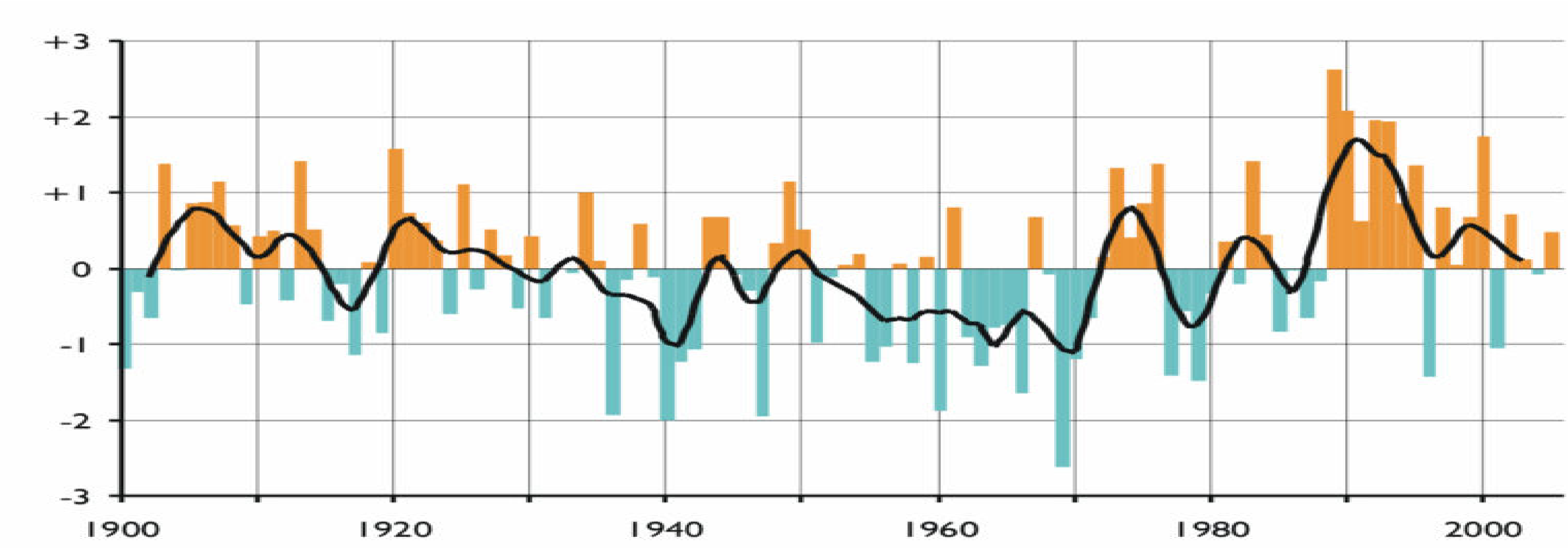
GLI INDICI E LA REALTÀ ITALIANA
2. MACROFITE

INDICI DI QUALITÀ PER LA COMUNITÀ MACROFITICA



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Gli indici per i laghi

- **Indice AMCI** **(Aquatic Macrophyte Community Index)** — Deppe *et al.* 1992 Res Manag; Nichols *et al.* 2000 Env Manag
- **Macrophyte Index** — Melzer 1999 Hydrobiologia
- **Reference Index** — Schaumburg *et al.* 2007
- **PLEX** **(Plant Lake Ecotype Index)** — Duigan *et al.* 2006
- **AIM** **(Austrian Index Macrophytes)** — Pall *et al.* 2009
- **MacroIMMI e MTI**

Gli indici per i laghi

Indice AMCI

A Proposed Aquatic Plant Community Biotic Index for Wisconsin Lakes

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ABSTRACT / The Aquatic Macrophyte Community Index (AMCI) is a multipurpose tool developed to assess the biological quality of aquatic plant communities in lakes. It can be used to specifically analyze aquatic plant communities or as part of a multimetric system to assess overall lake quality for regulatory, planning, management, educational, or research purposes. The components of the index are maximum depth of plant growth; percentage of the littoral zone vegetated; Simpson's diversity index; the relative frequencies of submersed, sensitive, and exotic species; and taxa number. Each parameter was scaled based on data distributions from a statewide database, and scaled values were totaled for the AMCI value. AMCI values were grouped and tested by ecoregion and lake type (natural lakes and impoundments) to define quality on a regional basis. This analysis suggested that aquatic plant communities are divided into four groups: (1) Northern Lakes and Forests lakes and impoundments, (2) North-Central Hardwood Forests lakes and impoundments, (3) Southeastern Wisconsin Till Plains lakes, and (4) Southeastern Wisconsin Till Plains impoundments, Driftless Area Lakes, and Mississippi River Backwater lakes. AMCI values decline from group 1 to group 4 and reflect general water quality and human use trends in Wisconsin. The upper quartile of AMCI values in any region are the highest quality or benchmark plant communities. The interquartile range consists of normally impacted communities for the region and the lower quartile contains severely impacted or degraded plant communities. When AMCI values were applied to case studies, the values reflected known impacts to the lakes. However, quality criteria cannot be used uncritically, especially in lakes that initially have low nutrient levels.

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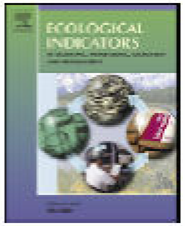

ELSEVIER

Indice AMCI

Development of a macrophyte-based index of biotic integrity for Minnesota lakes

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ABSTRACT

Traditional approaches for managing aquatic resources have often failed to account for effects of anthropogenic disturbances on biota that are not directly reflected by chemical and physical proxies of environmental condition. The index of biotic integrity (IBI) is a potentially effective assessment method to integrate ecological, functional, and structural aspects of aquatic systems. A macrophyte-based IBI was developed for Minnesota lakes to assess the ability of aquatic plant communities to indicate environmental condition. The index was developed using quantitative point intercept vegetation surveys for 97 lakes that represent a range of limnological and watershed characteristics. We followed an approach similar to that used in Wisconsin to develop the aquatic macrophyte community index (AMCI). Regional adaptation of the AMCI required the identification of species representative of macrophyte communities in Minnesota. Metrics and scaling methods were also substantially modified to produce a more empirically robust index. Regression analyses indicated that IBI scores reflected statewide differences in lake trophic state ($R^2 = 0.57$, $F = 130.3$, df = 1, 95, $p < 0.005$), agricultural ($R^2 = 0.51$, $F = 83.0$, df = 1, 79, $p < 0.005$), urban ($R^2 = 0.22$, $F = 23.0$, df = 1, 79, $p < 0.005$), and forested land uses ($R^2 = 0.51$, $F = 84.7$, df = 1, 79, $p < 0.005$), and county population density ($R^2 = 0.14$, $F = 16.6$, df = 1, 95, $p < 0.005$). Variance partitioning analyses using multiple regression models indicated a unique response of the IBI to human-induced stress separate from a response to natural lake characteristics. The IBI was minimally affected by differences in sample point density as indicated by Monte Carlo analyses of reduced sampling effort. Our analysis indicates that a macrophyte IBI calibrated for Minnesota lakes could be useful for identifying differences in environmental condition attributed to human-induced stress gradients.

Gli indici per i laghi

Macrophyte Index

0-1 m
1-2 m
2-4 m
> 4 m

Specie radicate flottanti, flottanti e sommerse.

Hydrobiologia **395/396**: 181–190, 1999.
D.M. Harper, B. Brierley, A.J.D. Ferguson & G. Phillips (eds), The Ecological Bases for Lake and Reservoir Management.

