CORSO DI BOTANICA SISTEMATICA

LEZIONE - 54

Licheni come biomonitor
(seconda parte)

Lichens, air pollution and lung cancer

The relationship between lung cancer and atmospheric pollution remains controversial[1–3] despite 50 years of discussion, partly because studies are frequently restricted to small, well-monitored areas. In contrast to instrumental monitoring, bioindication techniques allow the mapping of pollution effects over wide areas with a high sampling density. We have compared a biodiversity map of pollution-sensitive organisms, the lichens[4], with mortality maps of a large part of northeastern Italy, the Veneto region (18,364 km^2, population ~4 million). Our results strongly support a relationship between air pollution and lung cancer.

The lichen study (data from 1991)[5] was based on 2,425 measurements of epiphytic lichen biodiversity at 662 locations, calculated as the sum of frequencies of all species in a sampling grid of 10 units[6]. The mortality data at municipal level (1981–88) derive from the Italian National Institute of Statistics. Kernel indicators for the estimate of density functions[7,8] were used for the analysis.

Biodiversity shows low, if any, correlation with several types of cancer (including larynx cancer, $r = 0.016$), and with mortality by chronic bronchitis ($r = 0.15$) because of the high mortality in mountain areas. There is no correlation with lung cancer in male migrants ($r = 0.07$), or in resident women ($r = 0.12$). Municipal data concerning women have a poor statistical quality because lung cancer deaths in women are relatively few (13% of total lung cancer deaths), and there are pronounced differences in the smoking habits of women from rural and urban areas[9].

However, biodiversity (Fig. 1a) and lung cancer in young (aged under 55 years) native male residents (Fig. 1b) are highly correlated ($r = 0.82$, Fig. 2), even when corrected for spatial autocorrelation with bayesian analysis[7]. When all age-groups are included, the correlation becomes lower ($r = 0.6$), owing to higher mortality of older men in mountain areas, many of whom emigrated between 1950 and 1970 to coal mines in Belgium.

We tested the hypothesis that lung cancer is correlated with lichen biodiversity as a result of air pollution, using pollution data recorded in nine municipalities since 1986. In these regions the correlation between biodiversity and lung cancer in young male residents was high ($r = 0.95$, $P < 0.001$). Furthermore, there was a high correlation with common anthropogenous pollutants, such as SO_2, NO_3, dust and SO_4^{2-} ($r = 0.93$, 0.87, 0.86 and 0.85, respectively; $P < 0.01$ in all cases); and no correlation with non-anthropogenous substances such as Cl^-, Ca^{2+}, Mg^{2+}, HCO_3^-, K^+, Na^+, or with all other types of cancer.

Lichens are notoriously sensitive to sulphur dioxide[4], but the low SO_2 concentrations recorded in the survey area are unlikely to produce carcinogenic effects.

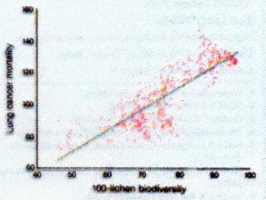


Figure 2 Scatter diagram relating lichen biodiversity (100 − sum of frequencies) and lung cancer mortality (observed/expected cases × 100; males aged under 55 years) in all municipalities of the Veneto region ($r = 0.82$, $F = 845.9$, $P < 0.0001$).

However, the patterns of SO_2 concentration revealed by lichens do reflect the long-distance transport of different pollutants that may be emitted with SO_2, some of which may have carcinogenic effects.

The densely populated eastern and western parts of the Veneto plain are upwind and downwind of the main pollution sources, which may explain the low correlation between lung cancer in young males and population density ($r = 0.23$). Pollution was higher between 1960 and 1980, but the main patterns of atmospheric transport have remained constant, indicating that time-lag factors are irrelevant.

The relative risk associated with pollu-

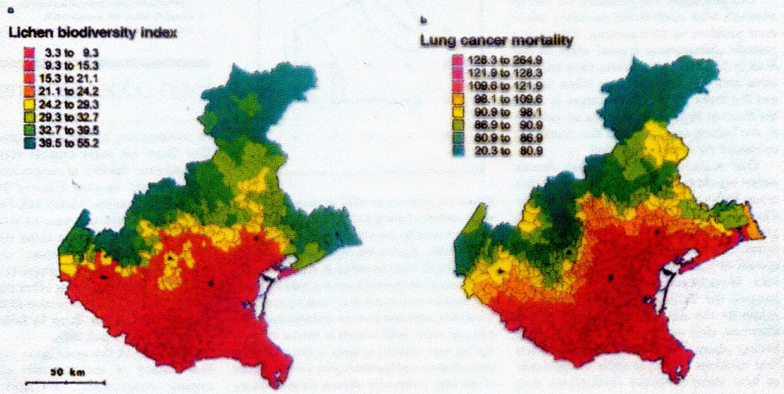


Figure 1 a, Lichen biodiversity, calculated as the sum of frequencies of all epiphytic species in a sampling grid of 10 units; and **b,** lung cancer mortality in young male residents (expressed as observed/expected cases × 100), in the region of Veneto. Scale intervals are based on percentiles of values distribution.

AGENZIA NAZIONALE PER LA
PROTEZIONE DELL'AMBIENTE

Atti del Workshop

Biomonitoraggio della qualità dell'aria sul territorio nazionale

Serie Atti 2 / 1999

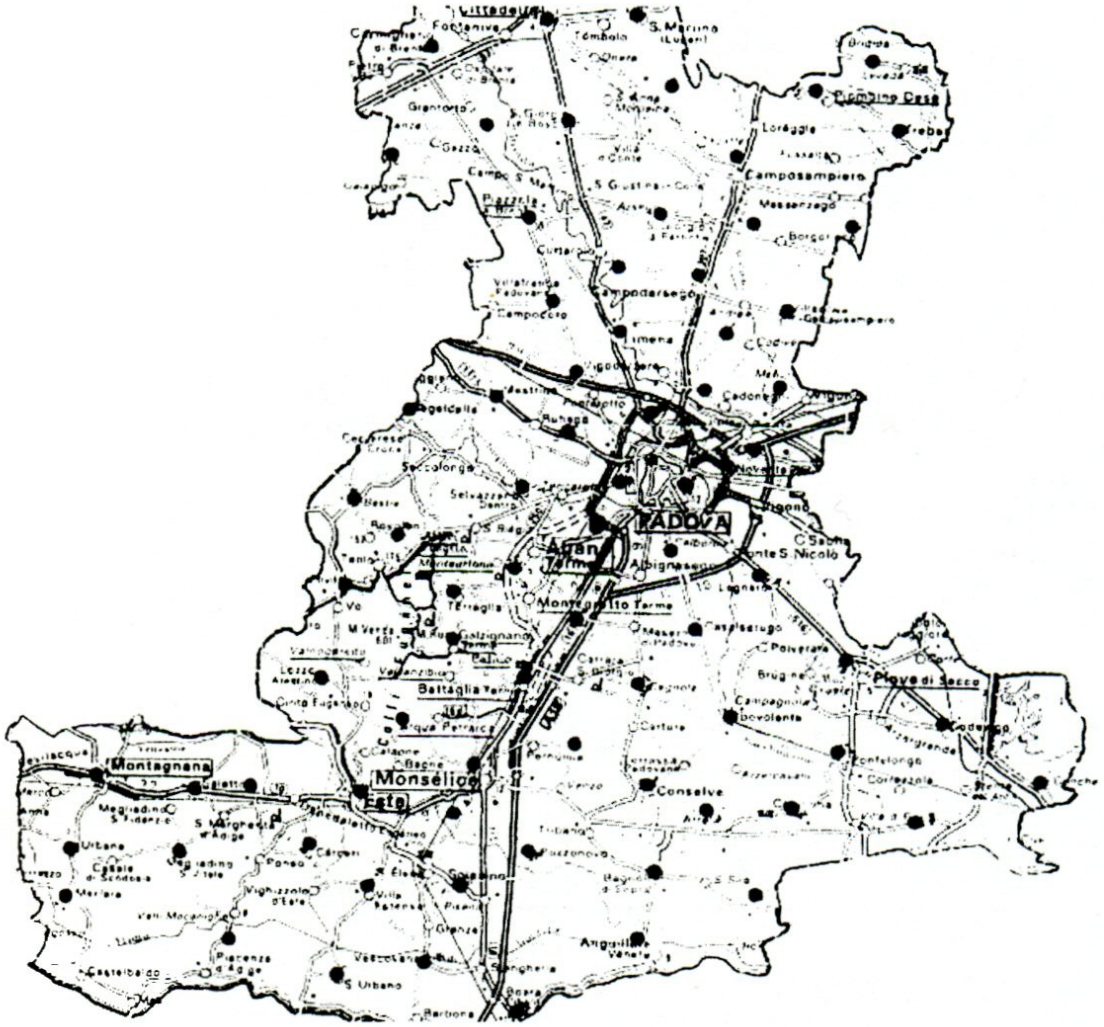


Figure 5. Location of lichen biomonitoring sampling sites (solid dots) selected according to preferential sampling in the province of Padova (Veneto Region, NE Italy) (after [72]). Note how sites tend to be located near settlements and motorways.

