Ecological transformations in the forest landscape unit at one alpine spruce (*Picea abies* K.) CONECOFOR plot, 1998-2004

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Abstract – The landscape unit (LU) of the Lavazé Pass (Trentino-AltoAdige) is mainly formed (75.3%) by a forest cover dominated by *Picea abies*. In the period 1998-2004 the LU changed the composition of its forest cover because of the increasing of the ski rides (+2.9%) and the naturally destroyed patches (+3.1%). These quite small transformations did not change the geo-botanical structure of the LU, while carried altered ecological consequences. The diagnostic index of the LU, based on a set of 10 landscape ecological parameters, diminished in only 6 years from 0.75 to 0.60. Consequently, in absence of re-balancing interventions, the landscape characters of the LU are changing from semi-natural to managed ones, thus affecting the selected plot too.

Key words: *landscape ecology, forest transformation, diagnostic evaluation.*

Riassunto – Trasformazioni ecologiche nell'unità di paesaggio di un'area CONECOFOR alpina di abete rosso nel periodo 1998-2004. L'unità di paesaggio (LU) del Passo Lavazè (Trentino-AltoAdige) è formata principalmente (73%) da foreste di *Picea abies*. Nel periodo 1998-2004 la LU ha cambiato la composizione della sua copertura forestale a causa dell'aumento delle piste da sci (+2.9%) e degli appezzamenti distrutti da cause naturali (+3.1%). Queste piccole trasformazioni non hanno cambiato la struttura geobotanica della LU, mentre hanno portato consequenze ecologiche. L'indice diagnostico della LU, basato su 10 parametri ecologici del paesaggio, è diminuito in soli 6 anni da 0.75 a 0.60. Conseguentemente, in assenza di interventi di riequilibrio, i caratteri paesaggistici della LU stanno cambiando da seminaturali a gestiti e ciò potrà influenzare lo stato dell'area di monitoraggio.

Parole chiave: *ecologia del paesaggio, trasformazioni forestali, valutazione diagnostica.*

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Introduction

Observing that vegetation - a biological system (Pignatti *et al.* 2002) - is the basilar component of the landscape - the upper biological organisation system (Forman 1995; Meffe & Carroll 1997; Ingegnoli, 1993, 2002) - the study of forest patches outside their landscape units (LU) fails its synecological significance. Therefore, the Italian CONECOFOR programme inserted a pilot study of a LU based on the permanent plot contest of TRE1 at the Lavazé Pass (Trentino-Alto Adige). It is possible to demonstrate that studying a LU, we can solve crucial problems, as:

a) how to use the ecological characters of all the different types of vegetation existing within a LU to arrive to a diagnostic evaluation of the ecological state of the studied forest and of its landscape;
b) how to integrate the other ecological parameters of the LU, like HH (human habitat) or SH/SH* (carring capacity) with vegetational ones (Ingegnoli 1993, 2002) to verify the human disturbance on a forest system;
c) how to weight the contribution of a forest tessera to the metastability of the LU;
d) how to compare the data of the forest patch with those of other vegetation elements in the same landscape unit.

Moreover, problems like these are linked with the study of the dynamic of a landscape unit, the period of time depending on the history of the system.

The case study of the Lavazè Pass LU (1800 m a.s.l, in the Dolomite Alps) focused on the landscape dynamic along a short period (1998-2004) and on the reconstruction of the landscape structure since 1935-40. The main objective of this study is to reach a diagnostic evaluation of the ecological state of the forest landscape after the transformations of this recent period. The small landscape unit of the Pass measures 172.6 ha and it is formed by four ecotopes (Figure 1): (1) the Lavazé Pass highland prairie veg-

