Kärntner Institut für Seenforschung
Naturwissenschaftliches Forschungszentrum

Lake Shorezone Functionality Index - Methodenevaluierung zur Bewertung der Funktionalität der Seeufer am Beispiel des Wörthersees und des Millstätter Sees

Endbericht

silmas alpine lakes network

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Im Auftrag des Amts der Kärntner Landesregierung, Abteilung 8 (Kompetenzzentrum Umwelt, Wasser und Naturschutz),
Flatschacher Straße 70, 9020 Klagenfurt am Wörthersee

Klagenfurt am Wörthersee, im August 2012

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1 Abstract

Within the scope of the SILMAS project the shorelines of two Carinthian lakes, Lake Wörthersee and Lake Millstätter See, has been investigated by using the Shorezone Functionality Index developed by Dr. Siligardi and his team during the last past five years. The investigations have been carried out using videos taken from boat and helicopter, integrated them with aerial photographs and on-site surveys.

The overall shoreline of Lake Wörthersee amounts to 46.300 m. Most of it is interested by a huge anthropogenic pressure, resulting in diffused settlements along the lake waters. Popular bathing localities like Velden, Pörtschach and Maria Wörth attract many tourists during the summer months. As a result, nearly 50 % of the shoreline shows a poor SFI value. Human disturbance results in artificial shores and impermeable sustaining walls, mostly in front of private properties. 15 stretches without functionality has been encountered during the survey. 10 from the remaining 16 stretches resulted to have a moderate shorezone functionality. Its length amounts to 6.755 m, while the remaining sections stood in the range of excellent/good values.

With a length of almost 27 km the shoreline of Lake Millstätter is consistently shorter than those of Lake Wörthersee, the largest Carinthian lake. As a popular bathing lake, there are several touristic settlements along its shores, especially along the bank line. Most of stretches that showed a low shorezone functionality are placed there, while the steep southern shores distinguish themselves through a near-natural state and low human pressures. 25 different stretches have been identified. 6 of them showed a excellent-good state, for a overall length of over 10.000 meters (or 39 %). The remaining stretches could be distinguished by typical human pressures, resulting in residential and recreational facilities. Those anthropogenic interventions caused an artificialization of the shoreline, often using impermeable materials, and strongly impacting on the natural, hygrophilus vegetation. The poorest functionality could be encountered on a total of 9.7 km. Reed belts along the shore are rather rare because of the high slope of the shorezones.

2 Einleitung

Wie viele Seen Europas, liegen auch die Kärntner Seen im Zentrum eines ewigen, gesellschaftlichen Tauziehens. Einerseits steht die anthropogene Nutzung der Seen und ihrer Ufer, an deren Spitze oft starke touristische Interessen wiederzufinden sind, andererseits das Interesse einen ökologisch guten, nachhaltigen Zustand des Gewässers zu bewahren und den kommenden Generationen zu sichern.

Die EU-Wasserrahmenrichtlinie sieht die Erhebung des ökologischen Zustandes stehender Gewässer vor, allerdings wurde diese in Österreich bis dato nur für einen Teil der Parameter umgesetzt. Zwar werden chemisch-physikalische bzw. biologische Parameter schon seit einigen Jahren routinemäßig zur Bestimmung der jeweiligen Zustandsklassen herangezogen, allerdings fehlen noch Methodenvorschriften für die Bewertung der morphologischen Parameter bzw. der strukturellen Gegebenheiten der Seeufer. Im Rahmen des vierten Arbeitspaketes des SILMAS Projekts wurde beschlossen, für zwei Kärntner Seen (Wörthersee und Millstätter See) Bewertungsverfahren anzuwenden, bei dem der Fokus vor allem auf den Uferbereichen liegt und die ökologische Funktionalität der Ufervegetationsstreifen im Vordergrund steht. Der starke anthropogene Druck resultierend aus den getätigten Baumaßnahmen führt zu einer Reduzierung der chemischen Puffereigenschaften der Uferbereiche und gefährdet damit auch die sich dort befindenden Lebensräume aquatischer Organismen.