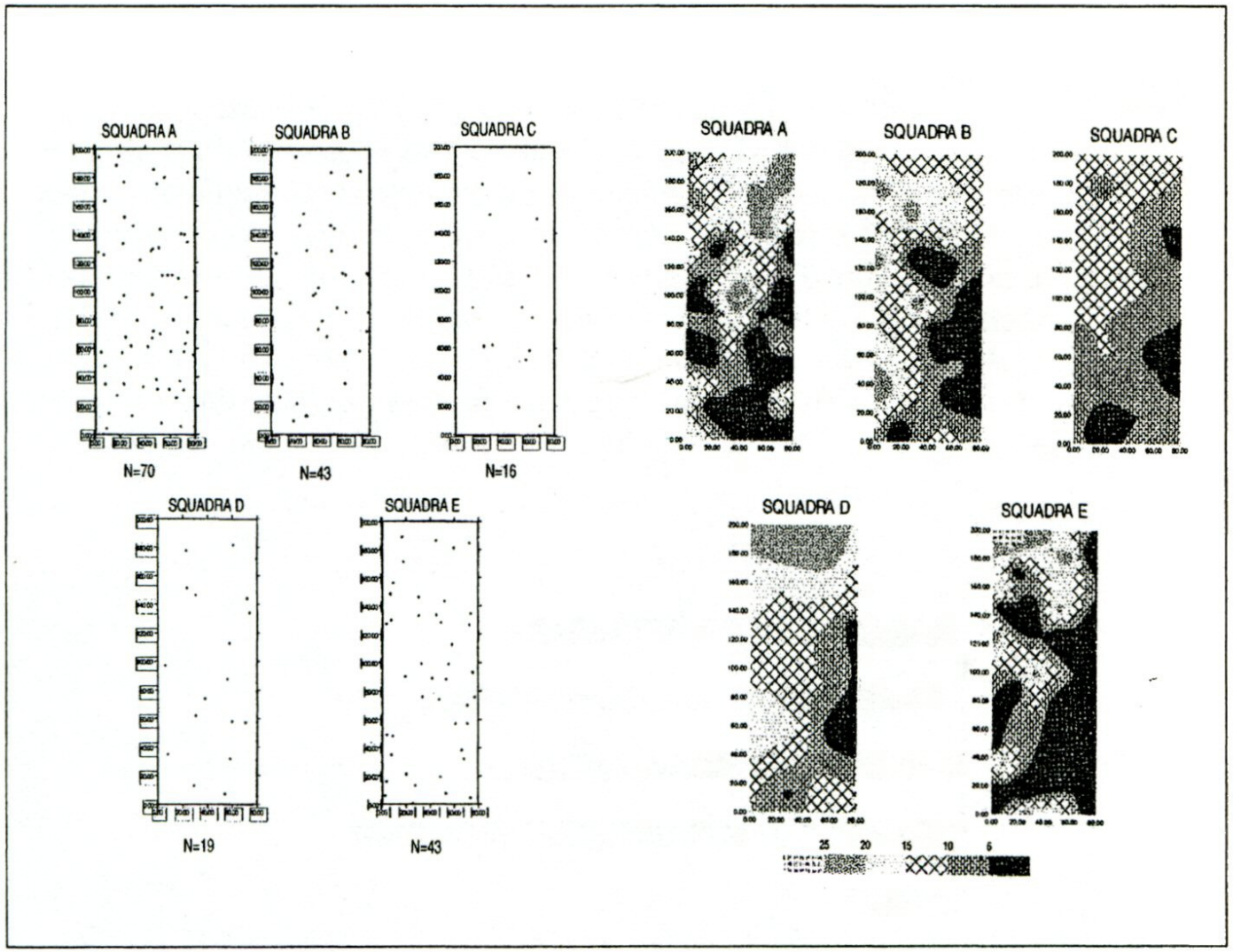
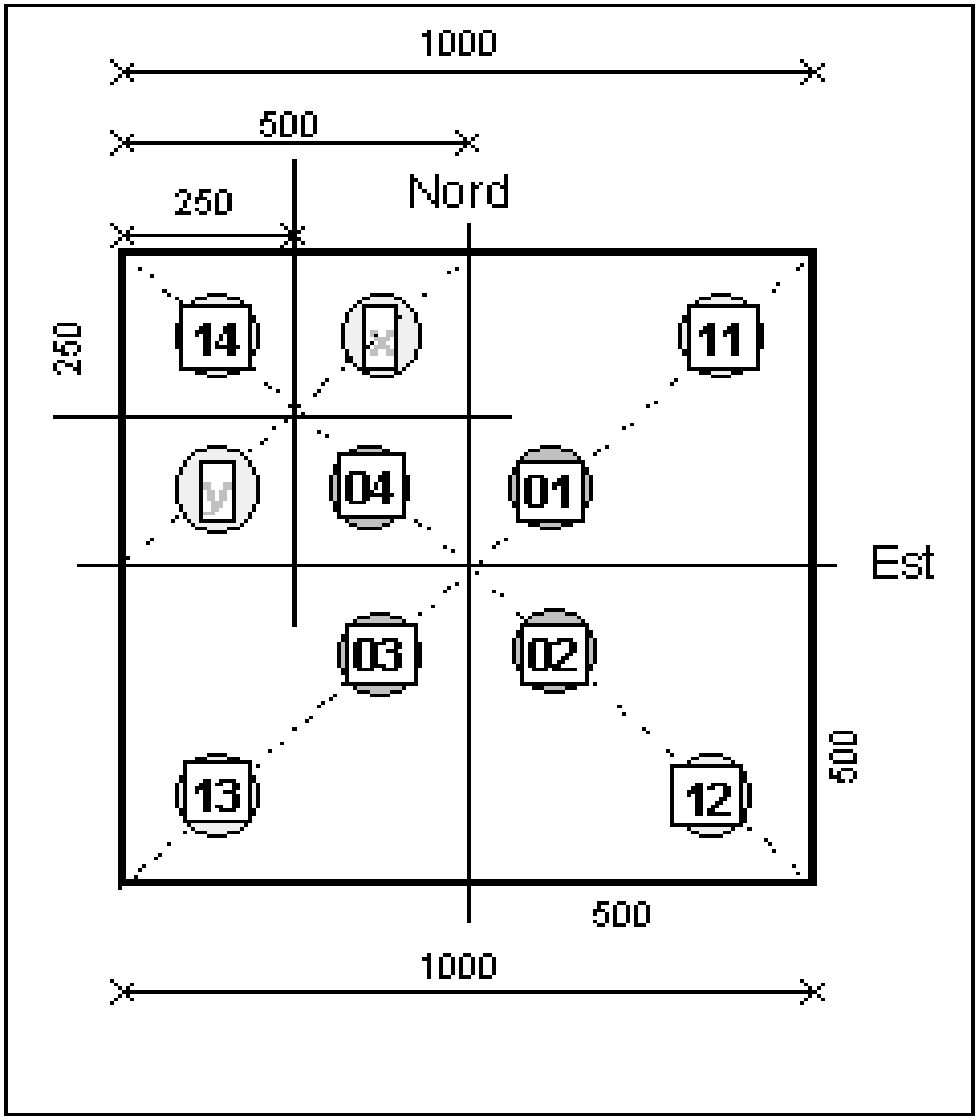


Figure 4. Sampling sites (left) and resulting lichen diversity maps (right) obtained from 5 field crews (A, B, C, D, E) operating indipendently in the same area with the same methodology (after Roella et al. *[88]).*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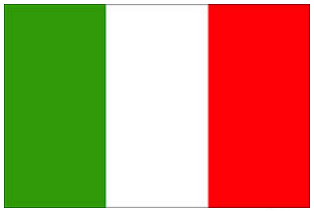
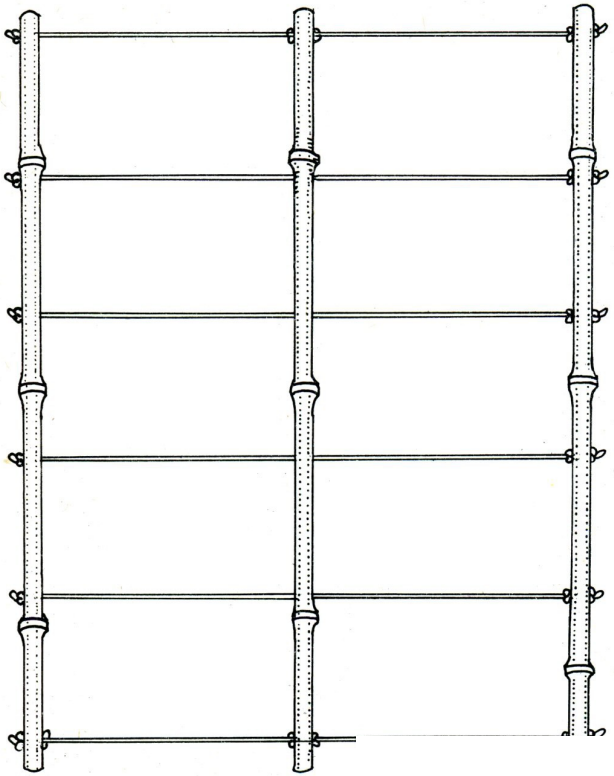
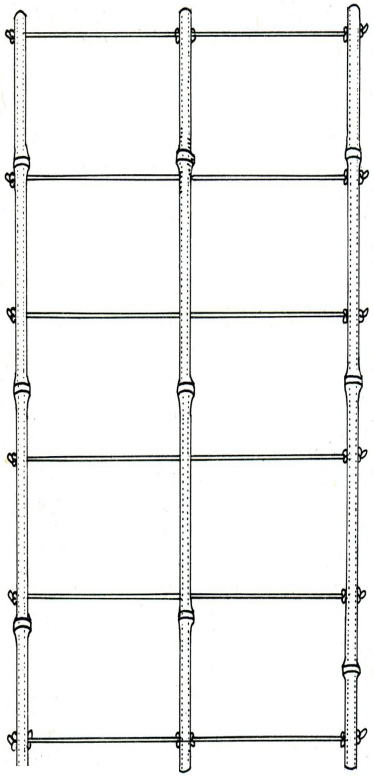
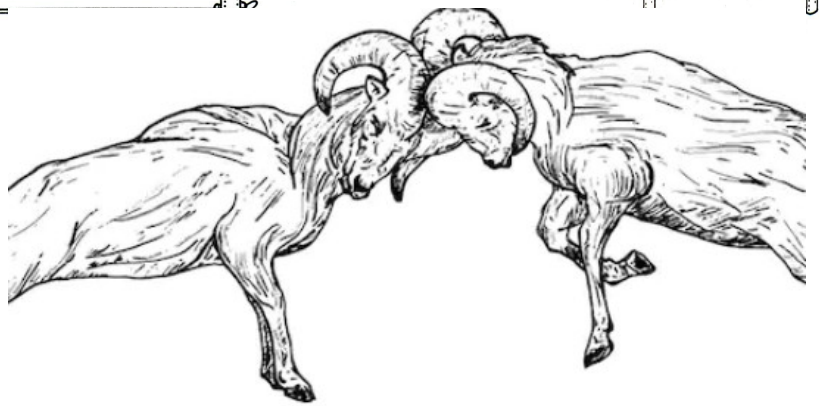








