated patches. Note that the values reported in Tab. 2. are mainly indicative, they can be locally updated.

(f) The **Bionomics Territorial Capacity of Vegetation (BTC)** can *quantitatively evaluate the flux of energy available to maintain the order reached by a complex eco-bionomics system.*
It is a landscape function linked to the metastability [15, 25, 5], based on:
(1) *the concept of resistance stability ;*
(2) *the principal types of vegetation communities;*
(3) *their metabolic data (biomass, gross primary production, respiration, B, R/GP, R/B).*
Two coefficients can be elaborated:

$$a_i = (R/GP)_i / (R/GP)_{max} \qquad b_i = (dS/S)_{min}/(dS/S)_i$$

a_i measures the degree of the relative metabolic capacity of principal vegetation communities;
b_i measures the degree of the relative antithermic (i.e. order) maintenance of the same main vegetation communities:

$$BTC_i = (a_i + b_i)\, R_i\, w \quad (Mcal/m^2/year)$$

Ranges (standard deviations) of BTC values can be measured, following a new methodology named LaBiSV (Ingegnoli & Pignatti) [26, 27], related to natural and human eco-bionomics systems, distinguishing BTC classes. These data can be useful in many LU analysis and landscape assessment.

(g) The **Transformation Deficit** (**TD**) is the quantitative measure of the loss of BTC function (compared with its regional average) *after* a *transformation impact* on natural systems, due to HH needs (farming and urbanisation). Actually, in a landscape and in its Landscape Units (LU), the main transformation processes depend on the hierarchical structuring of an eco-bionomics system and on its non-equilibrium dynamics, metastability, coevolution, evolutionary changes and ecological reproduction [5, 17].
The *Transformation Deficit (TD)* must be compensated with opportune protective (PRT) ecotopes and tesserae.

Upgrading Ecological Services. At the light of Landscape Bionomics, the conventional concept of "Ecosystem Services" have to be upgraded, becoming "Eco-Bionomics Services", because:

1. the concept of Ecosystem is not available to study a complex system [28, 10] and reality is complex;
2. the ecological "Services" can't be related only to human population, concerning all the Landscape Unit components;
3. health and protective functions have to be explicitly categorized among the sets of "Ecosystem Services", *vice versa* we can't understand and evaluate TD.

Consequently, to the 4 sets of Services [29, 30] we have to add Health Preserving Services and Protective Services, respectively signed as A and B (Tab.3).

Note that farming and urbanization require *economic costs* while their transformation of the previous environment present *bionomics costs*, to be compensated for sustainability reasons, being conscious of the decrease of ecological efficiency enhanced in the introduction.

Tab. 3. *The 6 sets of Eco-Bionomics Services.*

A.	Supporting Services • Nutrient Cycle • Food production • Pollination • Habitat • Hydrological cycles	Regulating Services • Regulation of atmospheric gases • Climate regulation • Regulation of disturbance • Regulation water cycle • Waste treatment • Nutrient cycle • Retention of soil
	Provisioning Services • Water • Food • Raw material • Genetic resources • Pharmaceutical elements	Cultural Services • recreational • aesthetic • spiritual • historical
B.	Health preservating services • Control of structural and functional LU bionomics alterations • Stress recover capacity • Pollution elimination • Environmental risk factor	Protective services • Transformation deficit compensation • Ecological network efficiency • Fragmentation rehabilitation • Disturbances incorporation • Resistence/resilience balancing

So, until ecosystem services don't change in eco-bionomics services and functions, to incorporate the *Equivalence between Bionomics cost and Economics cost* into the market should be impossible. Biological costs due to TD and economic costs related on the same TD can be well evaluated and incorporated in market processes.

