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Landscape Project Can Limit Bionomics Dysfunction Risk Factor vs. Premature Death Increase

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Abstract: The most important "ecosystem service" is the preservation of human health, which is damaged, even in absence of pollution, when the landscape disorder is too elevated. To reach this goal, a landscape project has to follow new ecological criteria, derived from Landscape Bionomics (LB), sensu Ingegnoli [1].

This discipline recognizes "land units" as living entities, studying their physiology and pathology. These principles update even vegetation science as underlined by Ingegnoli and Pignatti [2] allowing to express complex estimations through other systemic landscape indicators. So, the ratio "green space/urbanisation", too generic, is substituted with systemic models as HH/BTC (human habitat/vegetation land capacity). Following this method, we found in the district of Milan a clear increase of mortality rate MR correlated with the increase of landscape degradation.

A basilar ethological alarm process registers all the environmental alterations producing stress; so, landscape dysfunctions, even in absence of pollution, may attempt our health reducing our body defences. LB may help the landscape project to register the level of environmental alteration and to check the capacity to decrease degradations. Also territorial planning and strategic environmental assessment can be changed following landscape bionomics principles and methods to reach the goal of becoming strategic for environmental rehabilitation.

Key words: landscape bionomics, mortality rate/landscape alteration, landscape project, environmental dysfunction, premature death risk factor

1. Introduction

The landscape, as a level of the hierarchical organisation of life on Earth, is a *living entity*, so a *proper biological system* [3]. The physiology/pathology ratio permits a clinical diagnosis of its bionomics health state, after a good analysis and anamnesis. The subsequent "medical" therapy must be the main leading criterion characterising any landscape project LP, from territorial planning to urban parks.

In general, we have to underline that the health-environment relations are known to be, almost exclusively, generated by pollution. Globally, pollution was linked to 1 in 8 deaths in 2012 (as asserted by the research of World Health Organization) [12]: it is the biggest environmental-health problem.

But, in recent years, many ecologists observe also a strong increase of landscape dysfunctions. Being the landscape a living entity — as organism and population are- it may present many syndromes [1]. The majority of landscape syndromes are not due to pollution, so we must investigate if also these non-toxicological landscape pathologies can influence human health. If this hypothesis was proven, the importance of landscape bio-structural rehabilitation would become an imperative and the bio-monitoring would become more complex. The theoretical enhancement of

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psycho-neuro-endocrine-immunology (PNEI) [4] provides the basis to sustain our hypothesis.

So, as it's possible to demonstrate that if the landscape degradation is too elevated human health is damaged, even in absence of pollution [1, 5-7], the control of a LP must be based on the most adequate ecological discipline: Landscape Bionomics.

2. Landscape Bionomic Methods

Landscape Bionomics recognises the landscape as an hyper-complex, adaptive, dynamic, self-organising, hierarchical system, able to elaborate, process and exchange information and to follow correspondence rules, whose complex structural model is based on the concept of tissue, thus being named *ecotissue*. It recognizes *land units* LU as living entities, studying their physiology (as metastability, biologic functions, …) and pathology (e.g., diagnostic index) [1].

This new perspective inevitably leads to significant changes in how to assess and manage the environment. For instance, let us compare the main issue in traditional ecological criteria vs. bionomics criteria: the concept of "*environmental balance*", which follows classic thermodynamics (i.e., reversible processes) as degradation and recovery, is substituted by the concept of "*human and landscape health improving*", following irreversible processes (e.g., metastability levels) and non-equilibrium thermodynamics. In summary, we have to underline that:

- landscape bionomics must be considered as a discipline like medicine, biologically based and transdisciplinary. We can properly compare a true landscape scientist, which we call "ecoiatra", with a physician of a more wide and complex level of life;
- landscapepathologies, but also their influence on human health, which may be dangerous even in absence of pollution, must be diagnosed and healed;
- territorial planning has to be considered as a project for surgical operations, even in the case of "aesthetic surgery", and process of strategic environmental assessment as the related indispensable check-up, necessary to verify contingent therapy.