Aquatic macrophytes as tools for lake management

Arnulf Melzer

Abstract

Aquatic macrophytes can serve as useful indicators of water pollution along the littoral of lakes. In Bavaria, the submerged vegetation of about 100 lakes has been investigated by SCUBA diving over the past decade to evaluate the state of nutrient pollution. All lakes are marl lakes located in the northern calcareous alps and the prealpine region. The lakes differ in size, morphology, water residence time, nutrient loading, trophic status, recreational activities, and other characteristics. In all cases the entire shoreline of the lakes has been investigated. Among the investigated lakes are the three biggest Bavarian lakes, i.e. Lake Chiemsee, Lake Starnberg and Lake Ammersee. Mapping of the submerged vegetation occurred in four different depth zones, and variable shoreline sections. The length of each section was determined by the uniformity of the vegetation; as it changed, a new section was designated. Within each section and zone species were recorded and abundance of all observed macrophytes was estimated semi-quantitatively on a five-point scale. Nine different groups of macrophytes were recognised, including, in total, 45 different species of macrophytes. On the basis of this catalogue of indicator species, in combination with the abundance of the species, a 'macrophyte index' was devised, which ranges from 1 (unpolluted) to 5 (heavily polluted). Six groups of values of the macrophyte index, each represented by a different colour or grey-scale (in this publication), are presented to allow a clear illustration of the results. Important information for the successful restoration of lakes in Upper Bavaria has been obtained from the distribution patterns of the submerged vegetation. Many unknown waste water inflows or diffuse sources could be detected due to abrupt changes in the macrophyte index. Furthermore, the success of waste water removal by 'ring canalisation', resulting in a re-oligotrophication of many Bavarian lakes can be followed by changes in the macrophyte index.

Introduction

Aquatic macrophytes in the littoral zones of lakes have two fundamental properties which make them attractive as limnological indicators. In the first instance, they react slowly and progressively to changes in nutrient conditions, in contrast to bacteria and microalgae, i.e. over several years. Macrophytes therefore function as integrators of environmental conditions to which they are subjected and thus can be used as long-term indicators with high spatial resolution.

Secondly, the littoral zone may experience patterns of nutrient (and pollutant) concentrations (Dave, 1992; Drake & Heaney, 1987), caused by natural or artifical in limnological routine work. Since most important nutrient loading occurs in the land–water ecotone, programmes for the restoration of lakes are dependent on reliable data which give insight into quality and quantity of nutrient loading. Early investigations in Scandinavia have shown that aquatic macrophytes reflect the nutrient status of their immediate habitat by their presence/absence and abundance and thus can be effectively used as biological indicators (Suominen, 1968; Uotila, 1971).

In Central European lakes, the disappearance of a number of species as a consequence of rapid eutrophication has been recorded over the past three decades (Lachavanne & Wattenhofer, 1975; Lang,

Gli indici per i laghi

Macrophyte Index

Table 1. Classification of 45 submerged and free-floating macrophyte species into nine indicator groups

Group 1.0	Group 1.5	Group 2.0	Group 2.5	Group 3.0	Group 3.5
Chara hispida	*Chara aspera*	*Chara delicatula*	*Chara contraria*	*Chara vulgaris*	*Myriophyllum verticillatum*
Chara polyacantha	*Chara intermedia*	*Chara tomentosa*	*Chara fragilis*	*Myriophyllum spicatum*	*Potamogeton berchtoldii*
Chara strigosa	*Utricularia minor*	*Potamogeton alpinus*	*Nitella opaca*	*Potamogeton filiformis*	*Potamogeton lucens*
Potamogeton coloratus			*Nitellopsis obtusa*	*Potamogeton perfoliatus*	*Potamogeton praelongus*
Utricularia ochroleuca			*Potamogeton gramineus*		*Potamogeton pusillus*
			Potamogeton natans		
			Potamogeton × zizii		
Strettamente oligotrofe					

Group 4.0	Group 4.5	Group 5.0
Fontinalis antipyretica	*Callitriche cophocarpa*	*Ceratophyllum demersu*
Hippuris vulgaris	*Elodea canadensis*	*Zannichellia palustris*
Lagarosiphon major	*Elodea nuttallii*	*Potamogeton mucronatus*
Potamogeton pectinatus	*Potamogeton crispus*	*Sagittaria sagittifolia*
	Potamogeton obtusifolius	*Lemna minor*
	Ranunculus circinatus	*Spirodela polyrhiza*
	Ranunculus trichophyllus	*Potamogeton nodosus*
		Strettamente eutrofe

Abbondanza semiquantitativa		Quantità (Q)
1 = very rare		1
2 = infrequent		8
3 = common	$y = x^3$	27
4 = frequent		64
5 = abundant		125

Gli indici per i laghi

Macrophyte Index

$$\mathrm{MI} = \frac{\sum_{a-z} I_{a-z} \cdot Q_{a-z}}{\sum_{a-z} Q_{a-z}},$$

Group 1.0	Group 1.5	Group 2.0
Chara hispida	*Chara aspera*	*Chara delicatula*
Chara polyacantha	*Chara intermedia*	*Chara tomentosa*
Chara strigosa	*Utricularia minor*	*Potamogeton alpinus*
Potamogeton coloratus		
Utricularia ochroleuca		

MI = [tabella sopra] * Q specie dalla *a* alla *z*

/ Q specie dalla *a* alla *z*

Gli indici per i laghi

Macrophyte Index

Table 2. Relationship between index cla
gree of nutrient status and assigned colou

Index class	Degree of nutrient enrich	
1.00–1.99	Slight	Dark blue
2.00–2.49	Low	Pale blue
2.50–2.99	Moderate	Green
3.00–3.49	Immense	Yellow
3.50–3.99	Heavy	Orange
4.00–5.00	Massive	Red

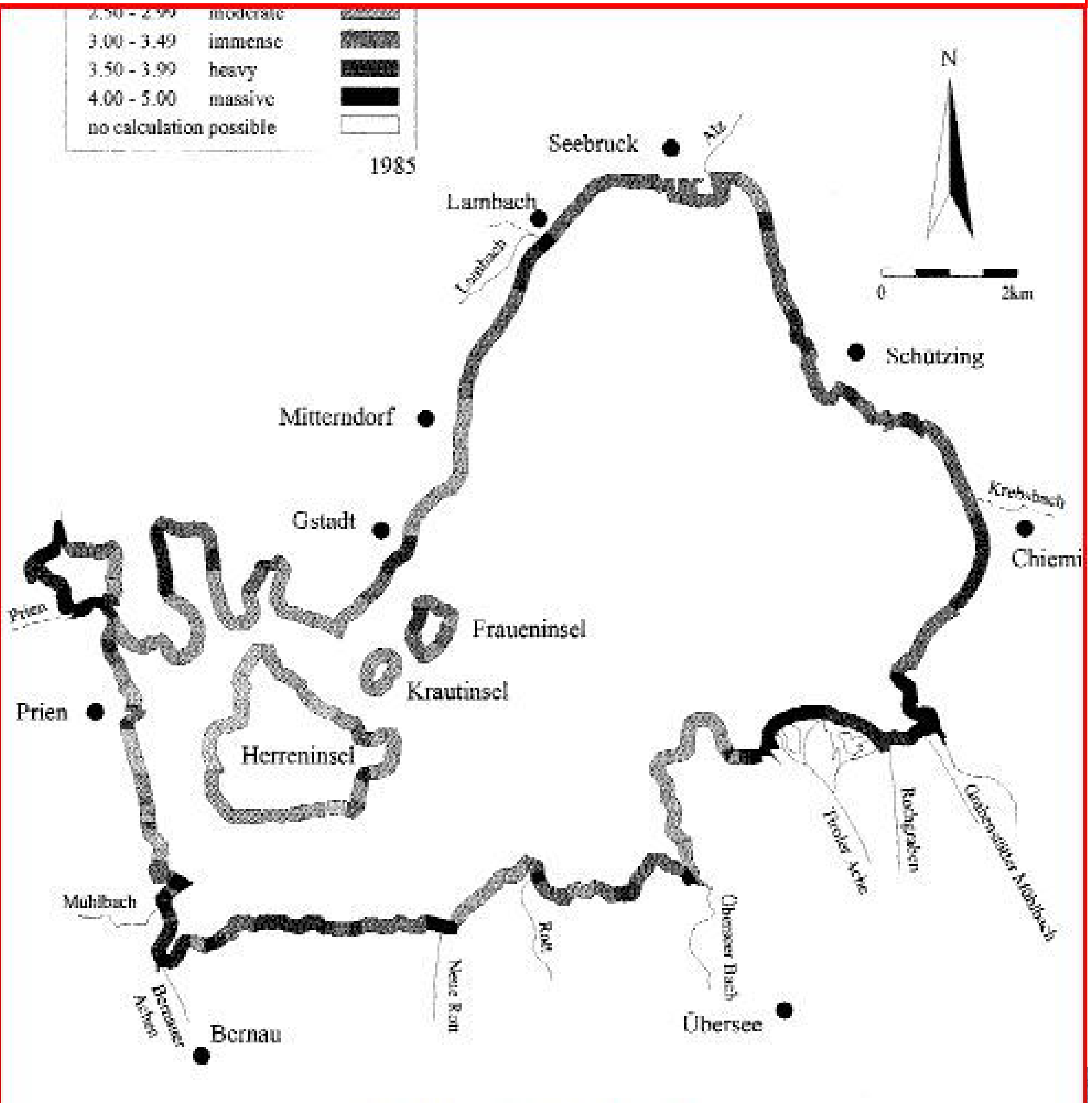

Figure 3. Macrophyte index of Lake Chiemsee.