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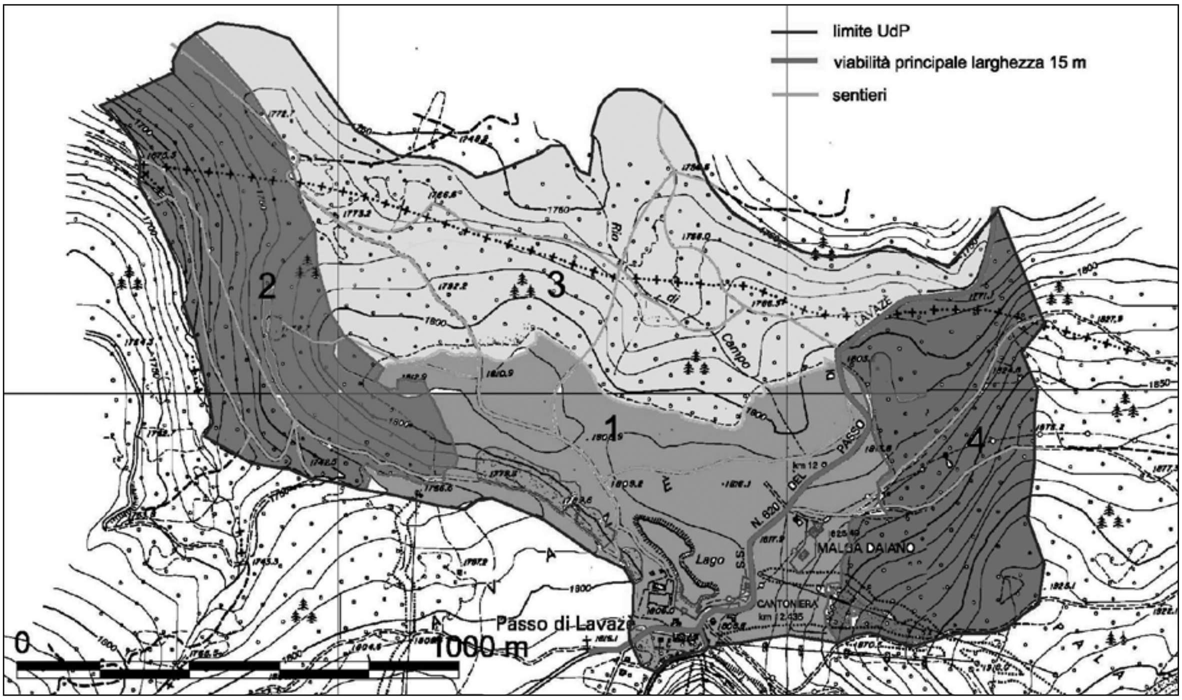

Figure 1 - The Lavazé Pass landscape unit (LU) 1800 m a.s.l. in the Alpine region of Trentino-AltoAdige, Italy. Forest cover 75.3%. We can see the 4 ecotopes composing the LU: only the ecotope 1 is mainly formed by prairie and shrubs.
L'unità di paesaggio (LU) del Passo di Lavazé, 1800 m s.l.m. nella regione alpina del Trentino-AltoAdige, Italia. Le foreste coprono 75.3%. Osserviamo 4 ecotopi: solo l'ecotopo 1 è formato da praterie e arbusti.

etation (25.9%), (2) the West slope forest (19.7%), (3) the North belt forest with bogs (36.6%) and (4) the East slope forest (17.8%). The forest is dominated by *Picea abies* with some presence of *Pinus cembra* in the classical syntaxonomic association of *Homogino-Piceetum*, Zukrigl 1973.

Methods

The study followed the Landscape Ecological discipline (NAVEH & LIEBERMAN 1984; FORMAN & GODRON 1986; FINKE 1986) in the form proposed by INGEGNOLI (1993, 2002) and INGEGNOLI and GIGLIO (2005) as "biological integrated". This school of landscape ecology is based on the recognition that the complex adaptive system of the landscape is a proper level of biological organisation, so much more than a simple set of spatial characters. Therefore, this school tried to focus the landscape ecological elements and processes, proposing new concepts (*e.g.* ecocoenotope, ecotissue), new functions (*e.g.* biological and territorial aspects of vegetation-BTC-) and new studying methods (*e.g.* LABISV landscape survey and evaluation of vegetation), *etc.* Let us briefly present some of them:

(i) The biological territorial capacity of vegetation or BTC (INGEGNOLI 1991, 2002), is a synthetic function, referred to the vegetation of an ***ecocoenotope,*** *i.e.* the ecological system, composed of the community (biotic view), the ecosystem (functional view) and the microchore (*sensu* ZONNEVELD 1995). It expresses the flux of energy a vegetation system must dissipate during a year to maintain its degree of organization and metastability. It is based on: (1) the concept of resistance stability (ODUM 1971); (2) the principal types of ecosystems of the ecosphere (WHITTAKER 1975); (3) their metabolic data (biomass, gross primary production, respiration, R/PG, R/B) (DUVIGNEAUD 1977; PIUSSI 1994; PIGNATTI 1995). Two coefficients are present within this function:

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

- where: *R* is the respiration, *GP* is the gross production, *dS/S* is equal to *R/B* and is the maintenance/structure ratio (or a thermodynamic order function; ODUM 1971, 1983) and *i* are the principal ecosystems of the ecosphere.