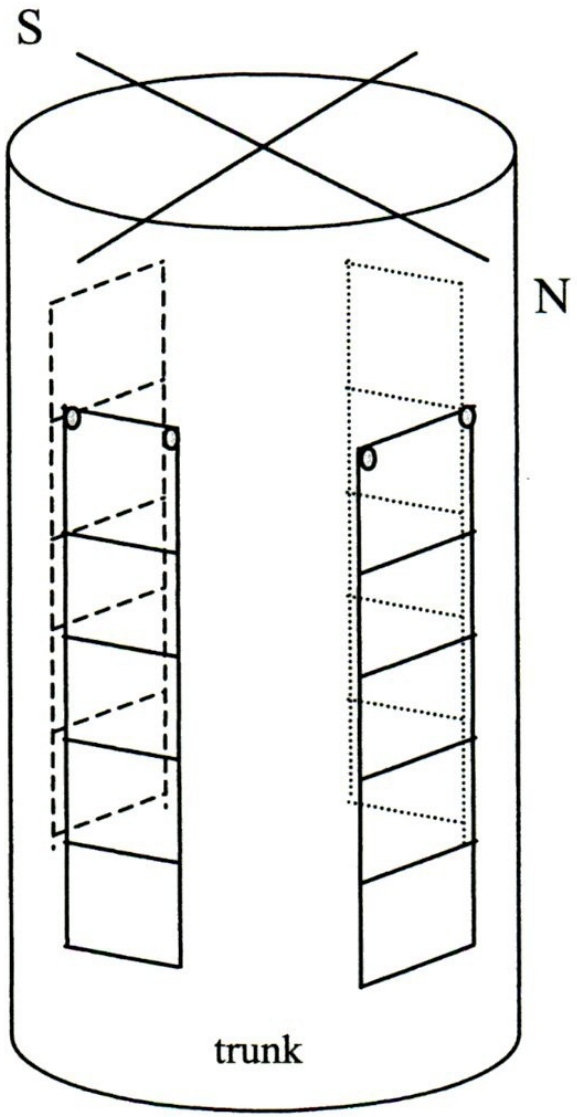


Figure 3. Sampling grid composed of four ladders each with 5 contiguous quadrats.

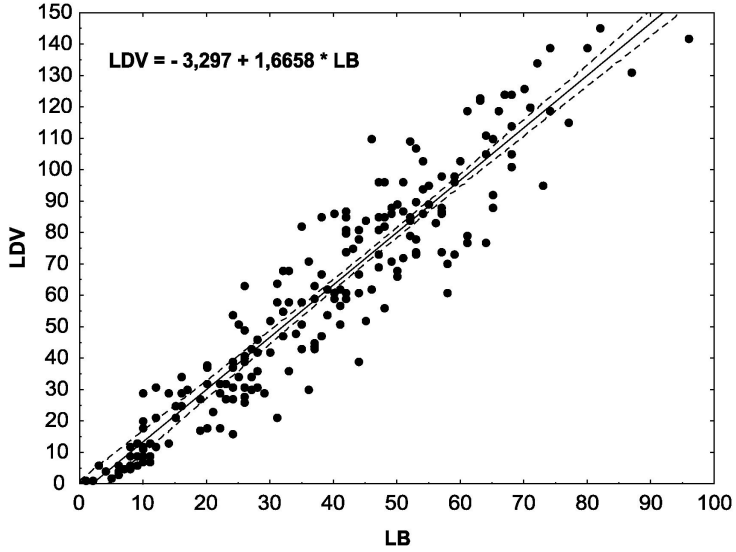


Fig. 2. Correlation between LB and LDV values of the 214 investigated trees. Dotted lines represent 95% confidence interval.

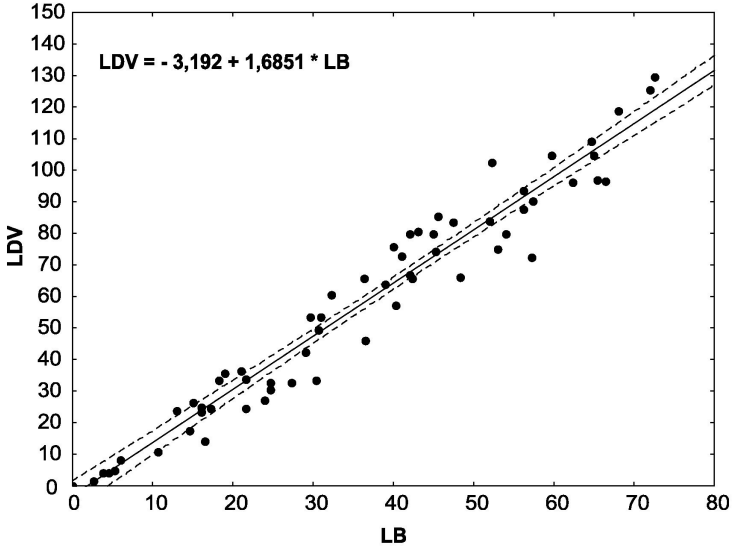


Fig. 3. Correlation between LB and LDV values of the 61 sampling sites. Dotted lines represent 95% confidence interval.

ANPA
Agenzia Nazionale per la Protezione dell'Ambiente

I.B.L. Indice di Biodiversità Lichenica

Manuale ANPA

2 / 2001

MANUALI E LINEE GUIDA

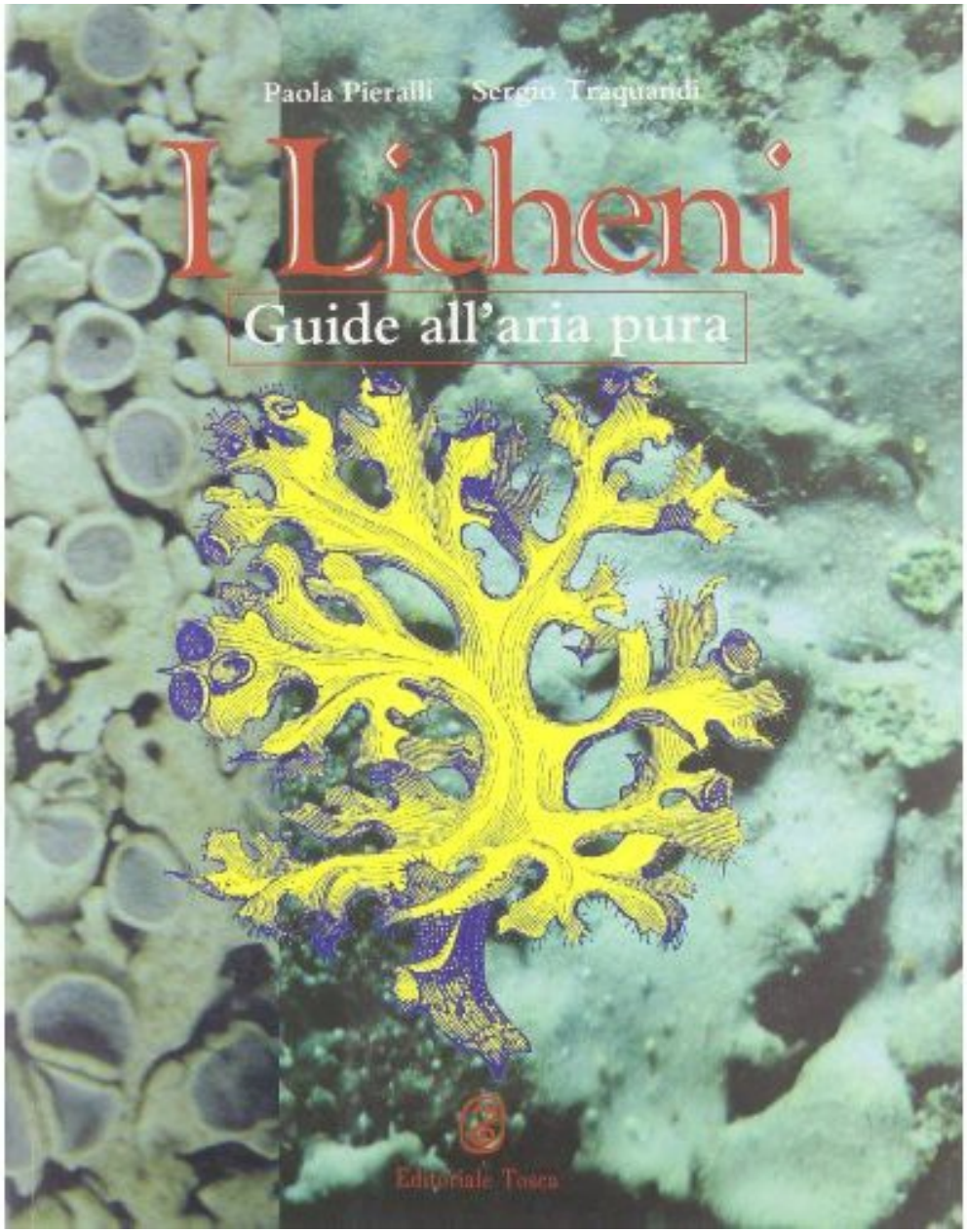
bsi.