3 Das Projekt SILMAS

Das Projekt SILMAS (www.silmas.eu) ist Teil des Programms für den Alpenraum, das zum INTERREG IIB der Europäischen Gemeinschaft gehört. Die Programme der Kategorie B betreffen die transeuropäische Zusammenarbeit zur Förderung einer harmonischen und ausgewogenen Entwicklung des Europäischen Raums. In diesem Zusammenhang entwickelte das Projekt SILMAS (Sustainable Instruments for Lakes Management in the Alpine Space) eine transnationale Zusammenarbeit zwischen den fünf Partnerländern: Deutschland, Österreich, Frankreich, Italien und Slowenien. Die überregionale Zusammenarbeit trägt zur territorialen Zusammenarbeit bei und stärkt den Alpenraum als einen attraktiven und leistungsfähigen Raum zum Leben und Arbeiten.

Das Projekt SILMAS lief über drei Jahre (September 2009 bis August 2012) und wurde von Rhône-Alpes Region (France) geleitet. Das Gesamtbudget betrug € 3.260.993,00 und 76 % wurden durch die Europäische Gemeinschaft (ERDF) finanziert. SILMAS ist ein Projekt zum Austausch von Erfahrungen und Know-how zur nachhaltigen Bewirtschaftung der Alpenseen. Es zielt darauf ab, konkrete, nachhaltige Instrumente zu schaffen, die die Bewirtschaftung der Seen im Alpenraum verbessern und das allgemeine öffentliche Bewusstsein für eine nachhaltige Seenentwicklung zu schärfen.

15 Partner aus lokalen Behörden, Forschungsinstitutionen und Universitäten waren in das Projekt involviert. Erhebungen und Untersuchungen wurden n 22 Alpenseen durchgeführt.

SILMAS Prioritäten

- Untersuchung der Auswirkung des Klimawandels auf die Alpenseen
- Lösung von Nutzungskonflikten im Zusammenhang mit den Alpenseen
- Erziehung zur nachhaltigen Entwicklung der Alpenseen

4 Methodik

Der Lake Shorezone Functionality Index (SFI) wurde in den letzten sechs Jahren von Dr. Siligardi und seinen Mitarbeitern (ISPRA (APAT) – Arbeitsgruppe) entwickelt und basierte zunächst auf der Aufnahme und Auswertung von achtundzwanzig morphologischen, ökologischen und sozioökonomischen Parametern. Die Anwendung verschiedener statistischer Methoden (wie hierarchische Klassifizierung, „ordinance“, selbstorganisierende Karten) ergaben letztendlich einen Klassifizierungsbaum, dessen Knoten sich auf neun Hauptparameter reduzieren, die zur Bestimmung des Funktionalitätsniveaus eines Ufervegetationsstreifens (UVS) herangezogen werden. Die Bewertung der Funktionalität eines Uferabschnittes erfolgt in der gegenständlichen Studie anhand dieser neun Hauptparameter.

Tab. 1: Auflistung der 28 Ausgangsparameter - die neun Hauptparameter sind rot formatiert

Breite des Ufervegetationsstreifens	
Zusammensetzung der Ufervegetation im Ufervegetationsstreifen (UVS)	**Bedeckung – Baumbestände (0-1)**
	Bedeckung - Buschbestände
	Bedeckung – Gräser (0-1)
	Bedeckung - kahler Boden
	Bedeckung – Schilfbestand (0-1)
	Hygrophile Arten
	Nicht-hygrophile Arten
	Exotische Arten
	Heterogenität der Zusammensetzung (0-1)
Kontinuität der Ufervegetation im UVS	Baum- und Buschvegetation
	Schilfbestand im Wasser
	Schilfbestand außerhalb des Wassers
	Art der Unterbrechung im UVS (0-1)
	Überwiegende Nutzung des Gebietes hinter dem UVS
Infrastrukturen	**Straßen (0-1)**
	Eisenbahntrassen
	Parkplätze
	Touristische Infrastrukturen (Strandbäder, Stege, kleine touristische Häfen)
	Mittlerer Neigungsgrad des Uferstreifens
	Übereinstimmung der Neigung von UVS und Lithoral
Profil der Uferlinie	**Konkavität (0-1)**
	Konvexität
	Komplexität
	Verbauungsgrad der Ufer (0-1)
	Run-off Kanäle
	Persönliches Urteil zur ökologischen Beschaffenheit des Abschnittes

Der Klassifizierungsbaum besitzt insgesamt 23 „Blätter“, die durch die in Tab. 1 aufgeführten Knoten (Parameter) verbunden sind.