The factor a_i measures the degree of the relative metabolic capacity of the principal ecosystems; b_i measures the degree of the relative antithermic (*i.e.*

order) maintenance of the principal ecosystems. We know that the degree of homeostatic capacity of an ecocoenotope is proportional to its respiration (Odum 1971, 1983). So through the a_i and b_i coefficients, even related in the simplest way, we can have a measure which is a function of this capacity:

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

(ii) The Human habitat (HH) and the ecotissue concept. The areas where human populations live and work permanently, limiting the self-regulation capability of natural systems form the human habitat. The HH is differentiated from the natural habitat (NH), but their sum is >1 , because of the concept of ecotissue. The *ecotissue* is the complex multidimensional structure of a landscape where a main spatial mosaic of tesserae (generally formed by the vegetation coenosis) is hierarchically integrated with the set of correlated mosaics and information of different temporal and spatial scales.

(iii) The landscape biological integrated survey of vegetation or LaBISV is the method proposed to study the vegetation in a landscape (Ingegnoli 2002; Ingegnoli e Giglio 2005; Ingegnoli 2005). It is able to integrate three different criteria (a biotic one, an environmental one and a configurational one) with different temporal and spatial scales. It helps in the definition of the so called "*normal state*" for each specific type of tessera (the term tessera can be used to individuate -in practice- an ecocoenotope).

It uses a *parametric standard form* (a proper one for each type of vegetation) for the analysis and evaluation of a vegetated tessera. The standard form (or schedule) (Figure 2) has been designed to check the

Example of the LABISV methodology synthetized in the present standard form

BOREAL FOREST T. TESSERA CHARACTERS (Ts)	1	5	14	25	score
T1 – Vegetation height (m)	< 9	9.1-18	18.1-29	**> 29.1**	Canopy
T2 – Cover of the canopy (%)	< 30	> 90	**31-60**	61-90	Ts surface
T3 – Structural differentiation	low	medium	**good**	high	Age, space groups, etc.
T4- Interior/edge (%)	none	< 30	**31-89**	> 90	(% Ts)
T5 - Management	simple coppice	coppice	wood	**natural forest**	Or similar
T6 – Permanence (years)	< 80	81-160	**161-240**	> 240	Old trees
F. VEGETATIONAL BIOMASS(ABOVE GROUND)					
F1- Dead plant biomass	near 0	> 10	**1-5**	5-10	% of living biomass
F2- Litter depth	near 0	< 1.5	**1.6-3.5**	> 3.5	cm
F3 – Biomass volume (m³/ha)	< 200	201-500	**501-950**	> 950	pB = **696** m³/ha
E. ECOCENOTOPE PARAMETERS					
E1- Dominant species (n°)	> 3	3	2	**1**	As pB volume
E2- Species richness	< 15	16-30	31-40	**> 40**	n° sp./Tessera
E3- Key species presence (%)	< 5	6-40	41-80	**> 80**	Phytosociological
E4- Allochthonous species (%)	> 10	10-4	< 4	**0**	From other ecoregions
E5- Infesting plants %	near all	> 25	< 25	**0**	Coverage on Ts
E6- Threatened plants	evident	suspect	risk	**0**	Even acid rain damage
E7- Biological forms (n°)	< 3	4-5	**6-7**	> 7	Cfr. Box 1987, mod.
E8- Vertical stratification	2	3	**4**	> 4	traditional
E9- Renew capacity	none	intense	**sporadic**	normal	Dominant species
E10- Dynamic state	degradation	recreation	**regeneration**	fluctuation	Cfr. Ingegnoli 2002
U. LANDSCAPE UNIT (LU) PARAMETERS					
U1- Similar veg. contiguity	0	< 25	**26-75**	> 76	% of perimeter
U2- Source or sink	sink	neutral	**Partial**	source	Species & resources
U3- Functional role in LU	reduced	minor	**evident**	important	Context & typology
U4- Disturbances incorporation	insufficient	scarce	normal	**high**	Local disturbances
U5- Geophisical instabilities	evident	partial	**risk**	none	On the phisiotope
U6- Permeant fauna interest	low	medium	**good**	attraction	Key species
U7- Tranformation modalities of the Ts	strong distubances	gradual changes	temporal instabilities	**fluctuation**	Today + tendency
U8- Landscape pathology interference	serious	near chronicle	**easy to incorporate**	none	From landscape
U9- Permanance of analogous vegetation (years)	< 100	100-300	300-1200	**> 1200**	Historical presence
RESULTS OF THE SURVEY					
Total score Y (= h+j+k+w)	h = 0	j = 0	k = 17	w = 11	Y = 513
Quality of the Ts	Q = Y / 700				**Q = 73,3** [%]
Estimation of the BTC	BTC (b) = 0,01339 (y-28) + 0,12 (pB / 70)				**BTC = 7,69** [Mcal/m²/a]