12/30258220 DC

Category: Environment and health protection. safety

BS EN 16413
Air quality
Biomonitoring with lichens
Assessing epiphytic lichen diversity
Radioactive sources, Emission, Air, Quality, Musci, Air pollution, Samples

Identical standards:	prEN 16413:2012 Identical
Release date:	11-04-2012
In stock:	Yes
Delivery format:	pdf, hardcopy
Price:	£ 20.00


Paola Pieralli Sergio Traquandi
I Licheni
Guide all'aria pura
Editoriale Tosca

Primo Piano 47

I dati forniti nel 2007 dalla centrale per ottenere l'Autorizzazione integrata ambientale

"Avvelenati dai metalli pesanti"

La Rete fermiamo il carbone definisce molto preoccupanti i risultati del biomonitoraggio di Tirreno Power

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arci ambiente — arcireport 7

Nelle aree interessate dalle emissioni della centrale a carbone si muore di più

Si è visto negli articoli precedenti come la Regione Liguria abbia deciso di rilasciare l'intesa per un nuovo gruppo a carbone da 460 MW nella centrale di Vado Ligure Quiliano (SV). In seguito nel ... Conferenza in riferimento agli elementi sopra riportati, rappresentando una versione non conforme a quanto effettivamente disquisito in merito» e ar... superiori rispetto ai riferimenti normativi, indica una molto probabile derivazione di tali inquinanti dalla centrale a carbone, che

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LA STAMPA MERCOLEDÌ 12 MARZO 2014 Cronache 17

CINQUE INDAGATI PER DISASTRO AMBIENTALE E SANITARIO

"Troppi morti per il carbone" Il gip spegne la centrale di Vado

Savona, 400 operai rischiano il posto. L'azienda: i nostri legali al lavoro

MARCO RAFFA
CLAUDIO VIMERCATI
SAVONA

La Procura di Savona spegne la centrale elettrica Tirreno Power di Vado Ligure. Ieri il giudice delle indagini preliminari Fiorenza Giorgi ha accol-

Le operazioni

1 ... 2 ... 3 Il raffreddamento

L'impianto sequestrato

Centrale elettrica a carbone Tirreno Power
Entrata in servizio: 1971
Potenza: due unità da 330 MW ciascuna

Genova, La Spezia, Savona, Imperia, Vado Ligure (Sv)

L'INCHIESTA

La procura di Savona indaga per disastro ambientale e per omicidio colposo

Tra il 2000 e il 2007
442 le persone morte a causa dei fumi

Tra il 2005 e il 2012
1.700 i ricoveri di adulti
2.000 per malattie respiratorie e cardiovascolari
450 i bambini ricoverati per patologie respiratorie

Dopo lo spegnimento delle ... c'è voluta tutta la

Il governatore Burlando

il caso

MARCO RAFFA
SAVONA

Il gip: ora servono indagini sulla carenza di controlli

Nuovo filone d'inchiesta suggerito dal giudice

---

8 IL SECOLO XIX GIOVEDÌ 13 MARZO 2014 radar

LE 45 PAGINE DEL DECRETO DI CHIUSURA DELLA CENTRALE

«A Vado Ligure la politica era complice»

Per i giudici gli organi pubblici «non hanno mai sanzionato i comportamenti dell'azienda»

LE CARTE

La centrale elettrica Tirreno Power di Vado Ligure

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INCOSCIENZA
«Tirreno Power ha reiteratamente ignorato le prescrizioni ambientali»

I RISULTATI DELLA PERIZIA I MILLE MORTI? «ELABORAZIONI GIORNALISTICHE»

Inchiesta Tirreno Power la Procura: "C'è stato un danno per la salute"

Il Procuratore Francantonio Granero

Personaggio

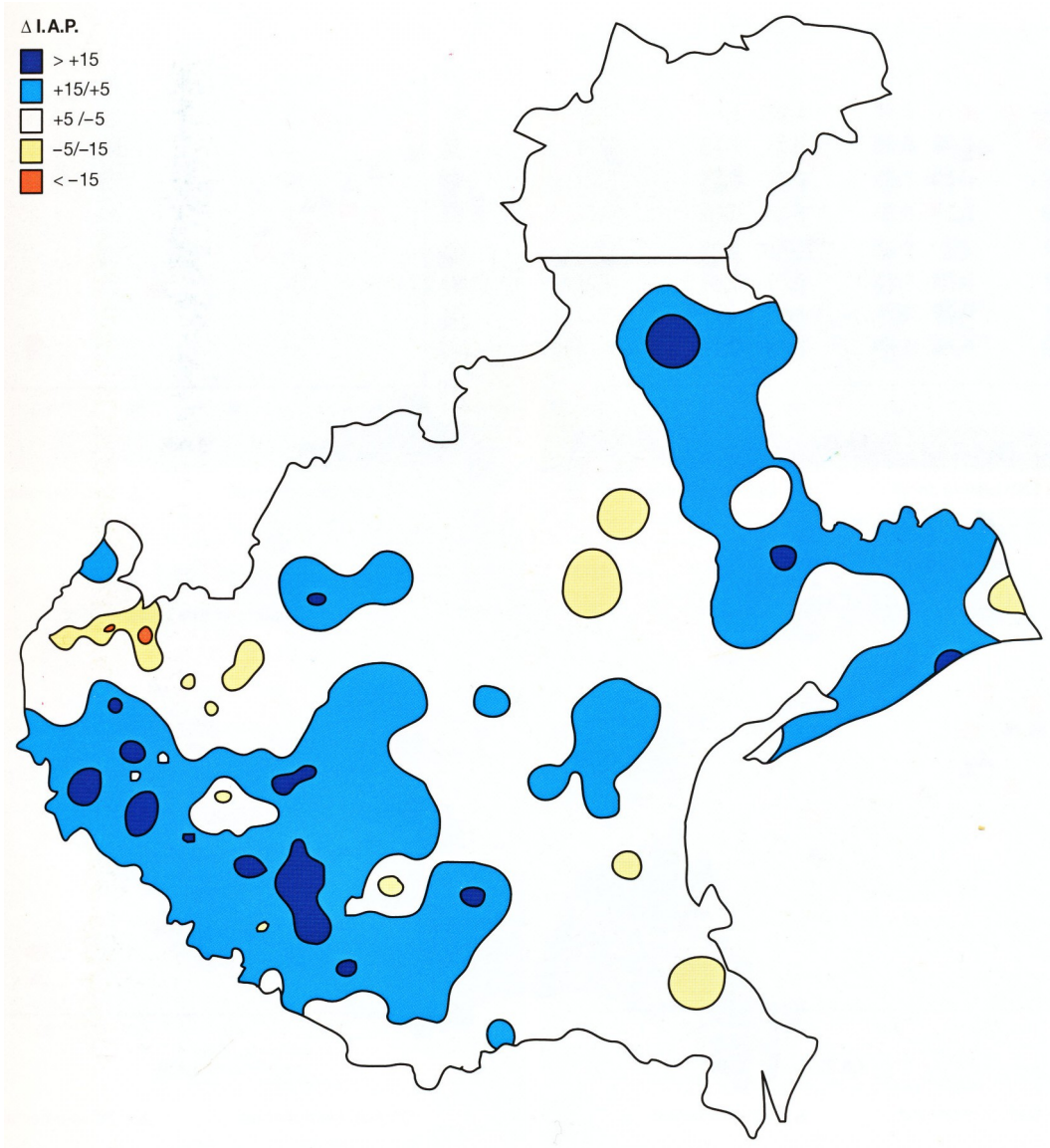
Come all'Ilva di Taranto "Noi magistrati costretti a sostituirci alla politica"

Il giudice: paesaggio rovinato da una mano di grigio

La frase

Il Gip di Savona
Abbiamo supplito alla neghittosità di chi aveva il controllo sulla centrale