Being the landscape a biological level, *it is the physiology/pathology ratio that permits a clinical diagnosis of the landscape*, after a good analysis and anamnesis. The landscape bionomics has its own predictive theory (i.e., prognosis), nevertheless, it is necessary to develop this discipline not as a simple predictive science, but also as a prescriptive one (i.e., therapy) — again just like medicine. Particular attention is paid to the fact that interventions in the landscape can be made with the best intentions yet cause serious damage if not carefully referred to bionomic principles. Against this background, the need to study "landscape units" (LU) following Landscape Bionomics emerges. This discipline proposes [1]

(1) new systemic functions, e.g., landscape carrying capacity (SH/SH*); biologic territorial capacity of vegetation (BTC);ecological efficiency of vegetation (CBSt concise bionomic state); human-habitat/BTC correlations; structural (Ψ), functional (τ) and complex landscape-diversity (ω); general landscape metastability (g-LM); …

(2) a new landscape bionomics survey of vegetation (LaBiSV) and of human habitat (LaBiSHH),

(3) the screening of landscape pathologies comparing levels of normality in a clinical-diagnostic way,

(4) the correlation mortality rate/bionomic dysfunction of a landscape unit even in absence of pollutants,

(5) the updating of the concept of environmental impact with that of bionomic rehabilitation strategy,

(6) the formation of a bionomic ecologist as "ecoiatra".

The function of biologic territorial capacity of vegetation BTC [1, 5, 8, 10] estimates the degree of the relative metabolic capacity of principal vegetation communities and their relative anti-thermic (i.e., order) maintenance. It expresses a valid correlation with an other basilar landscape function, the human habitat HH (i.e., the set of areas where human population lives, which are managed permanently and in which subsidiary energy is added, limiting the self-regulation capacity of natural systems NH): so the ratio "green space/urbanisation", too generic, is replaced with systemic models, such as the HH/BTC (*human habitat/vegetation land capacity*).

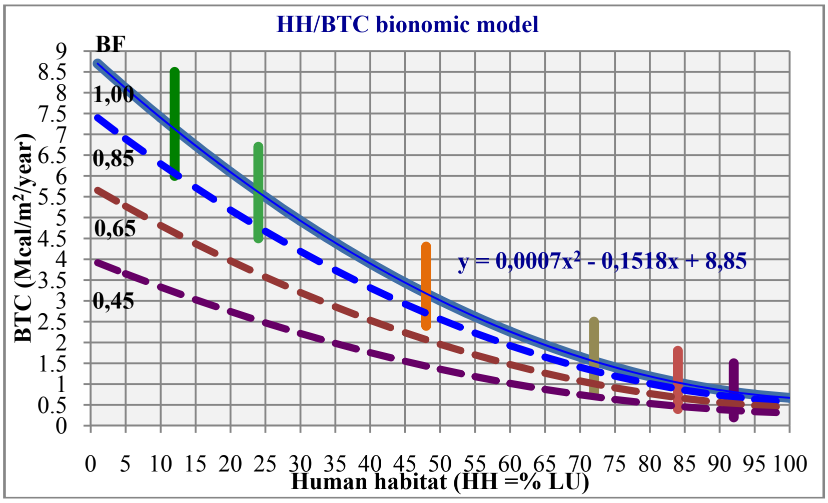

Fig. 1 The HH/BTC model is divided in 7 sections representing different types of landscape, from natural (left) to dense-urban (right). Dotted curves show different levels of bionomic functionality (BF).

The Fig. 1 presents the HH/BTC model. Below a tolerance interval (0.05-0.15 from the curve of normality) we register 4 levels of *bionomic functionality BF:* normal (1.15-0.85), altered (0.85-0.65), dysfunctional (0.65-0.45), degraded (< 0.45).

3. First Evidence of the Bionomic Dysfunction Risk Factor

Table 1 exposes what found applying the main bionomic parameters to a gradient of 72 municipalities from the centre of Milan to the Brianza hills (South-North direction), studied as landscape units LU, grouped in 6 types of landscapes with the *same level of pollution*. Only 19.4% presents a mortality rate MR = 7.6×10^{-3} normal value for this region, that is when the Bionomic functionality BF = 1.0. Among the 38.9% Landscape Units in dysfunctional/degraded condition (BF < 0.65), 20.8% attains MR = 9.7×10^{-3}, that is 128 % more!