Figure 2 - Example of the LaBISV methodology of survey synthesized in the present standard form. Forest permanent CONECOFOR plot TRE1 (Lavazè Pass, Alps) *Piceion abietis*, 1.800 m. Survey: August 2004 by Ingegnoli and Giglio. Also the equation of estimation of the BTC derives from the model of Ingegnoli (2002).
Esempio della metodologia LaBISV dell'indagine riassunta nella scheda standard. Area permanente CONECOFOR TRE1 (Passo Lavazè, Alpi) Piceion abietis, 1.800 m. slm. Rilevamento: Agosto 2004 (Ingegnoli e Giglio). Anche l'equazione per la stima della BTC deriva dal modello di Ingegnoli (2002).

Table 1 - Measure of the landscape elements forming the main mosaic of the LU of Lavazè Pass in 1998 and 2004.
Misura degli elementi di paesaggio che formano il mosaico principale al Passo Lavazè nel 1998 e nel 2004.

Landscape element	1998 Area (ha)	1998 LU%	2004 Area (ha)	2004 LU%
Forests	117.26	67.9	109.95	63.7
Destroyed patches or clearcuts	0,5	0.3	5.94	3.4
Ski rides	1	0.6	6	3.5
Paths	4	2.3	2	1.2
Bogs	3.66	2.1	3.66	2.1
Grass patches	3.5	2.0	2.37	1.4
Forest areas	***129.92***	***75.3***	***129.92***	***75.3***
Prairie	27.56	16.0	26.08	15.1
Shrub patches	4.5	2.6	4.5	2.6
Ski rides	2	1.2	2.9	1.7
Paths	2	1.2	2.1	1.2
Lake	1.75	1.0	1.75	1.0
Prairie areas	***37.81***	***21.9***	***37.35***	***21.6***
Built tesserae	2.9	1.7	3.31	1.9
Roads and parkings	2	1.2	2.05	1.2
Built areas	***4.9***	***2.8***	***5.36***	***3.1***
Landscape unit, 1998	**172.63**	**100.0**	**172.63**	**100.0**

organisation level and to estimate the metastability of a tessera considering both general ecological and landscape ecological characters:

- T = landscape element characters (*e.g.* tessera, corridor);
- F = plant biomass (quantity and characters) above ground;
- E = ecocoenotope parameters (*i.e.* integration of community, ecosystem and microchore characters);
- U = relation among the elements and their landscape parameters.

The evaluation classes are four, the weights per class depending on an evaluation model, one for each of the main types of vegetation ecosystem (Ingegnoli 2002).

The method let us evaluate the quality of vegetation per parametric set of data: proper equations, calibrated per vegetation type, combine the quality of the surveyed tessera vegetation and its plant biomass to estimate the BTC of the tessera itself, thus the degree of metastability of vegetation can be estimated. Results may be represented through ecograms.

Results

The first analysis concerned the measure of the landscape elements (*i.e.* types of tesserae) of the LU in 1998 and 2004 and their comparison, all based on the technical cartography (CTR) of the Province of Trento and on a program of field observations (Table 1).

The increase of both human and natural disturbances, mainly due to patches destroyed by hurricane and new ski rides, changed the forest areas, which lost about 8 ha in only 6 years. This amount (6.8% of the LU), to which we can add the small increase of built areas (0.3%), appeared to be without consequences to the Province authorities. But in the same time the tourist pressure increased, and in 2004 the total inhabitants of the LU can be estimated in 270 people (year equivalents). So, the ecological state of this LU have to be checked up more deeply.

The vegetation survey of the LU was made following the mentioned LaBISV method, choosing 13 samples based on the most significant tesserae, representing about 1/3 of their total number but all their characters, as we can see in Table 2 and 3. The forested samples presented an average BTC of 7.17 Mcal/m^2/year, corresponding to about 76% of the for-

Table 2 - Forest tesserae in the Lavazè Pass in 2004 measured through the LaBISV method.
Tessere forestali misurate al Passo Lavazè nel 2004 mediante il metodo LaBISV.