$$TD_{BTC} + SH^*PRT_{BTC} = 0 \qquad (1)$$
$$TD_{€} + SH^*PRT_{€} = 0 \qquad (2)$$

where: TD = Transformation Deficit,
*SH*PRT = Theoretical Minimum Protective SH*

Tab. 4. Economic evaluation of SH* components of TD

SH*-PRD	PRD crop-field	PRD farm	Tot.
m²	950	50	1000
%	95	5	100
€/m²	5	310	**20.25**
SH*-RSD	RSD house	RSD garden	
m²	50	60	110
%	80	20	100
€/m²	740	75	**607**
SH*-SBS	SBS Factory	SBS roads	
m²	40	30	70
%	57	43	100
€/m²	320	50	**203.9**
SH*-HGL	water	well	
m²	15	5	20
%	75	25	100
€/m²	6	150	**42**
TD cost (wieghted mean) **€/m²**			**85.11**
• **€/m²** intended as minimum market value x 1.10			

For assessing the bionomics value of TD the Lombardy data base are related to SH* analysis, *sensu* Ingegnoli [5, 7]. For assessing the economic value of TD the Lombardy data base are related to an Analysis (Tab.4) derived from the Polytechnic University of Milan [31].

As already underlined, the exchange values *per se* can not be the economic measure of everything, because the value of everything is concreting linked to its role in natural complex systems. Our *survival* depends on this kind of linkage.

Moreover, means and purposes are strictly linked, as a seed to its plant. These principles confirm what we underline: the economic cost of a Transformation Deficit measures also the bionomics cost of the PRT system indispensable to balance the same TD. *A refusal of these criteria is the principal way to destroy our environment, especially if this has been demonstrated to be a living entity!*

3 Findings

Note that the amount of farming and urbanisation produce an undoubted high transformation impact on natural systems; consequently, high will be the Transformation Deficit (TD), that must be compensated with opportune Protective (PRT) and Health preserve (HLH) systems. Remember that at the scale of SH* these systems coincide with ecotopes having opportune high BTC formations.

It is useful to begin from the control of the most basilar origin of the impact: the settling of a person in a territory (i.e. LU) of a given Region (e.g. Lombardy). The SH* and SH/L.Ap. (Standard Habitat/Landscape apparatus) concepts permit to calculate the bionomics Transformation Deficit through a balance on the mean regional Bio-potentiality of vegetation (BTC_R = 2.00 Mcal/m^2/year, in Lombardy) [5].

Remembering that (Tab.5): the landscape apparatuses implied in this operation are four functions (SH-PRD, -RSD, -SBS, -HGL) and their minimum theoretical values had been expressed in m^2/inhabitant (following Food Medicine, Agronomy, Urban-Planning); each SH*L.Ap function presents a peculiar BTC' value (derived from average Regional basis); the differences BTC'- BTC_R multiplied per the area of previous functions measure their Transformation Deficit (flux of BTC/year); the sum of TD gives the value of total TD; in this case TD = -1,462.5 Mcal/year.

To compensate a TD like this, we have to check the "potential PRT_{Reg}" of our examined Region (Fig. 3), that is an ecotope of high BTC formations, having a protection role. In Lombardy, the average of high BTC vegetation (i.e. Forest, 2012) result: 29.2% of Boreal Coniferous, the BTC of which being 6.60 Mcal /m^2/year; 70,3% of Temperate Broad-lived, with BTC of 5.50, giving a mean BTC = 5.80 Mcal/m^2/year. With a tolerance of about 1.085 for next future increase, we reach a mean value of Bio-Territorial Capacity of the available protective ecotopes BTC_{PRT} of 6.30 Mcal /m^2/year.

To evaluate the SH*PRT (Protective Theoretical Minimum Standard Habitat), we calculate the difference BTC'-BTC_R = 6.30-2.00 = 4.30 Mcal /m^2/year, a surplus. Dividing TD/4.30 we reach 340.1 m^2/inhab., that is the amount of needed PRT able to compensate TD, so the value of SH*PRT (Tab. 5).

The total SH* (Theoretical Minimum Standard Habitat) will be 1,200.00 + 340.1 = 1,540.10 m^2/inhab.