Gli indici per i laghi

Reference Index

4 zone di campionamento (0-1, 1-2, 2-4 e > 4 m), ma può essere necessario andare oltre i 4 m.

Transetti di numero variabile, posizionati in base all'uso del suolo.

Specie presenti in punti (GPS) lungo il transetto.

Abbondanza in ciascun transetto calcolata come Melzer.

Campionamento con strumentazione specifica o con subacquei.

Massima profondità di crescita.

Bavarian Environment Agency

Action Instructions for the ecological Evaluation of Lakes for Implementation of the EU Water Framework Directive: Makrophytes and Phytobenthos

April 2007

April 2007

Dr. Jochen Schaumburg
Christine Schranz
Dr. Doris Stelzer
Dr. Gabriele Hofmann

Specie radicate flottanti, flottanti e sommerse.

Gli indici per i laghi

Reference Index

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Specie presenti in punti (GPS) lungo il transetto.

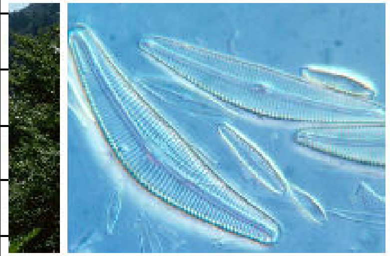
Abbondanza in ciascun transetto calcolata come Melzer.

Campionamento con strumentazione specifica o con subacquei.

Massima profondità di crescita.

Surface of water body	Number of transects
< 0,5 km²	1 - 5
0,5 - 2,0 km²	4 - 8
2,0 - 5,0 km²	5 - 10
5,0 - 10 km ²	6 - 12
10 - 20 km²	8 - 15
20 - 50 km²	10 - 20
50 - 100 km²	20 - 30
> 100 km²	30 - 50

Bavarian Environment Agency



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Surface of water body	Number of transects
< 0,5 km²	1 - 5
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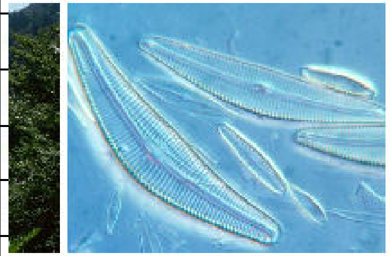
2,0 - 5,0 km²	5 - 10
5,0 - 10 km²	6 - 12
10 - 20 km²	8 - 15
20 - 50 km²	10 - 20
50 - 100 km²	20 - 30

Bavarian Environment Agency



ecological Evaluation of Lakes
for Implementation of the EU
W ive:
M benthos

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Abbondanza semiquantitativa		Quantità (Q)
1 = very rare	$y = x^3$	1
2 = infrequent		8
3 = common		27
4 = frequent		64
5 = abundant		125

Specie radicate flottanti, flottanti e sommerse.

Gli indici per i laghi

Tipi laghi

Reference Index

Se una specie non è in questa lista non deve essere utilizzata. Se le specie non menzionate sono ≥ 25% l'indice non può essere applicato.

	AK(S)	Akp	MTS	TKg10	TKg13	TKp
Butomus umbellatus (flutend)				B	B	B
Callitriche hermaphroditica	B	B	B	B	B	B
Ceratophyllum demersum 0-1m	C	C	C	C	C	C
Ceratophyllum demersum >1m	C	C	C	B	B	B
Ceratophyllum submersum						B
Chara aspera	A	A	B	A	A	A
Chara contraria 0-1m	B	B	B	B	B	B
Chara contraria 1-2m	B	B	B	B	B	A
Chara contraria 2-4m	B	A	B	A	A	A
Chara contraria >4m	A	A	B	A	A	A
Chara delicatula 0-1m	B	A	B	B	B	B
Chara delicatula 1-2m	B	A	B	B	B	A
Chara delicatula >2m	A	A	A	A	A	A
Chara denudata	B	B				
Chara filiformis				A	A	A
Chara globularis 0-1m	B	B	B	B	B	B
Chara globularis 1-2m	B	B	B	B	B	A
Chara globularis 2-4m	B	A	B	A	B	A
Chara globularis >4m	A	A	B	A	A	A
Chara hispida	A	A		A	A	A
Chara intermedia	A	A		A	A	A
Chara polyacantha	A	A		A	A	A
Chara rudis	A	A		A	A	A
Chara strigosa	A					
Chara tomentosa	A	A		A	A	A

Gli indici per i laghi

Reference Index

Se una specie non è in questa lista non deve essere utilizzata. Se le specie non menzionate sono ≥ 25% l'indice non può essere applicato.

$$RI = \frac{\sum_{i=1}^{n_A} Q_{Ai} - \sum_{i=1}^{n_C} Q_{Ci}}{\sum_{i=1}^{n_g} Q_{gi}} * 100$$

Abbondanza media nel lago.

Tipi laghi

	AK(S)	Akp	MTS	TKg10	TKg13	TKp
Butomus umbellatus (flutend)				B	B	B
Callitriche hermaphroditica	B	B	B	B	B	B
Ceratophyllum demersum 0-1m	C	C	C	C	C	C
Ceratophyllum demersum >1m	C	C	C	B	B	B
Ceratophyllum submersum						B
Chara aspera	A	A	B	A	A	A
Chara contraria 0-1m	B	B	B	B	B	B
Chara contraria 1-2m	B	B	B	B	B	A
Chara contraria 2-4m	B	A	B	A	A	A
	A	A	B	A	A	A
	B	A	B	B	B	B
	B	A	B	B	B	A
	A	A	A	A	A	A
	B	B				
				A	A	A
	B	B	B	B	B	B
	B	B	B	B	B	A
	B	A	B	A	B	A
	A	A	B	A	A	A
	A	A		A	A	A
	A	A		A	A	A
Chara polyacantha	A	A		A	A	A
Chara rudis	A	A		A	A	A
Chara strigosa	A					
Chara tomentosa	A	A		A	A	A

Gli indici per i laghi

Reference Index

Esistono dei criteri di utilizzo e criteri aggiuntive per il calcolo dell'indice a seconda del tipo di lago.

Il Reference Index è il solo modulo per le macrofite e c'è un modulo per il fitobentos la combinazione dei 2 fornisce la determinazione dello stato ecologico di un ambiente.

$$M_{MP} = \frac{(RI_{Seen} + 100) * 0{,}5}{100}$$

M_{MP} = Module Macrophyte Assessment
$RI_{Seen/Lakes}$ = type specifically calculated Reference Index$_{Seen/Lakes}$

$$M\&P_{Seen/Lakes} = \frac{M_{MP} + M_{D}}{2}$$

$M\&P_{seen}$ = Macrophyte & Phytobenthos-Index for lakes
M_{MP} = Module Macrophytes
M_{D} = Module Diatoms

Gli indici per i laghi

Reference Index

MATHES et al. (2002)	Type 1	Types 2, 3, 4	
Macrophytes	AKp	AK(s)	
Diatoms	D 1.2	D 1.1	D 1.2
Ecological status class			
1	1,00 - 0,74	1,00 - 0,81	1,00 - 0,74
2	< 0,74 - 0,47	< 0,81 - 0,54	< 0,74 - 0,47
3	< 0,47 - 0,25	< 0,54 - 0,28	< 0,47 - 0,25
4	< 0,25 - 0,00	< 0,28 - 0,00	< 0,25 - 0,00
5		- -	- -

Gli indici per i laghi

PLEX (Plant Lake Ecotype Index)

Dataset di 3447 laghi.