Tesserae (Ts) A. Forest Ts	sur. ha	Q.T %	Q.F %	Q.E %	Q.U %	BTC Mcal/m²/yr	BTC/BTC$_s$ %	H m	vFM m³/ha
Z, Ts (containing Tre1)	4.01	70.7	56	95.6	80.4	**8.50**	**90.0**	2.5	739
A, Est, q 1880 m	2.25	50	58.7	64.8	58.7	**6.19**	**65.0**	24.8	606
B, Est, q, 1800 m	4.25	50	32	74.4	71.6	**6.15**	**65.0**	26.1	320
C, Nord-Est, q 1780 m	4.40	64.7	56	73.6	67.6	**7.48**	**79.1**	25.7	872
D, Ovest di Z, q 1790m	4.18	56	56	74.4	71.6	**7.04**	**74.4**	25.6	629
E, Nord, q 1770 m	4.41	56	56	70.8	62.7	**6.93**	**73.3**	25.8	793
F, Ovest, q 1800 m	4.31	78	70.7	82.4	85.3	**9.09**	**96.1**	32	1086
G, Sud, q 1790 m	2.83	57.3	56	78.8	57.8	**6.94**	**73.4**	26.7	713
H, Sud-Ovest, q 1750 m	3.73	57.3	44	78.8	67.6	**6.65**	**70.3**	20.7	443
L, Ovest di D, q 1800 m	2.74	44	44	66.4	52.9	**5.67**	**59.9**	26.6	525
Tot. forest Ts	***37.11***	***59.4***	***53***	***76.6***	***68.9***	***7.17***	***75.8***	***26.5***	***686***

BTC_s = 0,85 BTC_F where: BTC_s= maturity threshold, BTC_F= flex of the development curve (from the model). (Ingegnoli 2002).
QT= quality of the tessera parameters, QF= quality of the phytomass parameters, QE= quality of the ecocoenotope parameters, QU= quality of the LU parameters.
H= mean heigh of the canopy, FM= Phytomass, (using the relascope).

Table 3 - Other types of vegetation in the Lavazé Pass.
Altri tipi di vegetazione al Passo Lavazè

Tesserae (Ts) B. Other vegetation Ts	sur. ha	Q.T %	Q.F %	Q.E %	Q.U %	BTC Mcal/m²/yr	BTC/BTC_s %	H m	vFM Kg/m²
a- shrubs (*Juniperus*)	1.2	45.5	36.9	78.6	69.8	1.44	65.1	0.7	1.9
b- grass (*Nardus*)	1.6	21.9	12.5	52.8	51.4	0.58	47.5	0.4	0.8
c- alpine bog	1.5	62	51	94	72.9	1.22	85.6	0.2-1	1.5
Tot. Ts	**4.30**					**1.04**			

QT= quality of the tessera parameters, QF= quality of the phytomass parameters, QE= quality of the ecocoenotope parameters, QU= quality of the LU parameters.

est maturity threshold. Some tesserae have not been managed by man since more than a century.

Following the old maps and the indication from local Forest Administration (asserting a constant and low management of the forest) it was possible to quantify an outline of the land use of the Lavazé Pass Unit since 1935-40. Then, always applying the methods of INGEGNOLI (2002) partially reported in the previous paragraph, some of the most important ecological parameters, ranked forward, have been measured or estimated as we can see in Table 4. In figures 3 we show the increasing fragmentation due to the new ski rides in only few years (1998-2004): in this LU the ratio interior/edge changed in the forest from 3.42 in 1998 to 1.82 in 2004.

As shown in Table 4, the most evident changes in this LU mainly appeared in the last period (1998-2004), therefore it needs a diagnostic evaluation, based on the comparison with normal state parameters (Table 5).

The first question for a diagnostic evaluation is the specification of the landscape type useful to express a proper rank of normal values. In this case we have to refer to a semi-natural forest alpine landscape, as confirmed by the BTC/HH ratio in 1998 (5.05/0.214=23.6). The normal values (NV) of main parameters of that landscape (*i.e.* sub-natural forested Alpine landscape) are synthesized as follows:

a) BTC (Mcal/m²/a), the Biological territorial capacity of vegetation (NV deduced from the HH/BTC model INGEGNOLI & GIGLIO 2005): 5.57-6.15 Mcal/m²/year;
b) HH (%), the Human habitat (NV deduced from the HH/BTC model INGEGNOLI & GIGLIO 2005): 20-22;
c) ψ = H (3+D), the Structural landscape diversity (NV deduced from ψ model INGEGNOLI & GIGLIO 2005): 5.5-5.7;
d) LM = τ *BTC, the general landscape metastability (NV deduced from HH/LM model INGEGNOLI 2002): 29-31;
e) C/F (%), the Core-area/Forest surface (%) ratio (NV deduced from field observations and ecological considerations): 80-90;
f) Allochthonous plants (%), the Presence of exotic plant species (NV deduced from field observations and ecological considerations): 0-1;
g) Forest area (%), the forested surface of a landscape unit (NV deduced from field observations and ecological considerations): 65-80;
h) Agriculture area (%), the agriculture surface of a landscape unit (NV deduced from field observations and ecological considerations): 10-20;
i) σ = SH/SH*, the HH carrying capacity index (INGEGNOLI 2002) (NV not less than values proper of an agricultural landscape): 3-10;
j) HCE = (BTC/HH)* σ. It represents the HH capacity evaluation. Deduced from the HH/BTC model, it helps in landscape classifying (NV from HCE model INGEGNOLI 2006): 65-700;
k) Diagnostic index. It considers the gaps (%) from NV on the entire set of ecological parameters. Evaluations: 0.85-1 = normal; 0.6-0.85 = alteration; 0.35-0.6 = syndrome; 0.15-0.35 = serious syndrome; < 0.15 extinction.

Table 4 - Results of the main landscape ecological analysis on the landscape unit of Lavazé Pass.
Risultati della principale analisi ecologica dell'unità di paesaggio del Passo Lavazè.

Ecological parameters	1935-40	1998	2004
BTC (Mcal/m²/year)	5.18*	5.05	4.76
Human habitat, HH (%)	20.6*	21.4	26.7
HH/NH	0.259*	0.272	0.364
ψ = H (3+D)	4.63	4.99	5.29
LM = τ *BTC	24.27*	24.16	23.09
Interior/edge ratio	4.14	3.42	1.82
Core-area/Forest surface (%)	80.54	77.39	64.55

HH is the human habitat, NH is the natural habitat, ψ is the structural landscape diversity, LM is the general landscape metastability (from INGEGNOLI 2002).
ψ = structural landscape diversity;
* estimated values