Tab. 5. Evaluation of SH*PRT

SH*/L.Ap	SH* m^2/inhab	SH* %	BTC' *Mcal/m²/year*	BTC'-BTC_R	TD Mcal/year
SH*PRD	1,000.0	64.94	0.90	*-1,10*	*-1,100*
SH*RSD	110.0	7.14	0.30	*-1,70*	*-187*
SH*SBS	70.0	4.55	0.05	*-1,95*	*-136.5*
SH*HGL	20.0	1.30	0.05	*-1,95*	*-39.0*
Tot. Trasform.	***1,200.0***	*77.92*			*-1,462.5*
Potential PRT_{Reg}			6,30	*4,30*	
Needed SH*PRT	**340,1**	**22,08**	[1.462,1 / 4,30 = 340,1]		
SH* tot	**1.540,1**	**100**	**2,00**	**0**	

BTC' = Mcal/m²/year, BTC_R = 2.00 Mcal/m²/year (Lombardy)

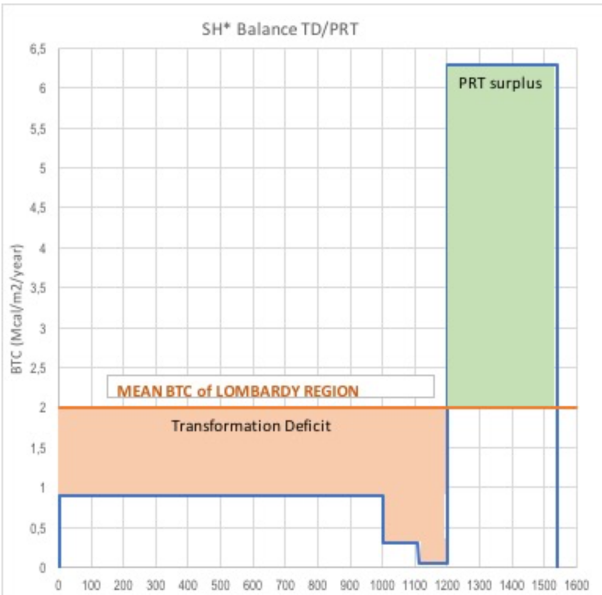

*Fig. 3. SH*balance of Transformation Deficit (TD) through PRT surplus, in relation to the Regional mean BTC = 2.00 Mcal/m^2/year. In abscissa: measures in m^2 of the components of SH*=1,540.1 m^2.*

SH* has been balanced on bionomics attributes (Fig. 3): the PRT ecotopes compensate the bionomics costs (see equation 1), evaluated as

$$TD_{BTC} = \Sigma\,(SH^{*}/L.Ap) \times (BTC' - BTC_{R}) = 1{,}462.50 \quad Mcal/year$$

$$SH^{*}PRT_{BTC} = TD_{BTC}/(BTC'_{PRT} - BTC_{R})$$

$$= 1{,}462.50 / 4.30 = 340.10 \quad m^{2}/inhab$$

There is no doubt that TD has even another cost, the economic one, given by the structures and functions needed for the real activation of SH*.

Tab. 6- Economical Evaluation of SH*PRT and SH*PRD

		Mcal/year	€ /m2	TD cost €	Mcal/yr
SH*/L.Ap	**m²/inhab**	**TD**	**CT**	**transf.**	**BTC-flux**
SH*PRD	1.000,00	*-1,1*	20.25	20,250.00	900
SH*RSD	110	*-187*	607.00	66,770.00	33
SH*SBS	70	*-136.5*	203.9	14,273.00	3,5
SH*HGL	20	*-38,6*	42.00	840.00	1
Tot. Trasform.	***1.200,00***	*-1,462,1*	**85.11**	**102,133.00**	
Potential PRT_R					2142,63
Needed SH*PRT	**340,1**	[SH*PRT= (102,13300 /340,1) x 0,90]		**270.27 €/m²**	Forest
PRD, €/m²		[SH*PRD = (270.27 x 42)/100]		**113.51 €/m²**	Agricultur
CT = cost of transfromation (€/m²), BTC-flux = Mcal/year, ratio 900/2,142.63= 0,42					

As presented in Tab. 6, each SH*/L.Ap. present a cost €/m² (CT), as synthetized in Tab. 4.

We can affirm that total minimum TD cost $TD_{€}$= 102,133.00 € x capita.