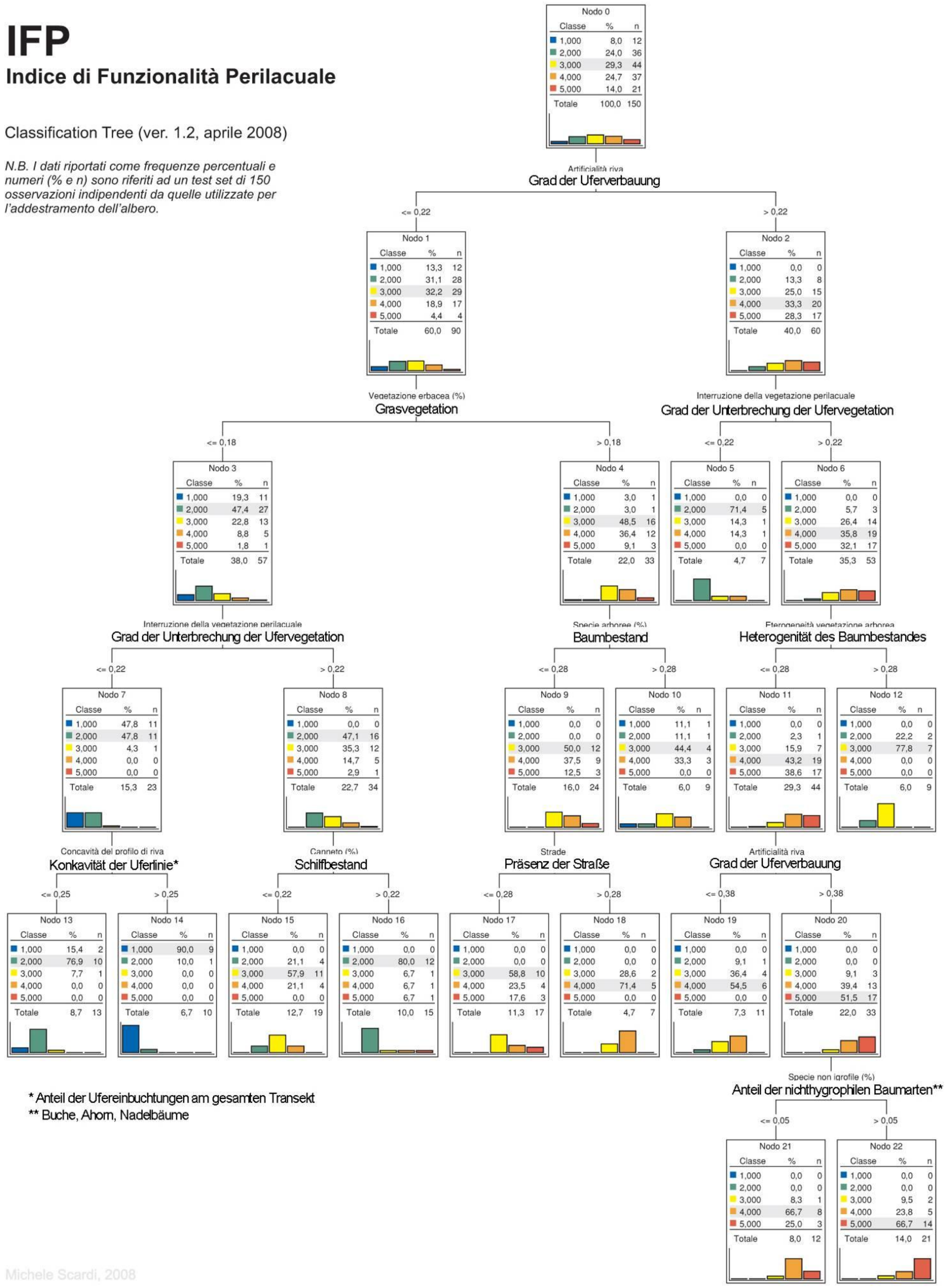

Abb. 1: Klassifizierungsbaum

Für die Befüllung des Erhebungsformulars ist in der Methodik eine Vor-Ort Begehung und Aufnahme der gefragten Parameter vorgesehen. Da es an den Kärntner Seen, anders als bei den italienischen, kaum die Möglichkeit gibt die Ufer direkt abzugehen und zu sichten, wurde dieser Teil der Methodik dahin gehend adaptiert, dass zur Kompilierung der

Fragebögen seeseitige Videoaufnahmen der Uferabschnitte herangezogen wurden. Die Aufnahmen stammten einerseits von Bootsbefahrungen, die zum Höhepunkt der Vegetationsentwicklung gemacht wurden, andererseits von Hubschrauberbefliegungen aus dem Herbst 2006. Ergänzt wurde beides durch hochauflösende (25 cm Bildauflösung), georeferenzierte Luftbilder des Amtes der Landesregierung Kärnten sowie Seeuferkartierungen, die vom KIS in einem vorhergehenden Projekt angefertigt wurden (siehe Tab. 2).

Tab. 2: Zeitpunkt der Aufnahmen

	Millstätter See	**Wörthersee**
Orthophotos (Auflösung 25 cm)	Jahr 2008	Jahr 2008
Hubschrauberbefliegungen	September 2006	September 2006
Bootsbefahrungen	Frühjahr 2007	Februar 2006 / August 2010
Seeuferkartierung	April 2008	April 2008

Gemeinsam bewertet werden mit dieser Methodik Seeuferabschnitte, innerhalb welcher kaum signifikante Veränderungen bei den zu erhebenden Parametern festgestellt werden können und man sie somit als homogen betrachten kann. Werden jedoch bedeutsame Änderung bei einem oder mehreren Parametern angetroffen, entsteht ein separat zu bewertender Abschnitt. Diese Seeuferteilstrecken werden auch als „homogene Abschnitte" bezeichnet. Homogene Abschnitte