Table 1 Gradient of landscape types emerged analysing 72 municipalities from Milan to the Brianza hills. A synthesis of bionomic parameters is exposed: note the bionomic functionality levels and the mortality rate.

ha	N°	Landscape type	% for.	% urb.	% agr.	HH	BTC	SH/SH*	PA	BF	MR
10.459	14	AGRICULTURAL Monza 1	15.68	28.84	54.91	74.97	1.44	0.71	42.43	1.01	7.6
11.005	17	RURAL-SUBURBAN Monza 2	8.19	37.71	53.15	81.04	1.03	0.52	42.05	0.89	7.26
7.680	13	URBAN-SUBURBAN Monza 3	8.98	60.63	29.48	83.49	0.92	0.27	42.99	0.86	8.38
2.723	2	URBAN-SUBURBAN Milano 1	8.09	62.16	28.95	84.55	0.78	0.24	43.95	0.64	8.83
11.360	11	DENSE URBAN Monza 4	1.39	68.84	28.26	89.37	0.51	0.22	43.35	0.58	8.43
22.350	15	DENSE URBAN Milano 2	0.94	80.78	17.42	93.82	0.42	0.12	45.32	0.53	9.68
65.577	72	total area	5.82	60.07	33.16	86.30	0.77	0.32	**43.31**	**0.78**	**8.34**

%for, %urb, %agr = % of Forest, Urbanized, Agricultural land use. SH/SH* = carrying capacity (following bionomic principles); MR = mortality rate (from ISTAT 2008-2011); PA = population age (ISTAT 2008-11); BF = level of bionomic functionality.

If we plot the Mortality Ratein function of the Bionomic Functionality (Fig. 2), an increase of MR appears evident with the decrease of BF. *MR = f(BF)* presents the Pearson's correlation coefficient that is twice the minimum value of significance. Also the population age PA increases in a way similar to BF, but their increments are very different: in the BF interval (0.4-1.0), MR increment is 30.3% vs 7.3% of PA; so 76% of MR increment is only due to landscape dysfunctions, as — remember — they present the same level of pollution.

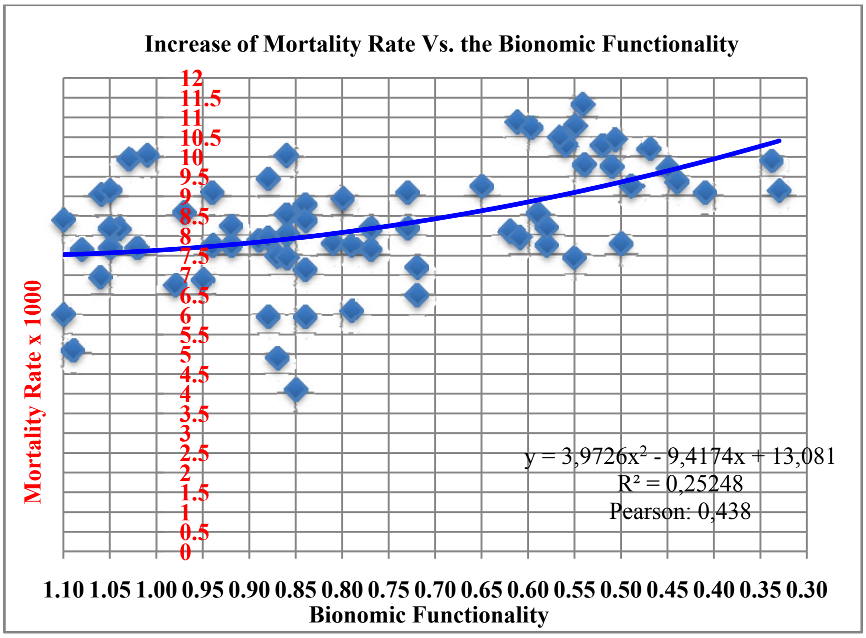

Fig. 2 Increase of the mortality rate in relation to the decrease of bionomic functionality: MR = f (BF). At full normality MR = 7.64 when BF = 1.00, becoming MR = 7.95 at BF = 0.85 but growing to MR = 10.27 with the decreasing of BF to 0.35 (deep dysfunction).