Specie radicate flottanti, liberamente radicate e radicate.

Intera linea di costa campionata.

Utilizzata la classica strumentazione.

Abbondanza valutata semi-quantitativamente con scala DAFOR: D = Dominant; A = Abundant; F = Frequent; O = Occasional; R = Rare

Gli indici per i laghi

PLEX (Plant Lake Ecotype Index)

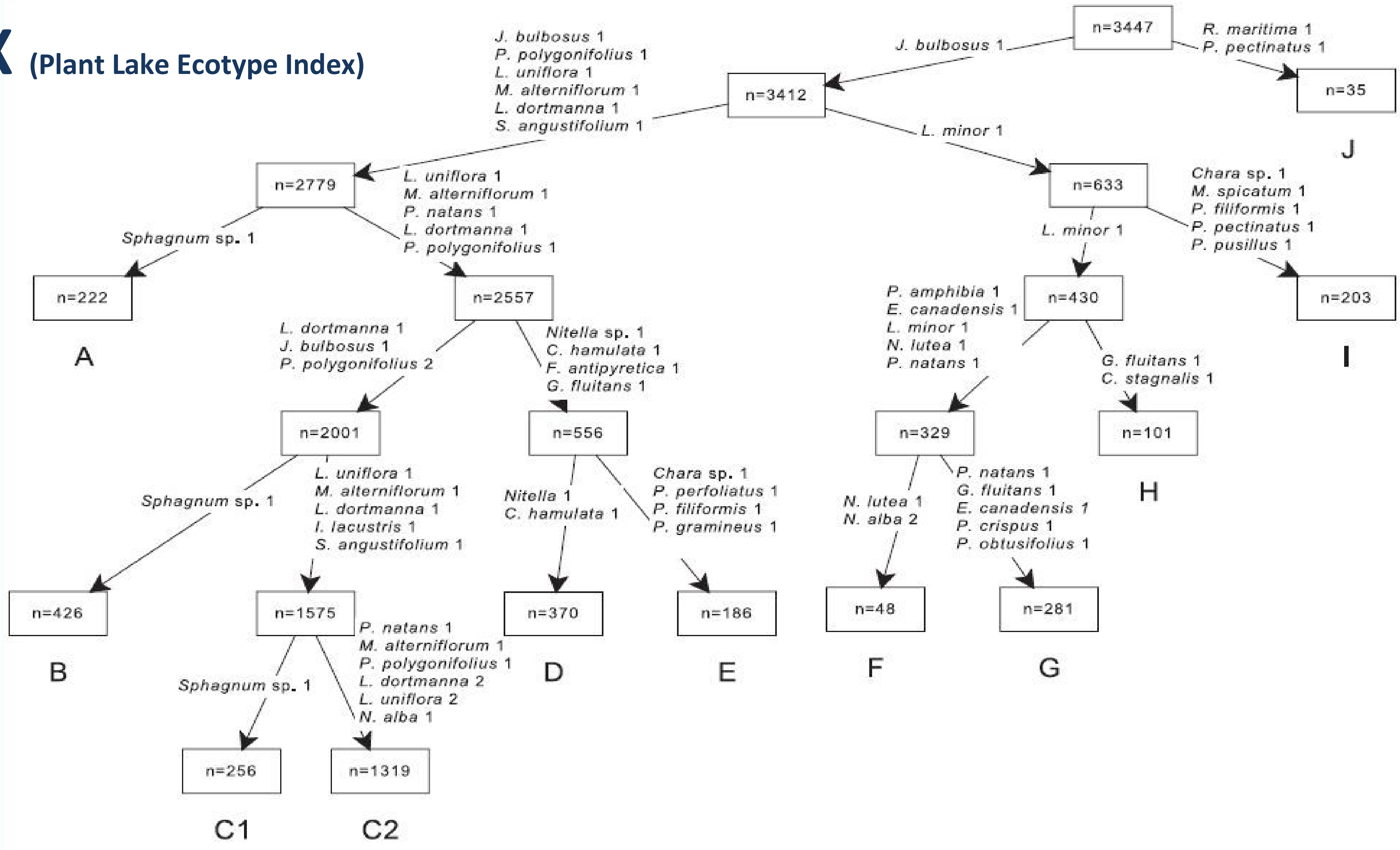


Figure 3.2. Dendrogram of TWINSPAN analysis showing major groups A-J
The differentiating plant taxa are shown on the branches.

Gli indici per i laghi

PLEX (Plant Lake Ecotype Index)

First, each TWINSPAN end group was assigned to one of five ecotype categories: dystrophic lakes with low plant diversity (Group A); heathland-associated soft waters in the lowlands and mountains (Groups B & C); circumneutral, mid to low altitude lakes with a diverse assemblage of plants (Groups D and E); hardwater, lowland lakes with low to moderate plant diversity (Groups F, G and H); and hardwater, lowland lakes with *Chara* (Group I). Brackish water sites (Group J) were excluded, as in Palmer *et al.* (1992). Any species with fewer than 25 non-brackish occurrences was also excluded.

V - Dystrophic lakes, with low plant diversity;
W - Heathland-associated soft waters in the lowlands and mountains, with low plant diversity;
X - Mid to low altitude lakes, with a diverse assemblage of plants;
Y - Hardwater, lowland lakes, with low to moderate plant diversity;
Z - Hardwater, lowland lakes with *Chara*.

Ecotype code	*PLEX Value*
V	1
v	2
w (adjacent to V or v)	3
W (or w with no V, v, X or x)	4
w (adjacent to X or x)	5
x (adjacent to W or w)	6
X (or x with no W, w, Y or y)	7
x (adjacent to Y or y)	8
y (adjacent to X or x)	9
Y (or y with no X, x, Z or z)	10
y (adjacent to Z or z)	11
z	12
Z	13

Gli indici per i laghi

AIM (Austrian Index Macrophytes)

Hydrobiologia (2009) 633:83–104
DOI 10.1007/s10750-009-9871-0

EUROPEAN SURFACE WATERS

Austrian Index Macrophytes (AIM-Module 1) for lakes: a Water Framework Directive compliant assessment system for lakes using aquatic macrophytes

Karin Pall · Veronika Moser

Published online: 29 July 2009

Abstract We describe a new macrophyte-based assessment tool for Austrian lakes elaborated according to the requirements of the European Water Framework Directive. Data from 38 out of 45, WFD-relevant (≥50 ha) lakes in Austria collected with the help of a new mapping procedure form the

zones. As a result of alteration of the shoreline, artificial water level fluctuations or wave action and even eutrophication, specific zones can be missing. The metric "characteristic zonation" helps to check, if all type-specific vegetation zones are present. The metric "trophic indication" uses the Macrophyte

Indice Italiano?