We know that the compensation of bionomics cost of TD needs 340,1 m²/inhab of a forested tessera with a BTC = 6.30 Mcal/m²/year. This needs that SH*PRT balances the TD of 1.200 m²/inhab., both in relation of bionomics and economics costs: so, considering a tolerance of 0.10, we can have immediately the value of the forested tessera:

$$TD_{€} = \Sigma\,(SH^{*}/L.Ap) \times CT = 102{,}133.00 \;\; €$$

$$SH^{*}PRT_{€} = (102{,}133.00 / 340{,}1) \times 0{,}90$$

$$= 270.27 \; €/m^{2}$$

The result is of the maximum importance, because this economic value represents the base of P.E.S. (Payments from Eco-Bionomics Services) [27] for Protective tesserae (PRT). If we compare a forest area under examination having BTC_{FOR} = Y with SH*PRT having a BTC_{PRT} = 6.30 (regional value), we find a proportion coefficient available to measure the PES value of the examined tessera: for example, an exceptional forested tessera with BTC_{FOR} = 8.70 Mcal/m²/year leads to a coefficient of 8.70/6.30 = 1.38, so a PES = 270.27 x 1,38 = 372.97 €/m², while a degraded forest with BTC_{FOR} = 4.25 will result 270.27 x 0,675 = 182.33 €/m².

As asserted before, today the PRD (i.e. agrarian) components of a landscape contribute to negative transformation deficit. Anyway, PRD areas are becoming precious for Gaia self-regulation, because given an increasing urbanization, forest preservation is not enough: we must improve the bionomics and ecological state of PRD landscapes. Without a congruent PES, agrarian landscapes would be more and more dominated by urban, road and technological growth.

In Tab. 6 we show also the PRD component, after the observation that PRD contributing to the *bionomics flux of energy* (BTC) have to be *proportional* to the PRT one, that is: 900.0/2,142.6 = 0,42. So, the PRD economic value will be:

$$SH^{*}PRD_{€} = (270.27 \times 0{,}42) = 113.5 \;\; €/m^{2}$$

Again, if we compare an agricultural area under examination having BTC_{PRD} = Z with SH*PRD having a BTC_{PRD} = 0.90 (regional value), we find a proportion coefficient available to measure the PES value of the examined tessera: for example, an exceptional agricultural tessera with BTC_{PRD} = 1.50 Mcal/m²/year leads to a coefficient of 1.50/0.90 = 1.667, so a PES = 113.51 x 1,667 = 189.18 €/m², while a degraded agrarian landscape with BTC_{PRD} = 0.68 will result 113.51 x 0,756 = 85.76 €/m².

In synthesis, we present Fig. 4: the main ranges of the costs of different lots in current market values (dotted lines) are divided in Built lots (red), Agrarian lots (yellow), Forest lots (green). Counting the Eco-Bionomics Services, the values of Agrarian and Forest lots must grow of *about one order of magnitude*.

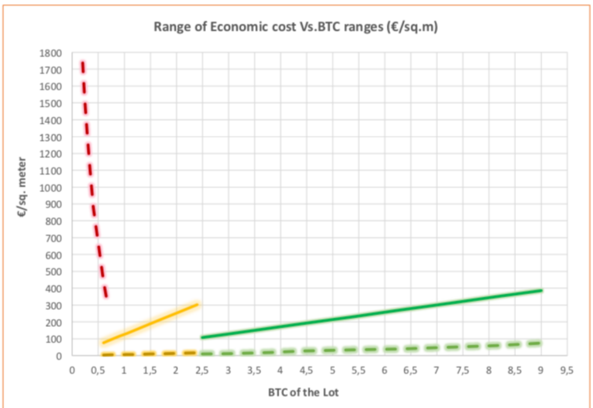

Fig. 4. *The main ranges of the costs of different lots in present market values (dotted lines) and in Eco-Bionomics services. Built lots in red, Agrarian lots in yellow, Forest lots in green.*

The differences of values among built lots Vs. agrarian and forest ones appear huge and is the main reason of the current progressive sprawling and urbanization, in turn the continuous destruction of our environment. We can note that the trend of Building line (red) is in opposition to the one of Agrarian and the Forest lines (yellow and green), reaching the highest values when the BTC decreases, confirming the abuse of the current neoclassical model on Nature. The range of BTC of Built lots is narrow, from 0.10 to 0.70 $Mcal/m^2/year$, while the range of economic values is very high from 330 to 1,740 €/m^2. The other dotted line shows the absurd range of current economic values of agrarian and forest lots, generally from about 3-9 to 10-30 €/m^2, passing from industrial agriculture to a mature forest.