Assuming the previous function MR = f (BF) equal to $MR = 3.9726\ BF^2 - 9.4174\ BF + 13.081$ as a model correlating MR and BF in the examined territory, we may estimate a *Risk Factor for premature death due to lack of bionomic functionality* ($RF_{BD} = \Delta MR_{BF}$). Noted from Table 1 that the mean value of BF is equal to 0.78, deducted the 24% of MR related to normal population aging, stated that MR_{BF} is the surveyed value of MR, $MR_{BF=1}$ is the MR at normal functional condition, it results:

$$RF_{BD} = \Delta MR_{BF} = (MR_{BF} - MR_{BF=1}) =$$
$$= (8.34 - 7.64) \times 0.76 = \mathbf{0.532 \times 10^{-3}}$$

Being the population of the examined territory 2.524 million inhabitants, the estimation of premature death probability (PD) related with BF should be:

$$PD_{BF} = 2.524 \times 10^{6} \times 0.532 \times 10^{-3} =$$
$$= 2.524 \times 10^{6} \times 0.532 \times 10^{-3} = 1{,}342.7 \text{ inhabitants/year}$$

The ratio with the total death per year ($M_{tot} = 21{,}050$) results:

$$PD_{BF}/M_{tot} = 1{,}342.7/21{,}050 = 6.4\ \%\ M_{tot}$$

Note that the percentage of premature death evaluated for Fine Dust pollution (FD) in the Metropolitan Area of Milan is

$$PD_{FD}/M_{tot} = 7.0\ \%\ M_{tot}$$

4. Interpretation

This research on the correlation between Mortality Rate and Bionomic Functionality was promoted after having studied comparative ethology and especially psycho-neuro-endocrino-immunology (PNEI).

A basilar ethological alarm process is linked with the concept of "values-judgment" [9] that is the "correspondence between the perception of values and the passage from the most probable and disordered to the most ordered and improbable". It is dependent on the subconscious mind, which is a database emotion-free having the function to decode environmental signals.

The information derived from this ethological process has an alarming meaning: so it registers all the environmental alterations, which remains memorized within our cells. These memories, conveying destructive energetic frequencies (e.g., the link: psychic emotions-inflammatory cytokines), create stress. If the stress persists within our body, it brings to pathologies.

Medicine is passing from a "strong causality" criterion, e.g., the infective illness of the past, to a "weak causality", concerning degenerative alterations for which a cause-effect relation is rather not understandable [11]. So, the new concept of risk factor is prevailing and the "*stress illness*" is becoming more important than the "infective" illness.

When the stress becomes persistent, it alters the circadian cycle of melatonin and cortisol, increasing the amount of cortisol which becomes dominant. Cortisol is linked to the immune circuit Th2 producing typical inflammatory cytokines (e.g., IL-4, IL-5, IL-13) [4]. But this immune reaction is unsuitable to fight viral infections, neoplastic cells, auto-immune disease cells, which would require a Th1 response. Therefore, the depression of the immune system brings to higher morbidity, enhancing the risk factor of premature death, independently from pollution.

In this vision, the Landscape Project acquires new importance and the Landscape Architect, or the Territorial Planner, following *Bionomic Criteria* and working together with a Physician of the Environment or "Ecoiatra" (i.e., specialised Agronomist or Biologist/Naturalist) may develop strategic rehabilitation actions.

5. Bionomic Criteria for the Landscape Project of an Urban Park

With Fig. 3 we show a W-E transect between the Regional Park of Ticino and the Simplon Park of Milan: note the urban heath isle UHI and the insufficient ecological role of the present urban parks, having Biological Territorial Capacity BTC < 1.95 Mcal/m^2/year (average regional value). To balance the urban desert, we need to activate a network, restore the vegetation of the urban parks and insert a new district with a good BTC level. The occasion could have been the plan for a new quarter on the area of the old Milan International Exposition (Fiera di Milano).