MacroIMMI (Macrophytes Italian MultiMetrics Index)

L-AL4

$$MacroIMMI = \frac{som + exot + S_d + s_k}{4}$$

L-AL5 e L-AL6

$$MacroIMMI = \frac{som + exot + S_d + s_k + z_{c-max}}{5}$$

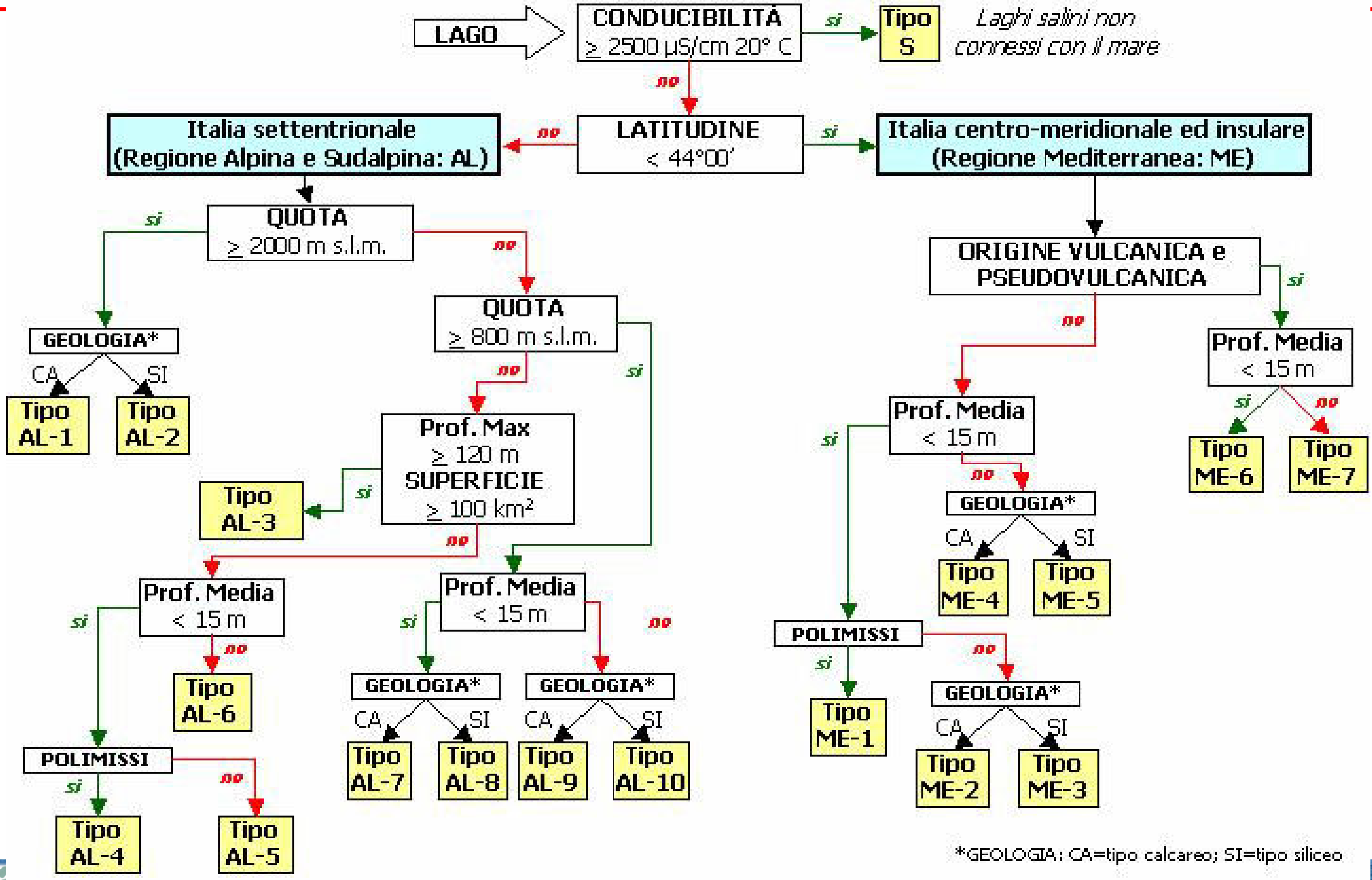
MTI (Macrophytes Trophic Index species)

L-AL3

$$MTI_{species} = \frac{\sum A_k \cdot v_k}{\sum A_k}$$

dove:
A_k: abbondanza della specie *k*;
v_k: valore trofico della specie *k*;

Indice Italiano?



*GEOLOGIA: CA=tipo calcareo; SI=tipo siliceo

Premesse

L’indice proposto è stato prodotto:

- utilizzando dati storici
- dati provenienti da ambienti lacustri sud-alpini < 800 m
- ambienti lacustri di piccole dimensioni
- con profondità inferiore a 125 m
- soli ambienti non alterati (no invasi)
- tipologia L-AL4, L-AL5 e L-AL6

Utilizzo dati storici

- Comparabilità metodologica: utilizzati solo quelli prodotti con lo stesso metodo
- Comparabilità nei valori di abbondanza forniti: questi valori erano indicati come abbondanza di una specie nel lago

Abbondanza relativa con valori da 1 a 4

Metodo a transetto

I numeri …

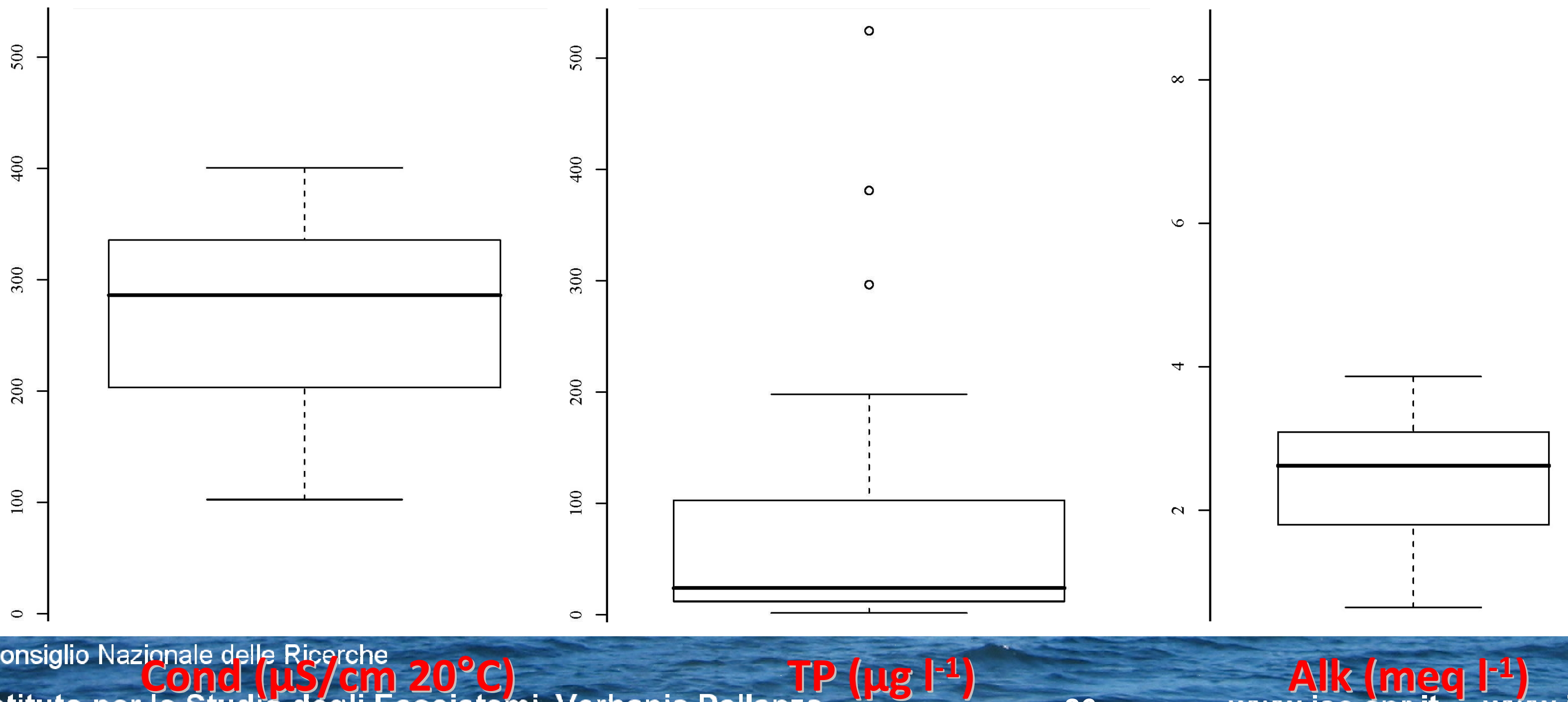
- 18 laghi (Alserio, Annone Est - Oggiono, Annone Ovest, Comabbio, Endine, Ghirla, Monate, Piano, Pusiano, Sartirana, Varese, Moro, Segrino, Montorfano, Mezzola, Pozzo di Riva, Candia e Viverone)
- dal 1971 al 2007
- 41 campagne
- 25 specie
- 5 Forme di colonizzazione: radicate flottanti, radicate sommerse, radicate anfibie (*Polygonum amphibium*), natanti foglie galleggianti e infracquatiche