Fiorenza Giorgi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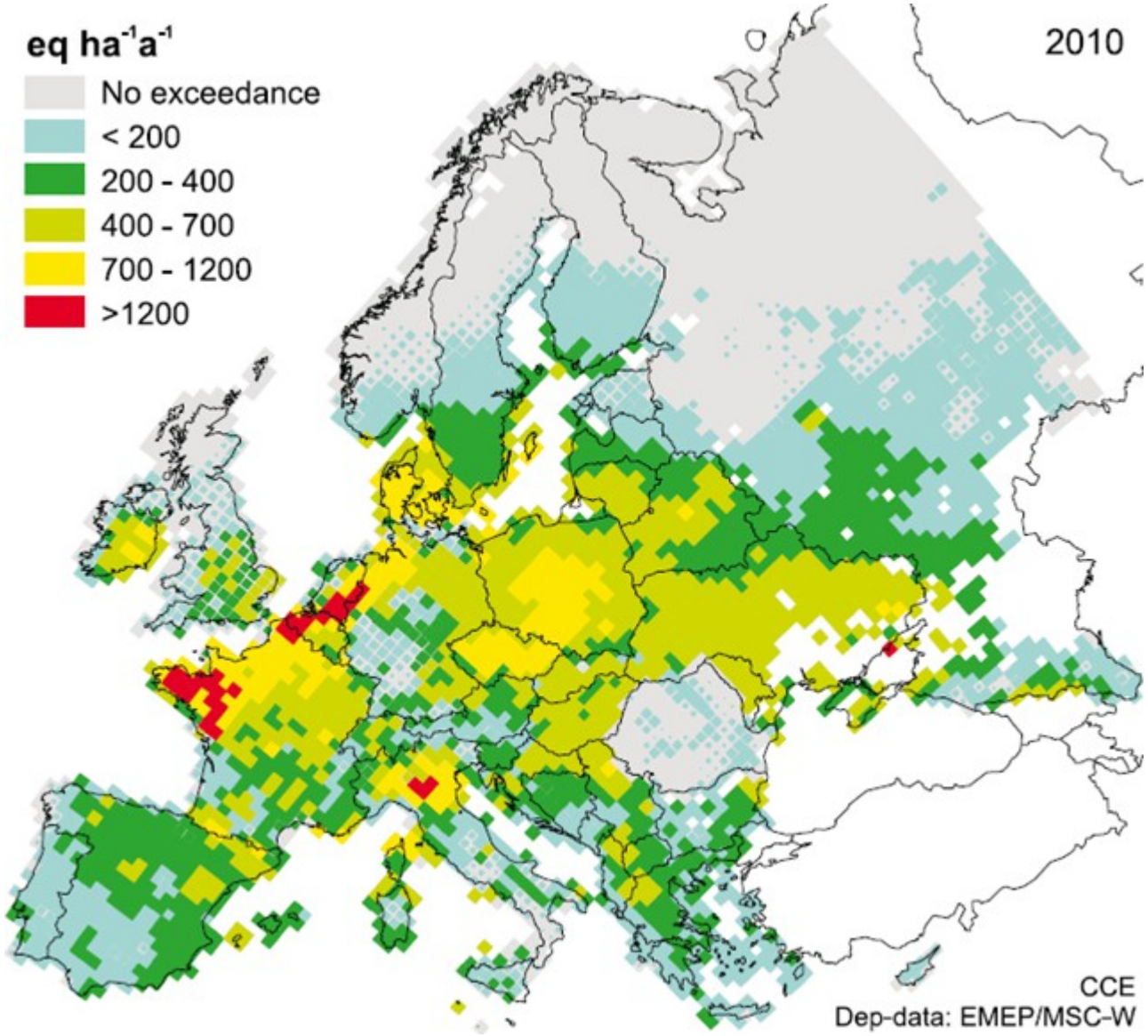
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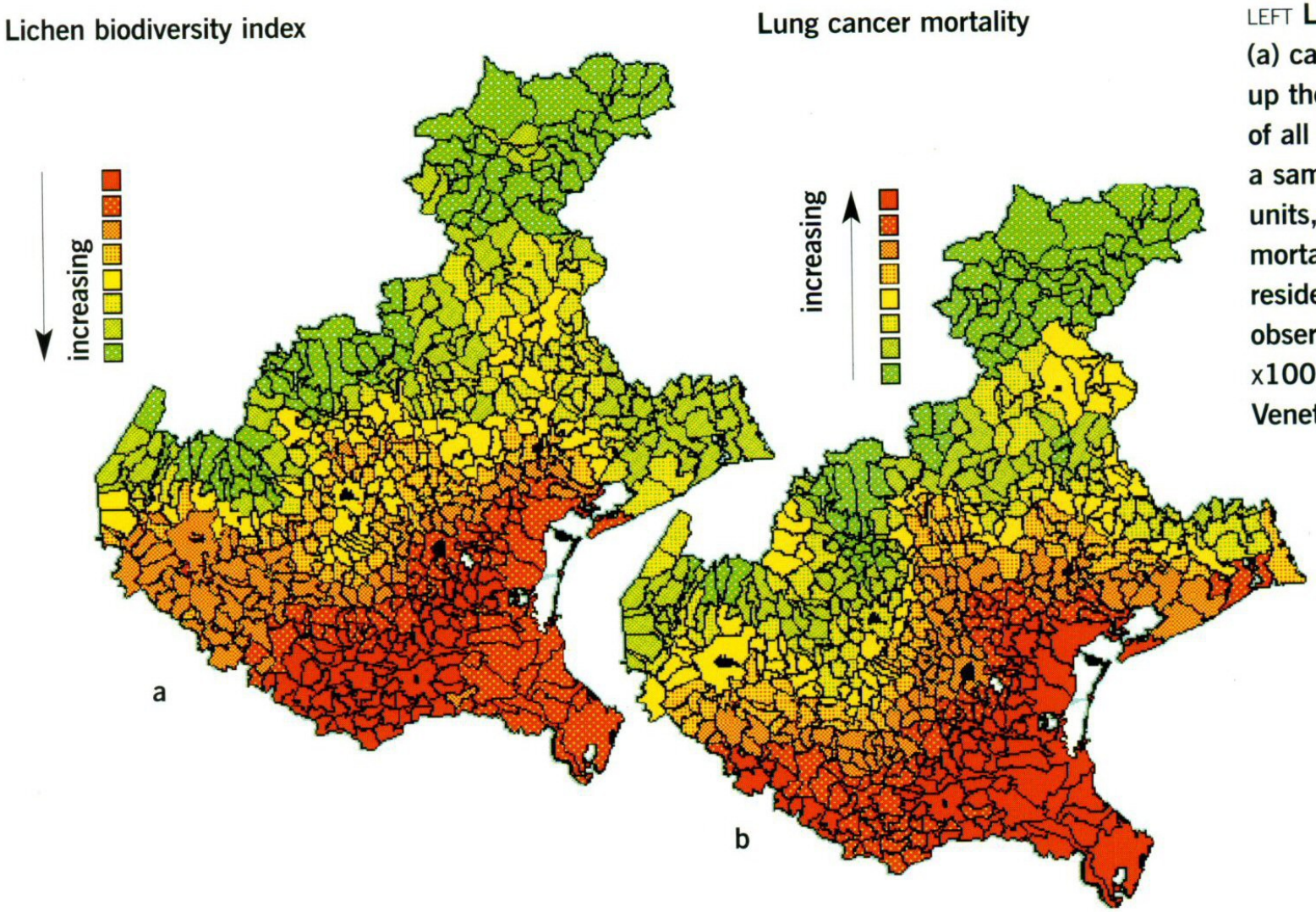
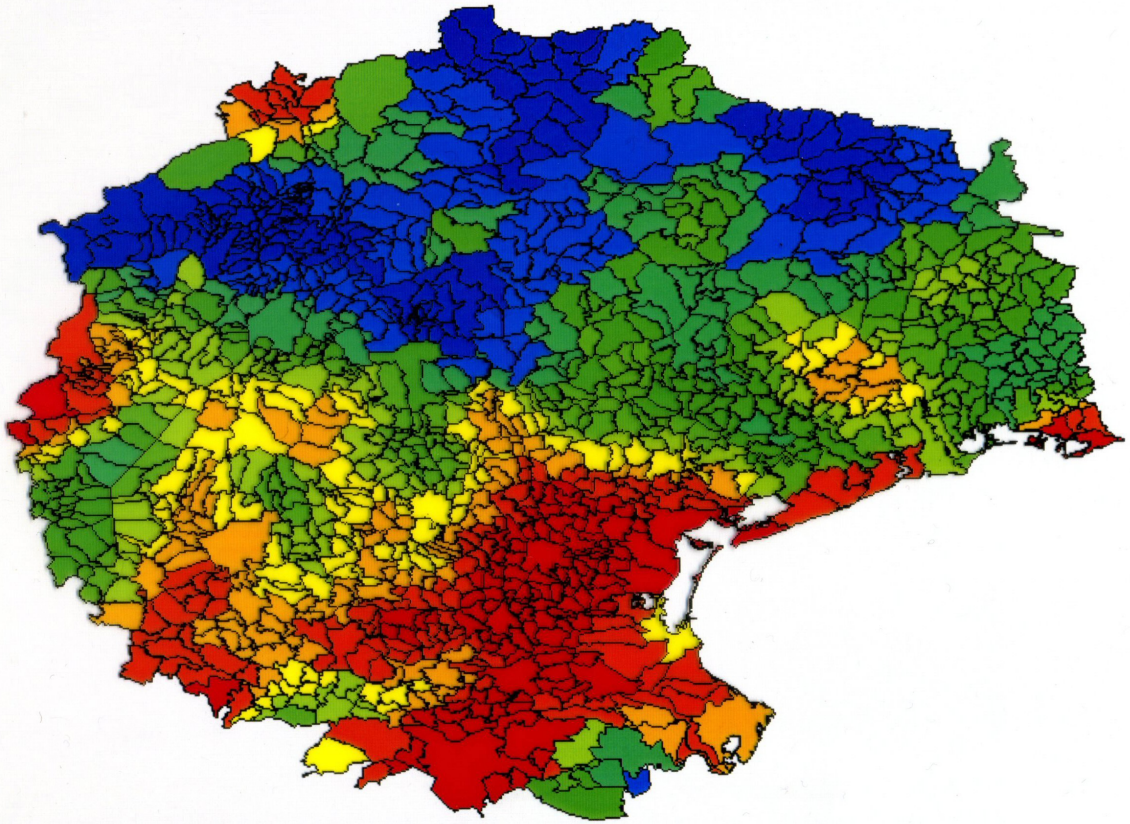