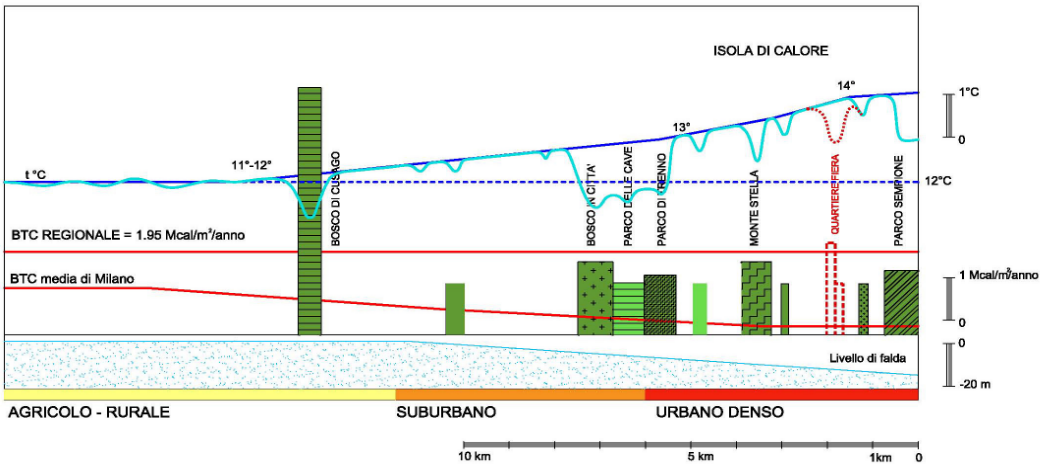

Fig. 3 Transect: from the West side to the Centre of Milan. In green the BTC values of existing Parks, dotted red the new Urban settlement. Blue: the Heath Isle on Milan.

Given that a complex adaptive system (as a landscape unit is) is strongly dependent on its configuration even if the components remains of the same extension and with the same function, to evaluate the properties of the shape and the configuration is crucial: but it is not simple, because the visual analysis is generally insufficient. In a case like this, to study the ecological properties of the urban green when its configuration, for new urban transformation (master-plan scenarios), may follow any free architects creativity, we had to adopt the landscape bionomics criterion (deepen results in [1, 8]).

A research to choose the most ecological advanced model among 10 master-plan scenarios (from M1 to M10) (Fig. 4) — each one reproducing a rectangular area of 25.95 ha, containing: 7.5 ha of residential areas (30% of which green), 5.2 ha of service buildings, 3.25 ha of squares and free areas, 10 ha of park, compatible with the Urban Plan of Milan — was entrusted to the writer in 2006-2008.

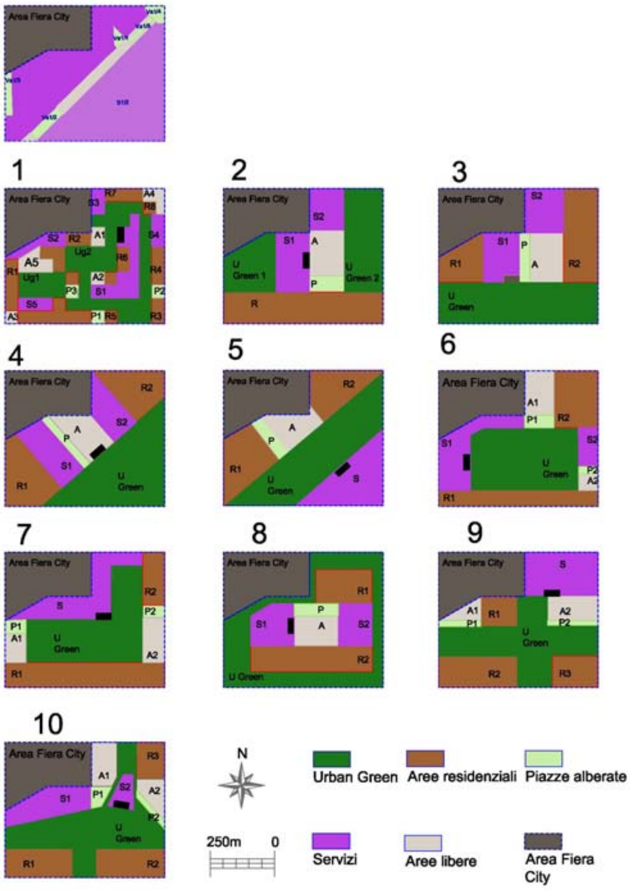

Fig. 4 New City-Life quarter (Milan): 10 main landscape projects. Only their form is changing, not the quantity of each element: perceptive parameters are not able to choose the best scenario [1,8].

Remember that, within the landscape units as within their ecotopes (i.e., the complex unitary portions of the LU), the functions related to the shape depend mainly on three principles of ecology and bionomy and are often unpredictable:

(1) Principle of the Emergent Properties: even if the parts of a system do not change their parameters but only their settlement, they change the functions of the system (often unpredictable);

(2) Form-Function Principle: the interaction among objects is proportional to their edge of contact and to the catching flux of energy;

(3) Scale dependence of ecological functions: the best situation at a specific spatio-temporal scale can be

worse when considered in relation to the neighbouring context.