I numeri … dataset

		Alserio	Alserio	Alserio	Alserio	Alserio	Alserio	Annone Est (Oggiono)
	Forma di colonizzazione	Alserio 1972-1973	Alserio 1984	Alserio 1999	Alserio 2003	Alserio 2006	Alserio 2007	Annone Est (Oggiono) 1972-1973
Callitriche stagnalis	I Rad Fl	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ceratophyllum demersum	I Rad S	2.0	3.0	0.0	2.0	2.6	0.8	3.0
Chara sp.	I Rad S	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Elodea canadensis	I Rad S	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Groenlandia densa	I Rad S	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hottonia palustris	I Rad S	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hydrocharis morsus-ranae	I Nat Fl	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lagarosiphon major	I Rad S	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lemna minor	I Nat Fl	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Myriophyllum spicatum	I Rad S	4.0	4.0	0.0	0.0	0.0	0.0	4.0
Najas marina	I Rad S	0.0	0.0	0.0	2.5	0.0	0.0	0.0
Nelumbo nucifera	I Rad Fl	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Nuphar luteum	I Rad Fl	3.0	2.0	4.0	3.4	3.7	4.0	3.0
Nymphaea alba	I Rad Fl	3.0	3.0	4.0	3.1	3.8	2.4	3.0
Nymphoides peltata	I Rad Fl	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Polygonum amphibium	I Rad Fl/I Rad E	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Potamogeton crispus	I Rad S	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Potamogeton lucens	I Rad S	0.0	0.0	1.0	0.0	0.0	0.0	0.0
Potamogeton pectinatus	I Rad S	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Potamogeton perfoliatus	I Rad S	2.0	2.0	0.0	0.0	0.0	0.0	3.0
Potamogeton pusillus	I Rad S	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Trapa natans	I Nat Fl	2.0	3.0	4.0	2.5	2.3	1.3	0.0
Utricularia vulgaris	I Nat S	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Vallisneria spiralis	I Rad S	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Zannichellia palustris	I Rad S	0.0	0.0	0.0	0.0	0.0	0.0	0.0

I numeri … chimismo

	min	max	media	SD
TP (µg l^{-1})	3.6	526.4	74.5	109.1
Cond (µS/cm 20°C)	105.5	403.5	276.0	86.6
Alk (meq l^{-1})	0.64	3.86	2.52	0.89



Richieste direttiva

22.12.2000 EN Official Journal of the European Communities L 327/35

Specific pollutants

Pollution by all priority substances identified as being discharged into the body of water

Pollution by other substances identified as being discharged in significant quantities into the body of water

1.1.2. Lakes

Biological elements

Composition, abundance and biomass of phytoplankton

Composition and abundance of other aquatic flora

Composition and abundance of benthic invertebrate fauna

Composition, abundance and age structure of fish fauna

Richieste direttiva

1.2.1. Definitions for high, good and moderate ecological

Biological quality elements

Element	High status	Good status	Moderate status
Phytoplankton	The taxonomic composition of phytoplankton corresponds totally or nearly totally to undisturbed conditions. The average phytoplankton abundance is wholly consistent with the type-specific physico-chemical conditions and is not such as to significantly alter the type-specific transparency conditions. Planktonic blooms occur at a frequency and intensity which is consistent with the type-specific physico-chemical conditions.	There are slight changes in the composition and abundance of planktonic taxa compared to the type-specific communities. Such changes do not indicate any accelerated growth of algae resulting in undesirable disturbances to the balance of organisms present in the water body or to the physico-chemical quality of the water or sediment. A slight increase in the frequency and intensity of the type-specific planktonic blooms may occur.	The composition of planktonic taxa differs moderately from the type-specific communities. Abundance is moderately disturbed and may be such as to produce a significant undesirable disturbance in the values of other biological and physico-chemical quality elements. A moderate increase in the frequency and intensity of planktonic blooms may occur. Persistent blooms may occur during summer months.
Macrophytes and phytobenthos	The taxonomic composition corresponds totally or nearly totally to undisturbed conditions. There are no detectable changes in the average macrophytic and the average phytobenthic abundance.	There are slight changes in the composition and abundance of macrophytic and phytobenthic taxa compared to the type-specific communities. Such changes do not indicate any accelerated growth of phytobenthos or higher forms of plant life resulting in undesirable disturbances to the balance of organisms present in the water body or to the physico-chemical quality of the water or sediment. The phytobenthic community is not adversely affected by bacterial tufts and coats present due to anthropogenic activity.	The composition of macrophytic and phytobenthic taxa differs moderately from the type-specific community and is significantly more distorted than at good status. Moderate changes in the average macrophytic and the average phytobenthic abundance are evident. The phytobenthic community may be interfered with and, in some areas, displaced by bacterial tufts and coats present as a result of anthropogenic activities.
Benthic invertebrate fauna	The taxonomic composition and abundance correspond totally or nearly totally to undisturbed conditions. The ratio of disturbance sensitive taxa to insensitive taxa shows no signs of alteration from undisturbed levels. The level of diversity of invertebrate taxa shows no sign of alteration from undisturbed levels.	There are slight changes in the composition and abundance of invertebrate taxa from the type-specific communities. The ratio of disturbance-sensitive taxa to insensitive taxa shows slight alteration from type-specific levels. The level of diversity of invertebrate taxa shows slight signs of alteration from type-specific levels.	The composition and abundance of invertebrate taxa differ moderately from the type-specific communities. Major taxonomic groups of the type-specific community are absent. The ratio of disturbance-sensitive taxa to insensitive taxa, and the level of diversity, are substantially lower than the type-specific level and significantly lower than for good status.

22.12.2000 EN Official Journal of the European Communities L 327/39

Richieste direttiva

1.2.1. Definitions for high, good and moderate ecological

Biological quality elements

Element	High status	Good status	Moderate status
Phytoplankton	The taxonomic composition of phytoplankton corresponds totally or nearly totally to undisturbed conditions. The average phytoplankton abundance consistent with the type-specific phys conditions and is not such as to significar type-specific transparency conditions. Planktonic blooms occur at a frequency a which is consistent with the type-speci chemical conditions.	There are slight changes in the composition and abundance of planktonic taxa compared to the	The composition of planktonic taxa differs moderately from the type-specific communities.
Macrophytes and phytobenthos	The taxonomic composition corresponds nearly totally to undisturbed conditions. There are no detectable changes in macrophytic and the average phytobenthic a	by bacterial tufts and coats present due to anthropogenic activity.	ies
Benthic invertebrate fauna	The taxonomic composition and abundance correspond totally or nearly totally to undisturbed conditions. The ratio of disturbance sensitive taxa to insensitive taxa shows no signs of alteration from undisturbed levels. The level of diversity of invertebrate taxa shows no sign of alteration from undisturbed levels.	There are slight changes in the composition and abundance of invertebrate taxa from the type-specific communities. The ratio of disturbance-sensitive taxa to insensitive taxa shows slight alteration from type-specific levels. The level of diversity of invertebrate taxa shows slight signs of alteration from type-specific levels.	The composition and abundance of invertebrate taxa differ moderately from the type-specific communities. Major taxonomic groups of the type-specific community are absent. The ratio of disturbance-sensitive taxa to insensitive taxa, and the level of diversity, are substantially lower than the type-specific level and significantly lower than for good status.

There are slight changes in the composition and abundance of macrophytic and phytobenthic taxa compared to the type-specific communities. Such changes do not indicate any accelerated growth of phytobenthos or higher forms of plant life resulting in undesirable disturbances to the balance of organisms present in the water body or to the physico-chemical quality of the water or sediment.