LEFT **Lichen biodiversity (a) calculated by adding up the frequency values of all lichens recorded in a sampling grid of 10 units, and (b) lung cancer mortality in young male residents (expressed as observed/expected cases x100) in the region of Veneto, Italy.**

S.P.M.R. (riferimento comuni del cerchio) , 1981 1982 1983 1984 1985 1986 1987 1988
"Causa di morte: "TUMORE AL POLMONE'
Popolazione maschile nativa, eta' 34-39



S.P.M.R. (riferimento comuni del cerchio) , 1981 1982 1983 1984 1985 1986 1987 1988
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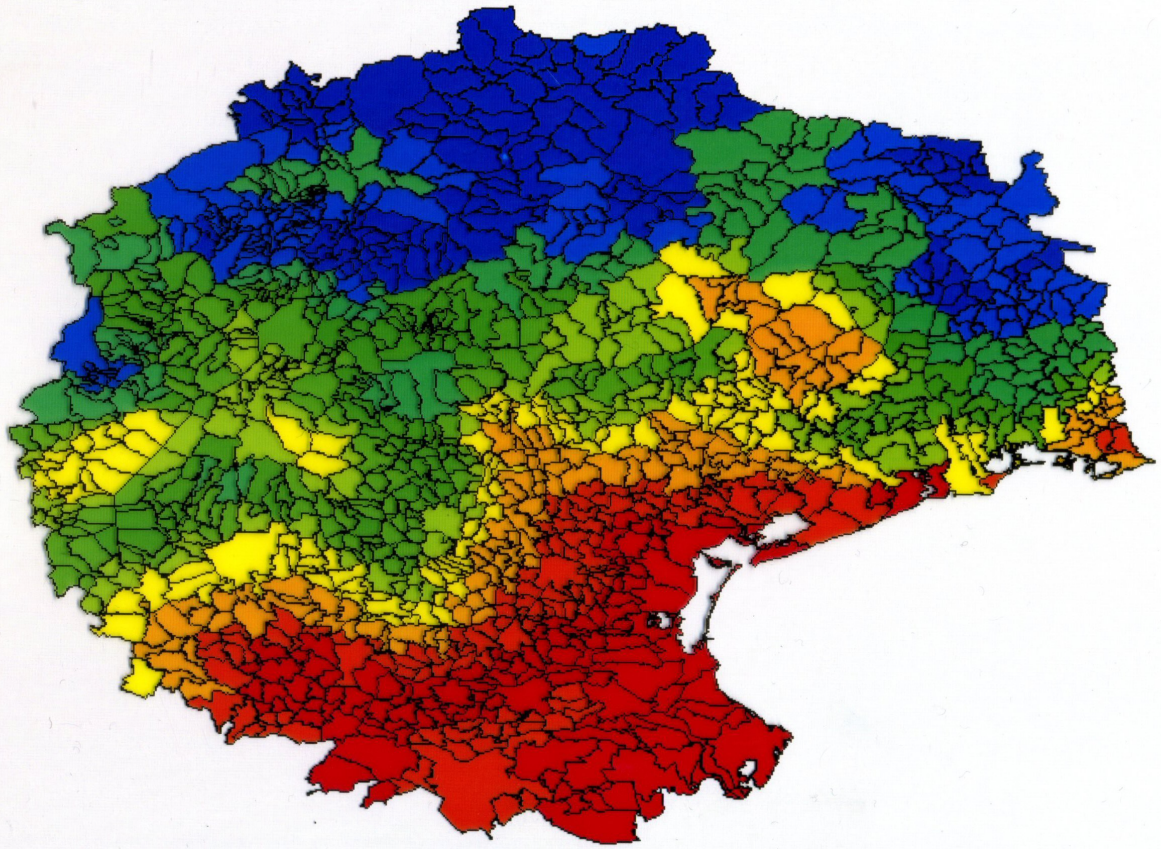
Popolazione maschile nativa, eta' 44-49



S.P.M.R. (riferimento comuni del cerchio), 1981 1982 1983 1984 1985 1986 1987 1988
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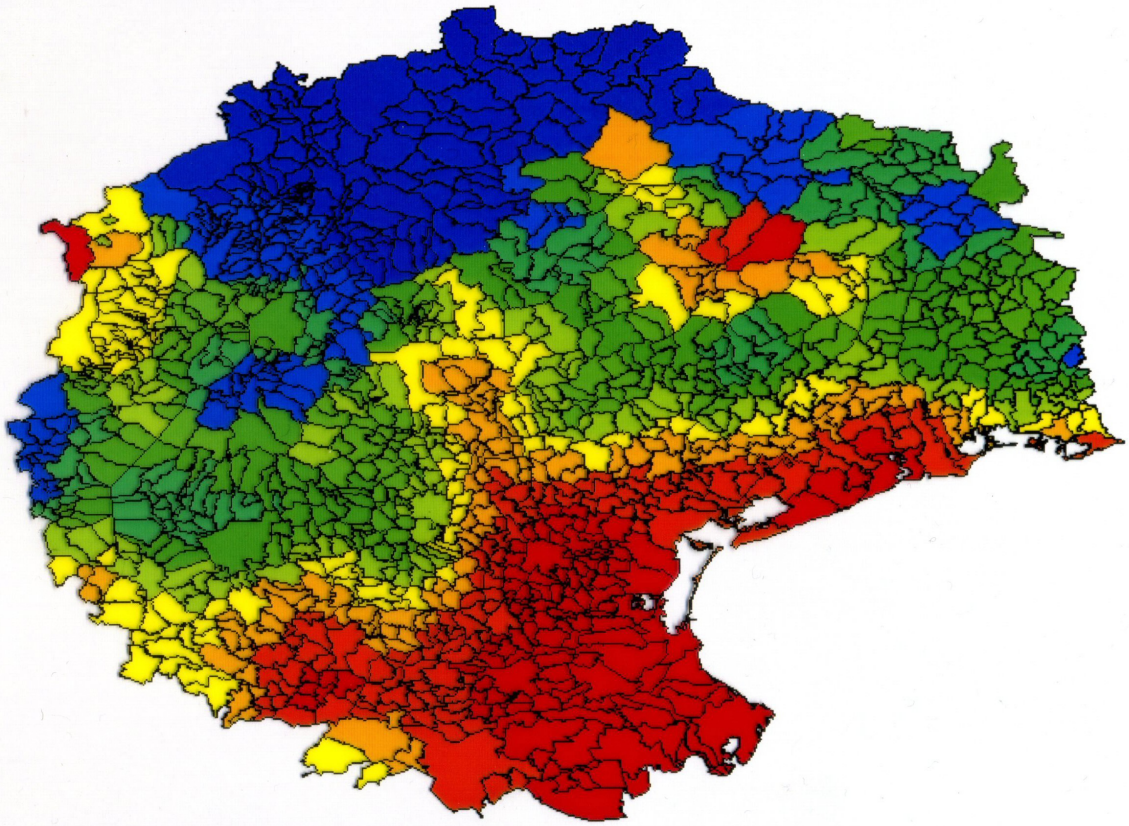
Popolazione maschile nativa, eta' 54-59