Thus, on the basis of the principles of landscape bionomics, through 17 landscape ecological and bionomic parameters (only two of which considered twice), two levels of diagnostic evaluation were considered: (A) the grounds of the Quarter, (B) the grounds of the urban operative LU.

The results were very significant [8], because the *diagnostic indexes* (DI) ranged from the present configuration (DI = 0.164) to the maximum of the model M10 (DI = 0.770) (DI = 0.844 for the Quarter and DI = 0.646, when inserted into the LU); the M4, the best for many people, reached only DI = 0.634 (DI = 0.711 for the Quarter but only DI = 0.503 when inserted into the LU).

The model 10 was changed in M15 (Fig. 5), therefore this last M15 was measured with the same method (Table 2) and its DI resulted equal to 0.786 (DI = 0.803 Quarter and DI = 0.769 when inserted into the LU).

Fig. 5 The final master-plan of the new city-life quarter in Milan: M15. The diagnostic index (DI) is the mean between neighbourhood and landscape unit of Table 2; so DI = 0.86.

Table 2 Diagnostic evaluation of the model M15.

ECOLOGICAL PARAMETERS	**NORMA**	**M 15**	**Δ15**	**Score**
Fractal dimension of green (D)	**1.5-1.8**	1.69	0	2
Connection of green (α+γ)	**0.75-1.15**	0.91	0	2
Core areas (%V)	**45-75**	35.2	21.8	0.65
Ratio A/P green	**30-60**	26.9	10.3	1.31
Contacts of green with the outside (%pV)	**20-60**	31	0	2
Built area/perimeter V (m^2/m)	**45-90**	34.1	24.2	0.63
Structural diversity (ψ)	**3.6-9.1**	9.5	4.3	1.72
Climatic balance (ΔT °C)	**0-0.75**	0.67	0	2
Neighbourhood BTC (Mcal/m^2/a)	**0.75-0.9**	0.75	0	2
Park BTC (30 yr)	**1.6-1.9**	1.53	4.4	1.75
scores				*16.06*
Diagnostic index of the neighbourhood	**0.85-1.0**			**0.803**
ECOLOGICAL PARAMETERS	**NORMA**	**M15**	**Δ15**	**Score**
Fractal dimension of green (D) LU	**1.45-1.75**	1.57	0	2
Connection of green (α+γ) LU	**0.5-0.9**	0.46	8	1.47
BTC of LU	**0.6-0.8**	0.49	18.3	0.78
Radius of ecological influence (min)	**310-500**	194	37.4	0.52
Source/sink (% transects)	**25-75**	29	0	2
Garden grain/general grain	**4.0-6.0**	5.6	0	2
Park orientation (% core area)	**45-60**	55	0	2
scores				*10.77*
Diagnostic index of Landscape Unit	**0.75-0.90**			**0.769**

Moreover, we have to remember that the "ecosystem services" characterising an urban park are the following:

(1) Reduction of environmental stress due to bionomic dysfunctions of the urban quarter;

(2) Air cleaning from fine dust;

(3) Break of UHI (Urban Heat Isle);

(4) Water percolation into soil (BFF) [13];

(5) Oasis of natural habitat in the urban desert;

(6) Element of the ecological network of the town;

(7) Social-aesthetic functions (e.g., educational, children, sport, old people, dogs, local aesthetic improving, etc.).

Through the ecological and bionomic parameters of Table 2 we verified also these listed functions, but the first can now be deepened, because it is linked with the human health. Therefore, following this best landscape project scenery (M15), we have to verify if the Milan District 8, containing the City-Life area, would have arrived to decrease the premature death due to bionomic dysfunctions. To reach this goal, it is possible to apply the previous model MR/BF (calculated on 72 LU, with BF = 0.78 and MR = 8.34 with PA = 43.31) after its adequacy to the new condition of the District 8 of Milan, which are: Bionomic Functionality BF = 0.55, Mortality Rate MR = 10.80 (PA = 46.75) as plotted in Fig. 6.