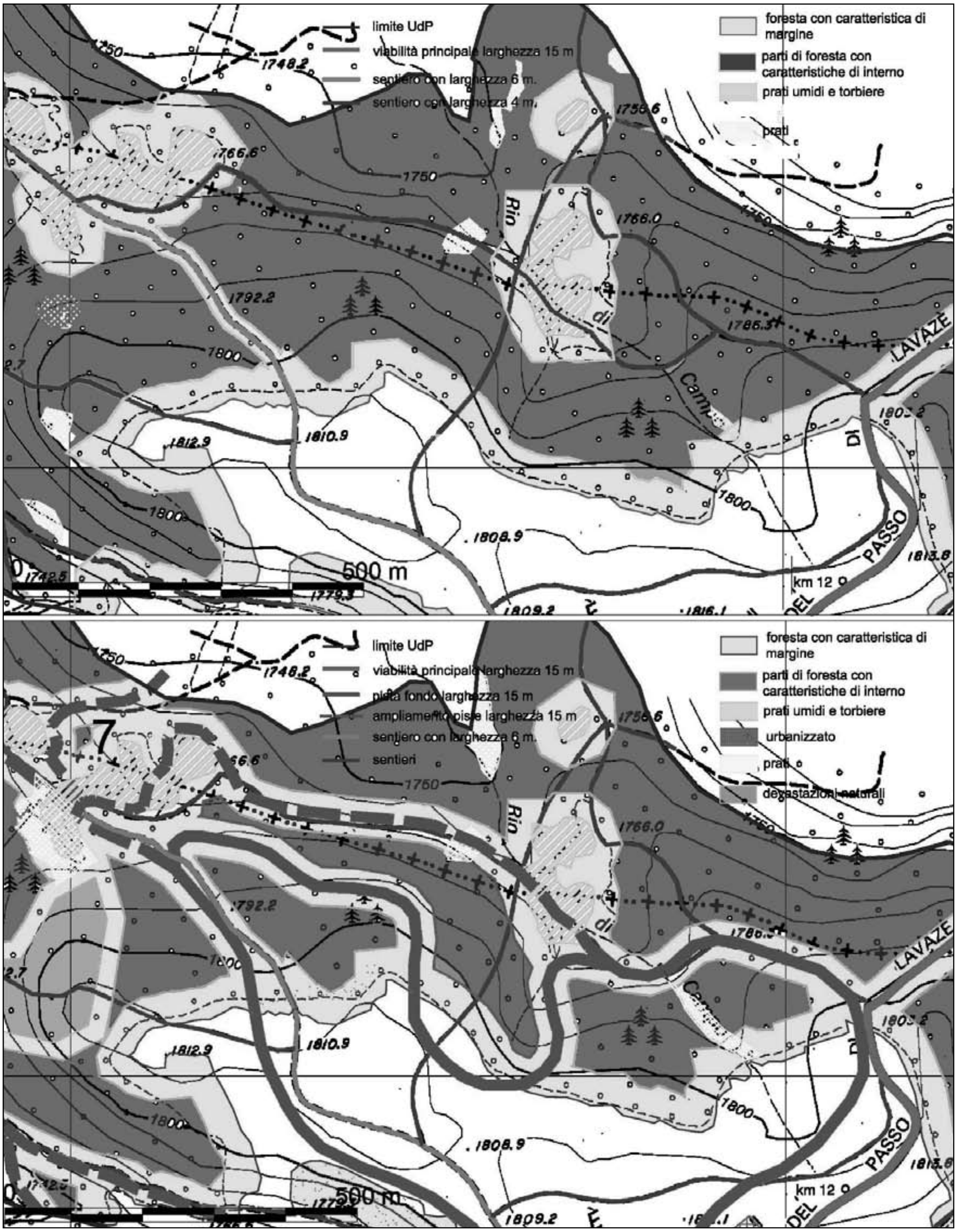

Figure 3 - Top: analysis of the fragmentation of the forest in 1998. The ratio "Core-area/For. surface" is related to forest patches and resulted 77.39 %. Therefore the inner/edge ratio was 3.42. Bottom: analysis of the fragmentation of the forest in 2004. The ratio "Core-area/For. surface" is related to forest patches and resulted 64.55 %. Therefore the inner/edge ratio decreased from 3.42 to 1.82.
Sopra: analisi della frammentazione della foresta nel 1998. Il rapporto "core-area/superficie forestale" è relazionato alle tessere forestali ed è risultato di 77.39%. Per questo il rapporto interno/bordo è risultato di 3.42. Sotto: analisi della frammentazione nel 2004. Il rapporto "core-area/superficie forestale" è relazionato alle tessere forestali ed è risultato di 64.55%. Per questo il rapporto interno/bordo è diminuito da 3.42 a 1.82.

Table 5 - Diagnostic evaluation of the ecological state of the Landscape Unit (Lavazé Pass) (Ingegnoli 2002).
Valutazione diagnostica dello stato ecologico dell'unità di paesaggio (Passo Lavazè) (Ingegnoli 2002).

Main parameters	Normal values*	1935	Gaps %	1998	Gaps %	2004	Gaps %
BTC (Mcal/m²/y)	**5.57-6.15**	5.18	**- 7**	5.05	**-9.3**	4.76	**-14.5**
HH (%)	**20-22**	20.6	**ok**	21.4	**ok**	26.7	**21.4**
ψ = H (3+D)	**5.5-5.7**	4.63	**-15.8**	4.99	**-9.3**	5.29	**-3.8**
LM = τ *BTC	**29-31**	24.27	**-16.3**	24.16	**-16.7**	23.09	**-17.6**
C/F (%)	**80-90**	80.54	**ok**	77.39	**-3.3**	64.55	**-19.3**
Allochthonous pl. (%)	**0-1**	0	**ok**	0	**ok**	0.1	**ok**
Forest area (%)	**65-80**	68.9	**ok**	67.9	**ok**	63.7	**- 2.0**
Agriculture area (%)	**10-20**	18.7	**ok**	16	**ok**	15.1	**ok**
σ = HS/HS*	**3-10**	2.9	**-3.3**	1	**-66.7**	0.92	**-69.3**
HCE = (BTC/HU)* σ	**65-700**	72.9	**ok**	23.6	**-63.7**	16.4	**-74.8**
Diagnostic index	***0.85-1***	*0.90*	***ok***	*0.75*	***-11.8***	*0.60*	***-40***

Distance (%) Evaluation Scores: 0-10 =2; 10-30 = 1; 30-60 = 0.5; > 60 = 0.
Diagnostic index: 0.85-1 = normal; 0.6-0.85 = alteration; 0.35-0.6 = syndrome; 0.15-0.35 = serious syndrome; < 0.15 extinction.
(*)Normal values: according to a sub-natural forest Landscape.