4 Discussion and conclusions

In neoclassical Economy [32], today still dominating our societies, the interaction between nature and the economy is not regulated by the law of *equal exchange*. Economy is in fact founded upon the assumption of an impossible exchange. So, the economy is primordially indebted to nature [33]. In this vision, the value of the soil is measured in terms of the labour, which also provides the value of the land. This is in open contrast with the reality, because the exchange values derived from labour can not be the economic measure of everything, the value of everything being linked to its role in natural complex systems [5]. Our *survival* depends on this kind of linkage, therefore we need to exceed this contrast. But today a convergence between the natural role and the concept of labour is possible to be considered.

The recent concept of “Ecological Services” may be used to turn economy to approach the real world. The neoclassical “Labour Theory” can finally recognise that even the eco-bionomics services are clearly labour, done by a living entity (e.g. an ecotope or a Landscape Unit) in favour of its components, first of all our society. For instance, the protective land compensating the Transformation Deficit develops important labours, like:

1. maintaining a proper level of BTC,
2. TD compensation
3. protection of human health,
4. fine dust purification,
5. temperature control,
6. rainfall regulation,
7. food and wood production, etc.

This signifies that the value of a land is given by the labour of a farmer plus the labour of the ecotope. Remember that in this case the labour of farmer is widening: (a) traditional food production and (b) ecological protection.

The problem is to find a correct methodology available to express this labour, that was the aim of this study.

Moreover, we have to note that if the labour made by ecotopes or by landscape units is not considered in the land evaluation, the market prices remain low, but the difference with their eco-service labour value is shifted to the local/district society, in a way not dissimilar to what happens with a new urban settlement. Is today well known that the majority of the Nations had to develop a tax on “infrastructure costs” inherent to new urbanizations.

In the case of ecotope services, we must note that their eco-bionomics costs are 2-4 times higher than the mentioned costs of urbanization and in some aspects our society is not able to made all these kind of labours. Therefore, we suggest to divide the costs of this ecological labour by arising the price of land (cropland and forest lots) in the market exchanges and developing a tax on “eco-bionomics costs”.

We insist: it should be impossible to avoid the continuous destruction of our environment because of the huge abusive differences among built lots Vs. agrarian and forest ones. The sprawl of urbanization on the agricultural landscape around a city is similar to a cancer on healthy tissue as underlined by the Nobel Konrad Lorenz near 50 years ago [34].

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Tab. 1. Hierarchical levels of biological organisation on the Earth

SCALE	**BIOTIC** viewpoint*	**FUNCTIONAL** Viewpoint**	**SPATIAL CONFIGUR.** Viewpoint***	**ECONOMY & CULTURE** Viewpoint****	**INTEGRATED LIVING ENTITIES** (real systems)
Singular	Organism	Organism niche	Living space	Individual activity	Meta-organism
Stationary	Population	Population niche	Habitat	Site activities	Meta-population
Local	Community	Ecosystem	Micro-chore	Historic culture, Local Economy	Ecocoenotope
Territorial	Set of communities	Set of ecosystems	Chore	Historic-cultural Economic L.	Landscape
Regional	Biome	Biogeographic system	Macro-chore	Historic-cultural Regional economy	Ecoregion
Global	Biosphere	Ecosphere	Geosphere	Noosphere and Global economy	Ecobiogeosphere°

* biological and general-ecological criterium** traditional ecological criterium;
***not only a topographic criterium, but also a systemic one (Crf. Emergent Property Principle);
****cultural indented as a synthesis of anthropic signs and elements; ° remember the “Gaia Hypothesis”…