As exposed in this plot, the value of BTC of the District 8 should have grown from 0.41 to 0.44, so the estimation is calculated between BF = 0.55 (red/circular, i.e., present situation) and BF = 0.58 (green/square, i.e., project), related to a Population of 181,000 inhabitants (2010), growing to about 186,000 inhabitants in 2030. The result shows a decrease of the premature death from 187 to 165 people per year: a reduction of 12%. Ingegnoli suggested the possibility to design an urban park with a mean BTC of about 24-25% more elevated: in this second case, the death reduction would have been of about 24.6% (141 dead people per year), but his recommendation was not followed. The elimination of premature death (corresponding to BF ≥ 0.85, edge of normality, i.e., blue/triangular) should need to pass from 136 to at least 300 ha of parks in this portion of Milan.

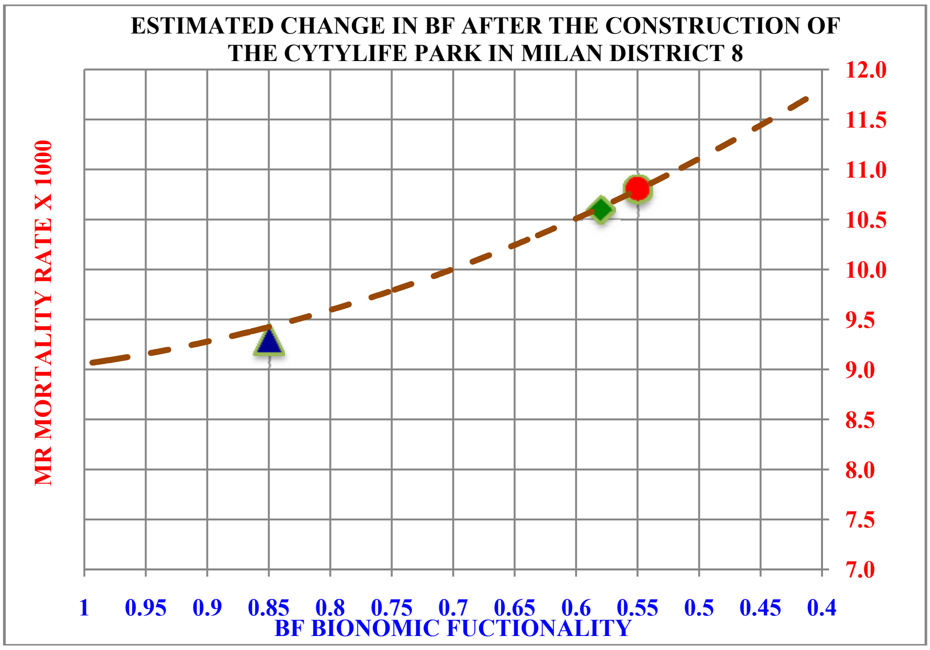

Fig. 6 The bionomic functionality of the district N°8 of Milan, after the construction of the park of the new city-life quarter following bionomic criteria, should have improved from BF = 0.55 (red/circular, i.e., present situation) to BF = 0.58 (green/square, i.e., project). The difference, measured along the MR/BF model, shows the reduction of at least 12% in premature death, which could have been reached by the project, according to Bionomic criteria.

6. Conclusions

The environment influences our health in many ways, through exposures to physical, chemical, but also through bionomic risk factors, and through related changes in our behaviour in response to those factors. So, the Landscape Architect, or the Territorial Planner, following *Bionomic Criteria* and working together with a Physician of the Environment or "Ecoiatra" (i.e., specialised Agronomist or Biologist/Naturalist) may develop strategic rehabilitation actions, put into practice through the Landscape Project.

We are conscious that, even if this study brings interesting results, it represents only a first beginning, because it should be necessary to investigate other gradients of landscape types in other regions and other Nations, both in Europe and USA. But this should imply much more research funds.

In addition there are other important applications, first of all in the strategic environmental assessment SEA reports [14]: some international meetings on the relation SEA/Health were done by W.H.O. The overall aim of the consultation meeting was to seek further advice from SEA and health experts and to discuss challenges and opportunities for the further involvement of the health sector in SEA and strategic planning processes. Flooding, working environment, vibrations, access for handicapped, visual impacts, dust, housing, soil pollution, risk of crime, security, barrier effect, gasses, shadowing, light/reflections, smell, radiation, recreation, traffic, air pollution, bathing water, drinking water, noise. These are the most frequent included health aspects in environmental reports of local planning: but there is no mention of landscape bionomics dysfunctions! This means that "Risk Factor for Premature Death Due to Environmental Alterations, Independently from Pollution" needs a wider diffusion.

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