Indice

Massima profondità di crescita: $Z_{c-\max}$

Frequenza relativa delle specie sommerse: $som = \sum \left(\frac{f_{k_{som}}}{\sum f_k} \cdot 100 \right)$

Frequenza delle specie esotiche: $exot = 100 - \sum \left(\frac{f_{k_{exot}}}{\sum f_k} \cdot 100 \right)$

Diversità (Indice Simpson) $S_d = \left[1 - \sum \left(\frac{\frac{f_k}{\sum f_k} \cdot 100}{100} \right)^2 \right] \cdot 100$

Frequenze:

$$f_k = \frac{n_k}{n_{tot}} \cdot 100$$

Score trofico per ciascuna specie: $s_k = \frac{\sum A_k \cdot v_k}{\sum A_k}$

Indice

$$MTI_{species} = \frac{\sum A_k \cdot v_k}{\sum A_k}$$

dove:
A_k: abbondanza della specie *k*;
v_k: valore trofico della specie *k*;

3 passaggi

Applicazione Multivariate Regression Trees (MRT) → ***Ridistribuzione delle specie nei clusters usando IndVal*** → ***Abbondanza media ponderata su logTP***

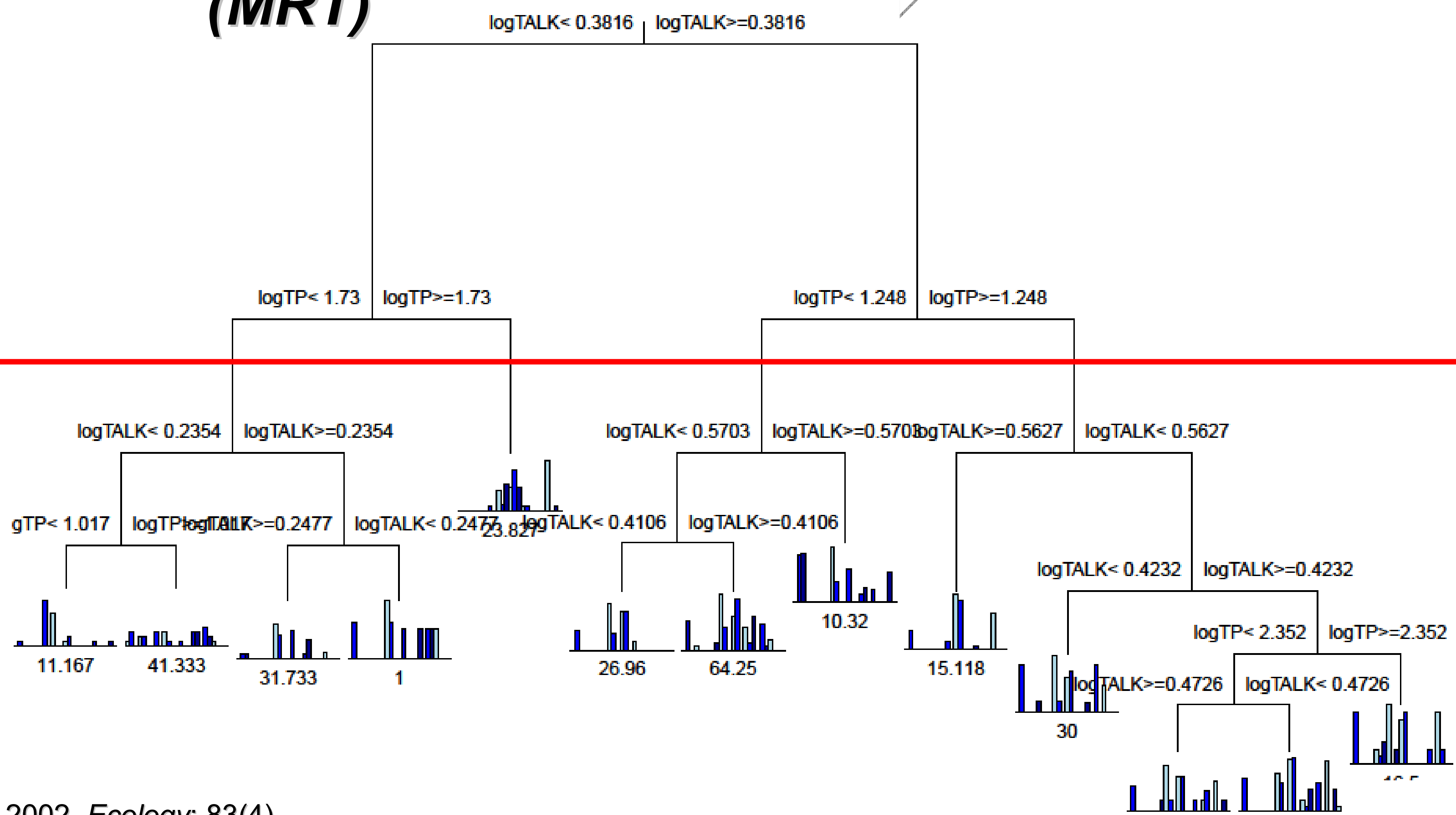
De'ath G., 2002. *Ecology*: 83(4)

Dufrêne M. *et al.*, 1997. *Ecological Monographs*: 67(3)

Indice

Applicazione Multivariate Regression Trees (MRT)