The evaluation scores depend on the concepts of tolerance and alteration of an ecological vegetation system, deduced from field observations. Ingegnoli (2006) proposed the following thresholds, based on the gaps between the NV and the measured ones: [0-10] = 2; [10-30] = 1; [30-60] = 0,5; [> 60] = 0. Therefore, a diagnostic evaluation using 10 parameters, as in this case study, should summarise a total score of 10x2 = 20. Applying this method (Tab. 5) the results (diagnostic index) were 18/20 = 0,90 in the period 1935-40, 15/20 = 0.75 in 1998, but only 12/20 = 0.60 in 2004.

The diagnostic evaluation of a landscape unit in an European (and Alpine) region is based on the five classes associated with the diagnostic index as exposed in the note of table 5, following the most significant physio-pathological phases, which implies consequent ecological health state and interventions per class, as ranked here:

I. (0.85-1.00) Normal. Homeostatic plateau, quite good health, only prevention;
II. (0.60-0.85) Alteration. Compensation needed, instable health, some therapies;
III. (0.35-0.60) Disorder. Some physiological damages, dysfunction, intervention needed;
IV. (0.15-0.35) High disorder. Harmful effects, high dysfunctions, difficult intervention;
V. (< 0.15) Extinction. Irreversible damages, degenerative transformations.

In this case study the Lavazé Pass LU results at the limit between alteration and pathology.

It is possible to confirm the previous diagnosis applying the correlation expressed in the HH/BTC model (Ingegnoli & Giglio 2005) in the case study of the Lavazé Pass (Figure 4). This figure shows the thresholds differentiating the landscape typologies (*i.e.* natural forested landscape, semi-natural forested landscape, managed forested -or forest-agricultural-landscape, agricultural landscape, rural-suburban landscape *etc.*). Five intervals of these are plotted in Figure 4. The last transformation period (1998-2004) of the LU is shown to pass from the second to the third interval, corresponding to a degradation of the traditional semi-natural type of landscape.

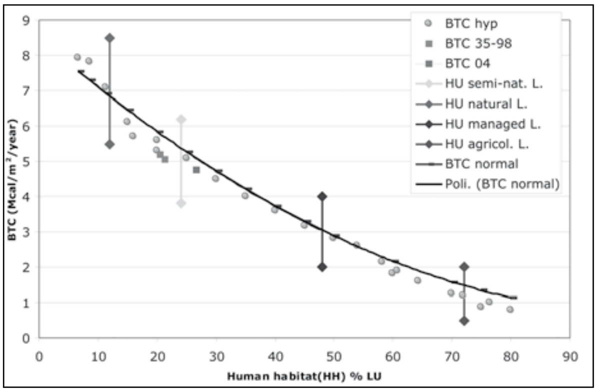

Figure 4 - The polynomial curve of the BTC/HH model is in accordance with the hypothesis of possible transformations of our case study (grey sq). We can see the movement of the LU system from 1935-98 to 2004 passing through the threshold between two landscape (L) types. These forested L. types are separated by vertical segments: 1st belt: natural L.; 2nd belt: semi-natural L.; 3rd belt managed (or forest/agricultural) L.; 4th belt: agricultural L.; 5th belt: suburban L.
La curva polinomiale del modello BTC/HH è in accordo con l'ipotesi di possibili trasformazioni del nostro caso di studio (riquadri grigi). Possiamo vedere la LU dal 1935-1998 al 2004 passare attraverso la soglia di due tipi di paesaggio (L). Questi tipi di paesaggi forestali sono separati da segmenti verticali: 1° fascia: L naturale; 2° fascia: L seminaturale; 3° fascia: L gestito (o forestale/agricolo); 4° fascia: L agricolo; 5° fascia: L suburbano.

Conclusion

This case study demonstrates that if we want to evaluate the ecological state of a forest and the transformation in a forested landscape unit, we must follow a landscape ecological method. Through a method like the one proposed by Ingegnoli we have seen that apparently small changes in few years may bring to near pathologic consequences in a forest system. Other more traditional methods, mainly referred to permanent plots, are not able to reach similar results. For instance, phytosociologic characters are not really altered in a forest like this. We hope to apply the landscape ecological theory and its proper methodologies (*e.g.* the LaBISV) to other forested landscape units, in different climatic areas, at least in Italy.

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