S.P.M.R. (riferimento comuni del cerchio) , 1981 1982 1983 1984 1985 1986 1987 1988
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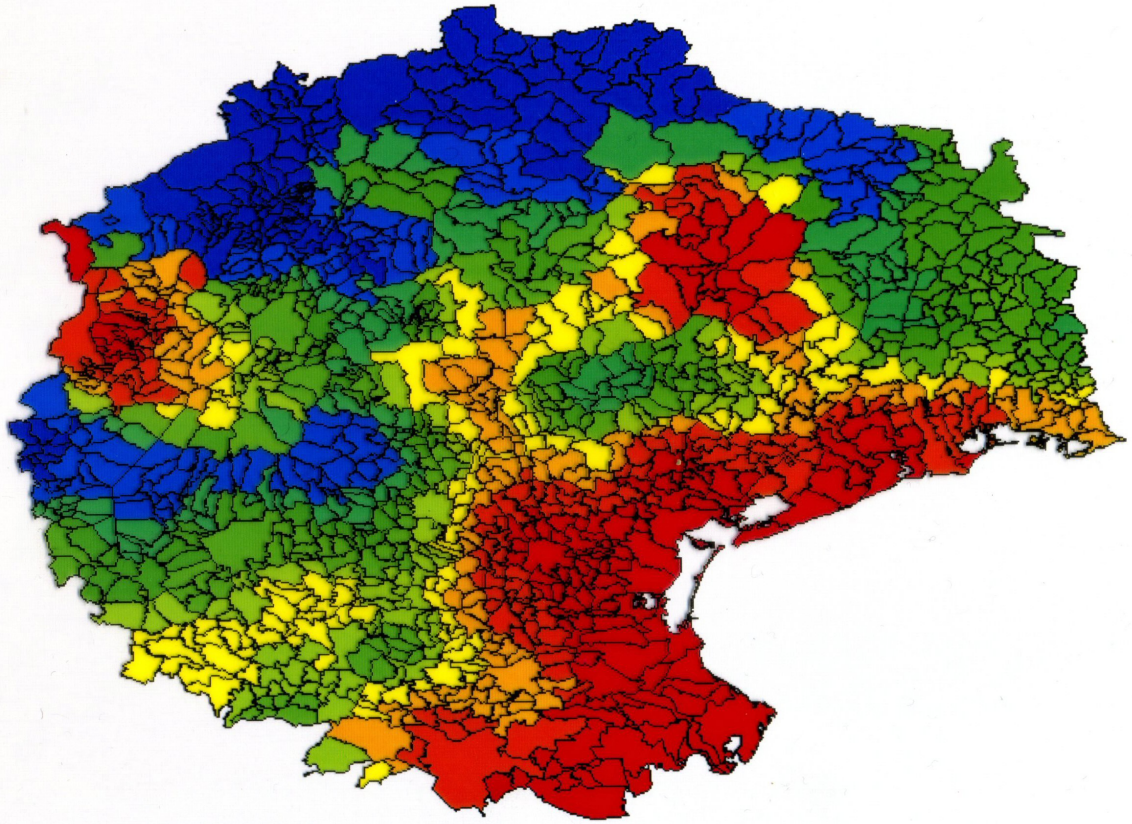
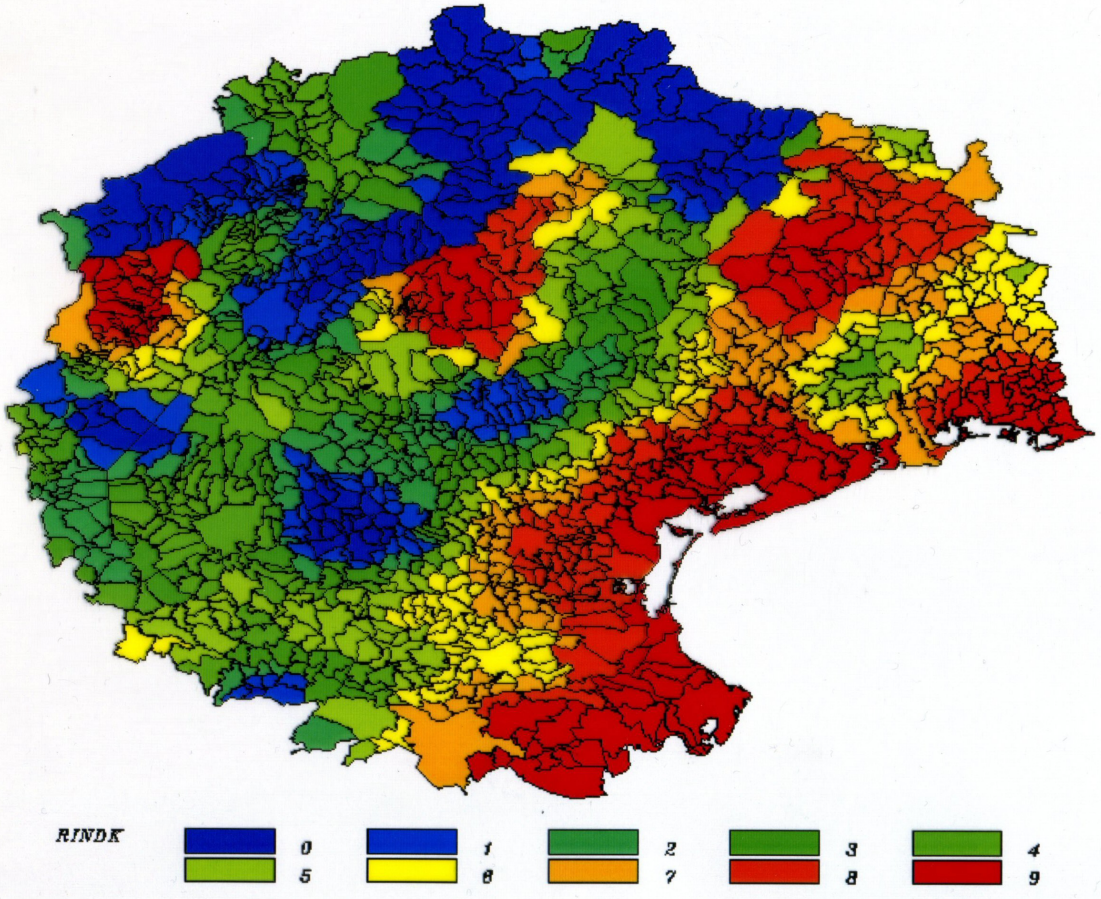
Popolazione maschile nativa, eta' 64-69



S.P.M.R. (riferimento comuni del cerchio), 1981 1982 1983 1984 1985 1986 1987 1988
"Causa di morte: "TUMORE AL POLMONE"
Popolazione maschile nativa, eta' 74-110



BIOMONITORAGGIO DI METALLI IN TRACCIA TRAMITE LICHENI IN AREE A RISCHIO DEL FRIULI-VENEZIA GIULIA

Pier Luigi NIMIS, Nicola SKERT e Miris CASTELLO

Dipartimento di Biologia, Università di Trieste, via L. Giorgieri 10, I-34127 Trieste

Keywords: biomonitoring, Friuli-Venezia Giulia, Italy, lichens, pollution, trace metals.

Abstract: BIOMONITORING OF TRACE METALS BY LICHENS IN HIGH-RISK AREAS OF FRIULI-VENEZIA GIULIA (NE ITALY). This study is based on the concentrations of 16 metals in peripheral parts of the thalli of the lichen *Xanthoria parietina*, collected on trees satisfying standard conditions in 155 stations located in the lowlands of Friuli-Venezia Giulia (NE Italy), previously selected as potential high-risk areas by Regional Authorities. The interpretation of metal concentrations is based upon two maps, showing, for each metal, its distributional pattern and the degree of deviation from background (natural) conditions. The latter has been estimated through a seven-class scale based on the percentile distributions of several hundreds measurements of metal concentrations carried out in foliose lichens throughout Italy during the last ten years, using similar methods. The joint occurrences of all metals in the stations are synthetized by maps based on three indices, an index of naturality (indicating the number of metals with concentrations within normal conditions), an index of environmental alteration (indicating the number of metals strongly deviating from the norm), and an index of potential toxicity (derived from that of alteration, with each metal weighed according to its toxicity). The central-southern part of the Province of Udine is the most severely affected by metals in general, while in several other stations single metals strongly deviate from normal conditions. These sites are suggested to the Regional Authorities as focal points for instrumental monitoring of environmental pollution. The introduction includes some basic considerations about epistemological, methodological and terminological matters related to the use of biomonitoring techniques.