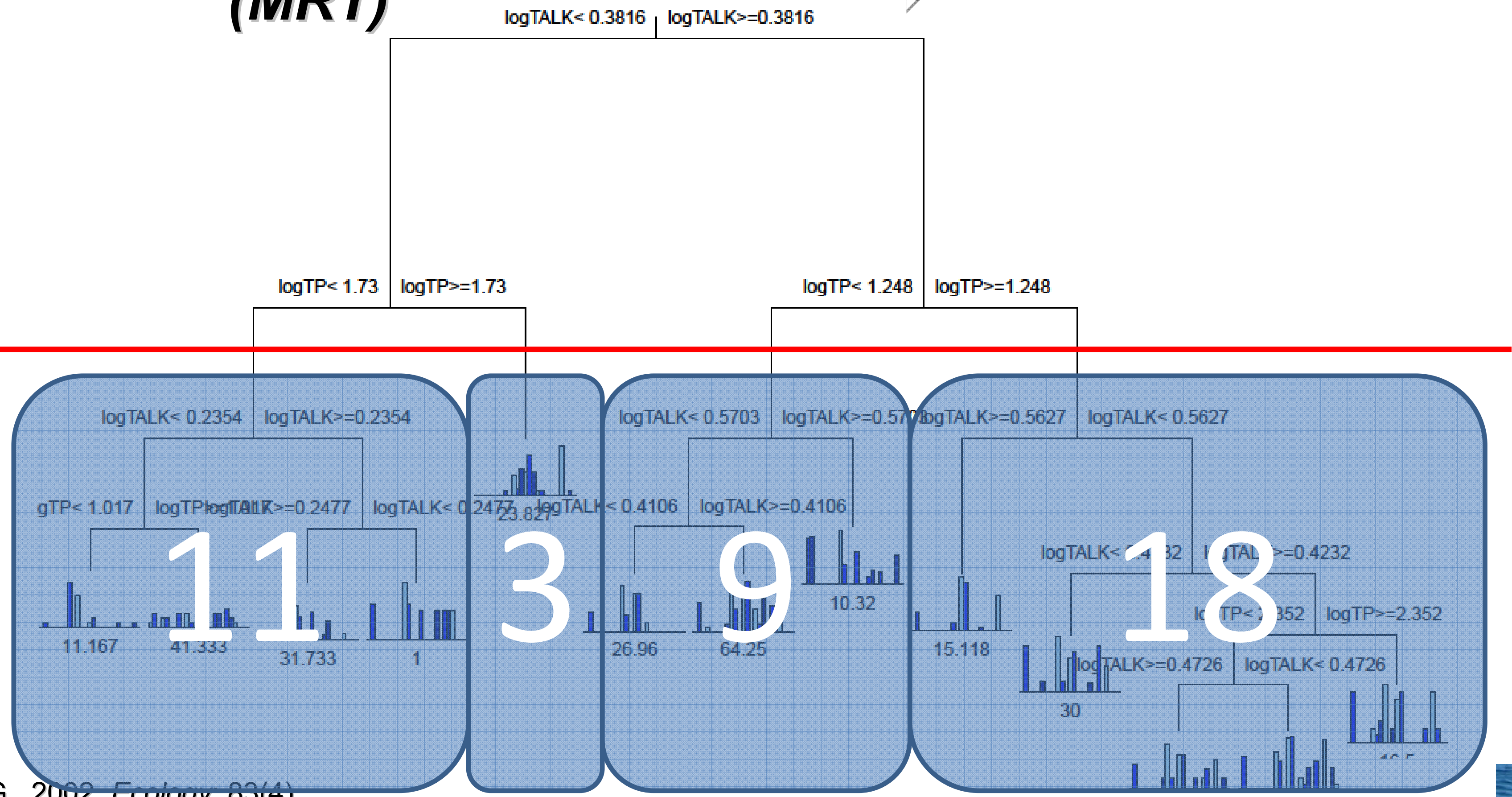
Clusterizzazione degli ambienti



De'ath G., 2002. *Ecology*: 83(4)

Indice

Applicazione Multivariate Regression Trees (MRT) → ***Clusterizzazione degli ambienti***



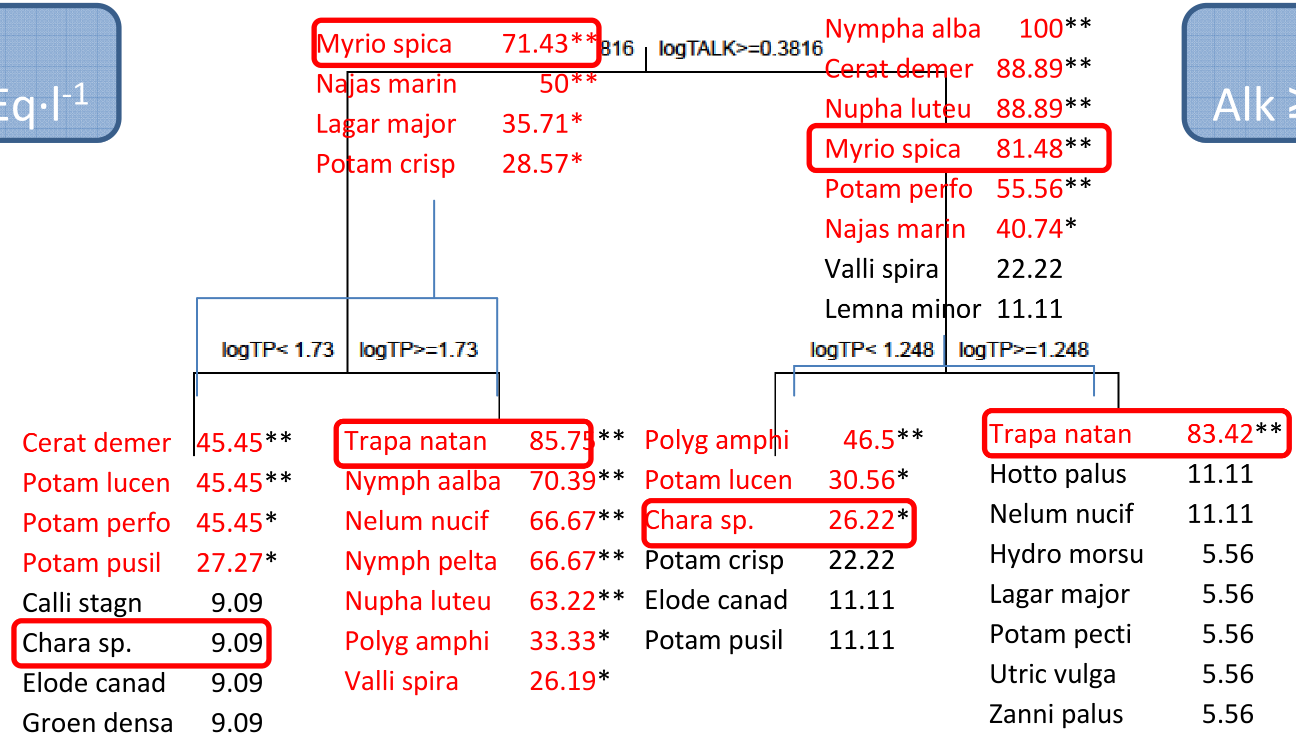
De'ath G., 2002. *Ecology*. 83(4)

Indice

Ridistribuzione delle specie nei clusters usando IndVal → ***Individuazione delle specie target***

Si
Alk < 2.4 mEq·l^{-1}

Ca
Alk ≥ 2.4 mEq·l^{-1}



Dufrêne M. *et al.*, 1997. *Ecological Monographs*. 67(3)

Indice

Abbondanza media ponderata su logTP → **_Fornire un valore di V_k_**

$$v_k = \frac{\sum \left(A_k / \sum_{k}^{1} A_j \right) \cdot \log TP_j}{\sum \left(A_k / \sum_{k}^{1} A_j \right)}$$

Specie	v_k - L-AL3	v_k - L-AL4, AL5 e AL6	
		Alk ≥ 2,40 meq·l^{-1}	Alk < 2,40 meq·l^{-1}
Ceratophyllum demersum	0,37	0,34	0,36
Chara globularis	0,78	0,40	0,74
Chara sp. (non *C. globularis*)	0,56	0,59	-
Lagarosiphon major	0,64	-	0,59
Myriophyllum spicatum	0,47	0,35	0,43
Najas marina	0,43	0,39	-
Nelumbo nucifera	0,25	0,12	0,04
Nuphar lutea	0,35	0,35	0,06
Nymphaea alba	0,46	0,36	0,39
Nymphoides peltata	0,37	-	0,10
Persicaria amphibia	0,66	0,33	0,01
Potamogeton crispus	0,43	0,39	0,28
Potamogeton lucens	0,46	0,34	0,35
Potamogeton perfoliatus	0,37	0,27	0,4
Potamogeton pusillus	0,47	0,42	0,31
Trapa natans	0,32	0,32	0,16
Vallisneria spiralis	0,46	0,47	0,31

Indice

Foglio di calcolo Indice

Lago di Viverone 2007

	Valori	*Valori normalizzati*
$z_{c\text{-}max}$	5.50	0.35
sub	85.00	1.45
exot	95.00	0.91
S_{div}	70.00	0.00
s_k	0.39	0.39
MacroIMMI		0.62

Moderata

Lago di Candia 2007

	Valori	*Valori normalizzati*
$z_{c\text{-}max}$	4.50	0.25
sub	68.00	0.86
exot	90.00	0.80
S_{div}	71.00	0.05
s_k	0.37	0.34
MacroIMMI		0.46

Cattiva

Reference Index

Schaumburg *et al.* 2007

Lago di Viverone 2007:

RI	*-50.8*
M_{MP}	*0.25*
Ecological status	**4**

Lago di Candia 2007:

RI	*-44.9*
M_{MP}	*0.28*
Ecological status	**4**

Conclusioni

- L'utilizzo come dataset di solo dati storici può solo fornire informazioni sulla caratterizzazione delle specie target rispetto alla trofia (vedi TP)
- Il range trofico degli ambienti considerato è troppo ridotto per permettere di effettuare estensioni o individuare ambienti di riferimento e comunità di riferimento (l'approccio IndVal per cercare specie target)

Conclusioni

- Senza ambienti di riferimento non è possibile effettuare una classificazione se non come giudizio esperto
- L'approccio multimetrico rimane importante per inserire nell'indice metriche altrimenti non considerate dalla WFD

Prossimi passi

- Incrementare la lista dei valori trofici delle specie
- Semplificazione del protocollo di campionamento:
  1. Riduzione del numero transetti per sito;
  2. Percentuale di copertura tipo B&B.
- Incremento del dataset
- Riproduzione indice multimetrico per le altre tipologie lacustri