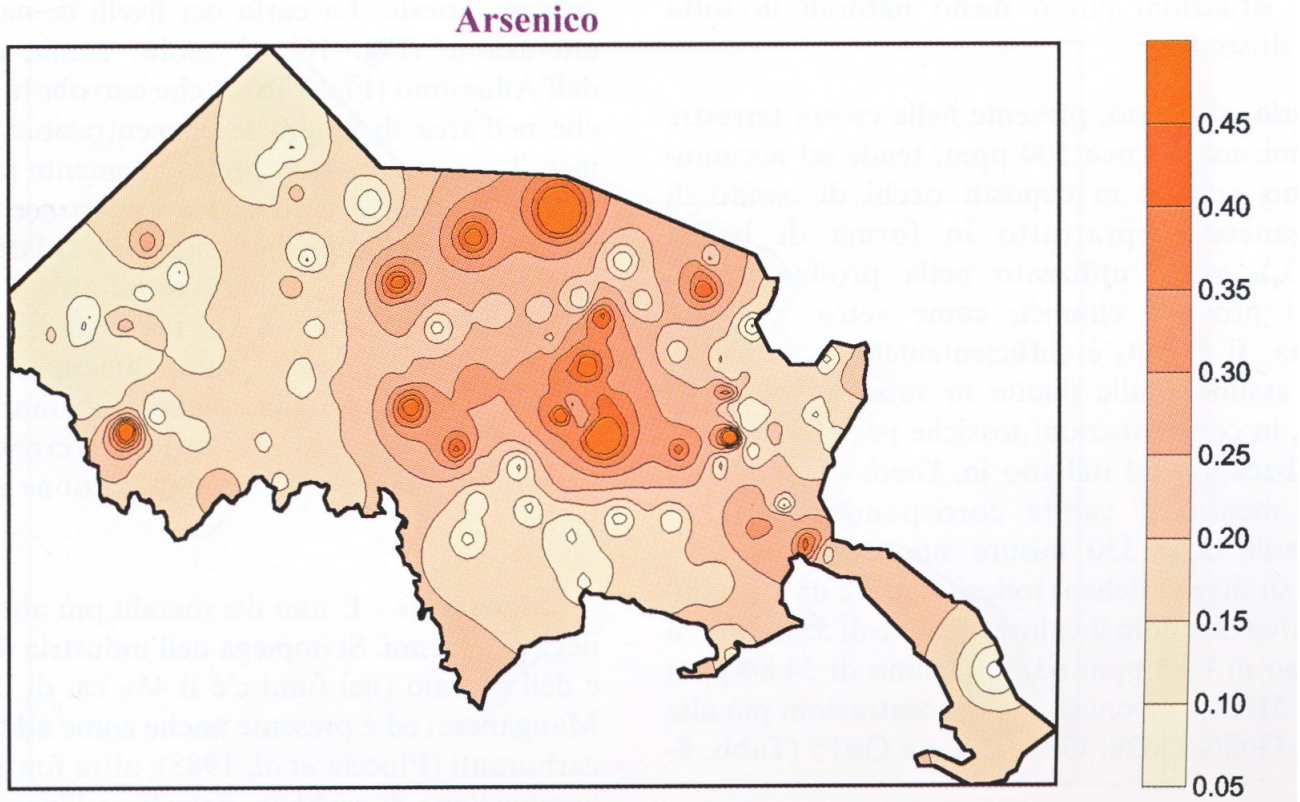
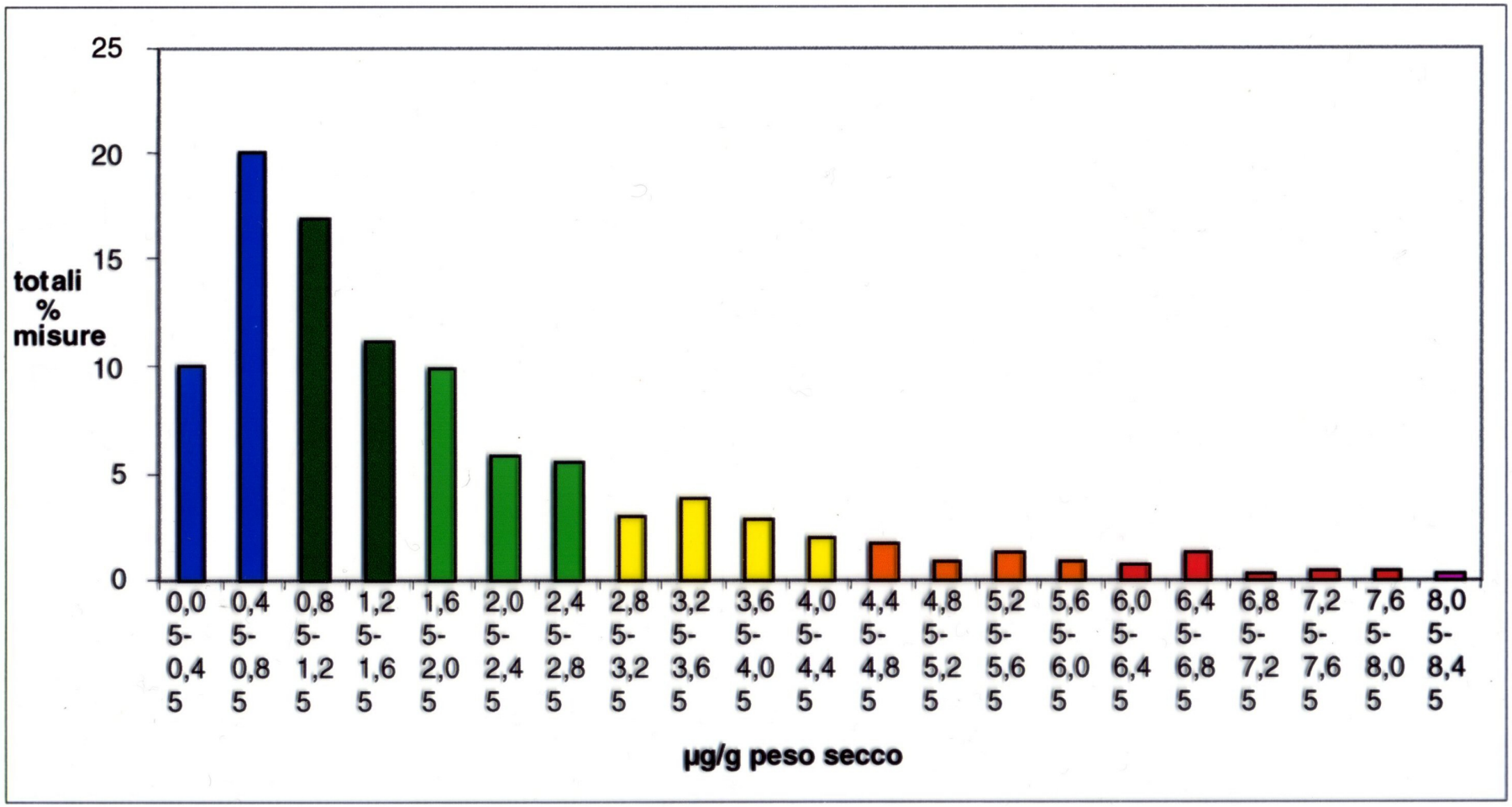


Fig. 14a - Carta delle concentrazioni di As nei talli lichenici (ppm).
Map of the concentrations of As in lichen thalli (ppm).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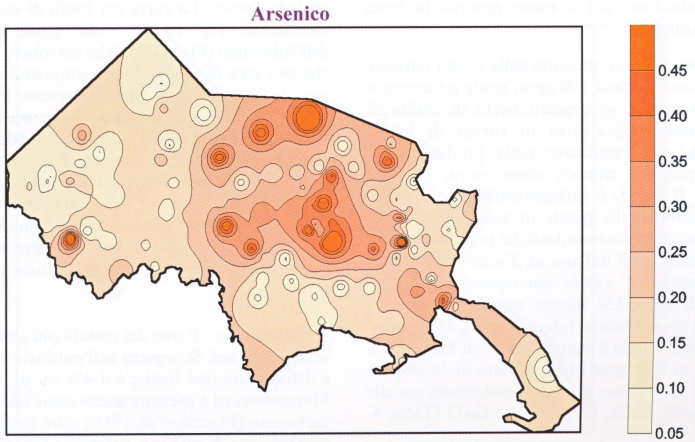
µg/g peso secco



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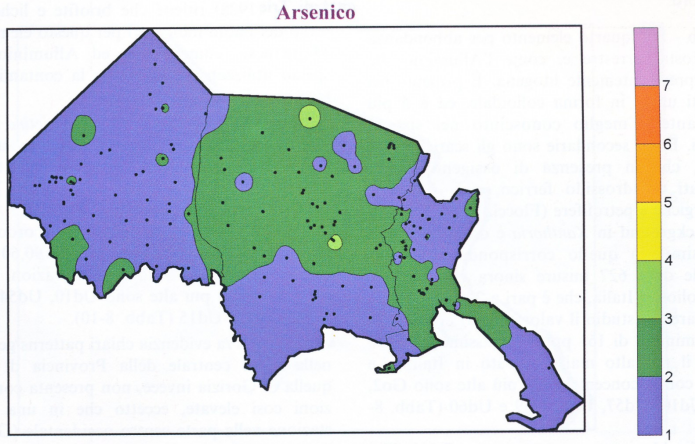

Fig. 14b - Carta dei livelli di naturalità/alterazione di As (v. Tab.1).
Map of the levels of naturality/alteration of As (see Tab.1).

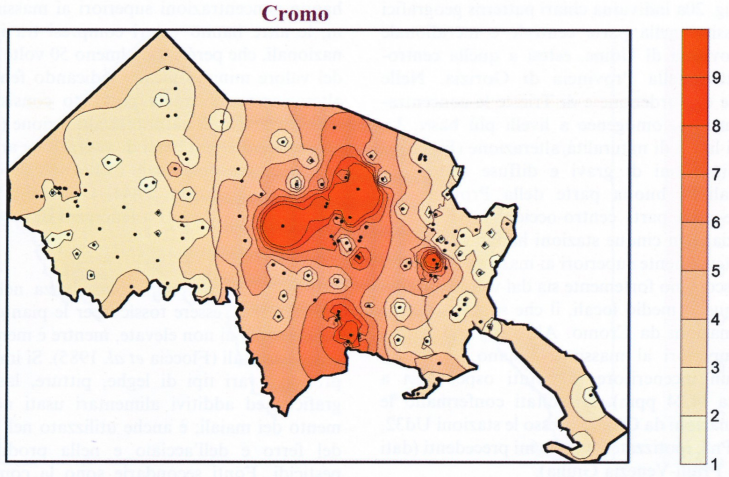

Fig. 20a - Carta delle concentrazioni di Cr nei talli lichenici (ppm).
Map of the concentrations of Cr in lichen thalli (ppm).

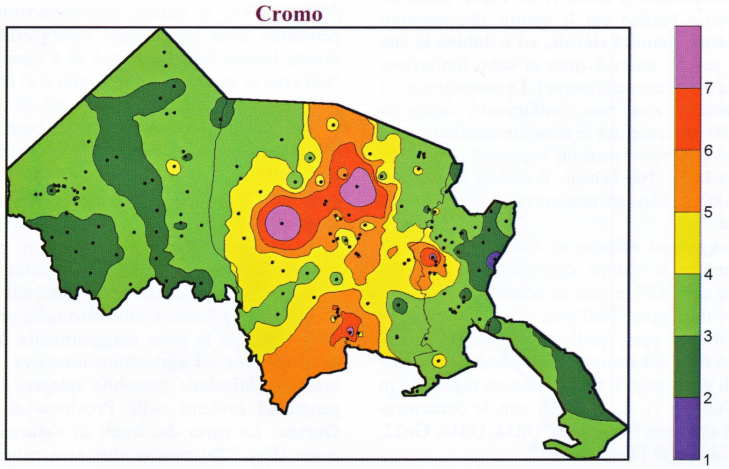

Fig. 20b - Carta dei livelli di naturalità/alterazione di Cr (v. Tab. 1).
Map of the levels of naturality/alteration of Cr (see Tab.1).


Thank you for
the attention!