erstrecken sich je nach morphologischen Gegebenheiten des Umlandes bis zu 50 m in Richtung Hinterland, da besonders dieser Bereich wichtige Funktionen im Ecosystem eines Sees innehält. Dabei spielen zwar ökologische Aspekte (Pufferfunktion, Nährstoffaufnahme aus dem Untergrund, Erosionsschutz, Lebensraum für eine Vielzahl von Tieren, etc.) eine übergeordnete Rolle, aber auch aus einem natürlichen bzw. touristischen Sichtpunkt kann eine Instandhaltung anthropologisch unbeeinflusster Uferabschnitte von großer Bedeutung sein.

Ein Großteil der Kriterien betrifft zwar nur die ersten 50 m hinter der Uferlinie des Sees (auch „Ufervegetationsstreifen" genannt), es finden allerdings auch Parameter Anwendung, die bis zu 200 m ins Hinterland reichen und sich somit auf das Umland des Ufervegetationsstreifens beziehen.

Anthropologische Eingriffe können aber auch zu einer Reduzierung des Ufervegetationsstreifen führen (< 50 m), bis hin zu dem Extrem, wo durch massive menschliche Eingriffe (wie zum Beispiel durchgehende Uferverbauungen) die Präsenz der natürlicher Vegetation gänzlich unterbunden wird.

Die Bewertungen erfolgten nach der letzten Version des SFI – Handbuches, Stand August 2011 (siehe 7.2 Detaillierte Methodik). In Klagenfurt wurde Anfang Juli 2010 eine 3-tägige

Schulung zur der Anwendung des SFI in der Praxis von Seiten der Autoren (Dr. Siligardi, Dr. Zennaro) durchgeführt, infolge erfolgte die Evaluierung der Methodik.

Für eine bessere Illustrierung der Methodik wird die Anwendung des SFI an zwei Abschnitten (zwischen den Endpunkten 3 und 4 bzw. 4 und 5) des Wörtherseeufers erläutert.

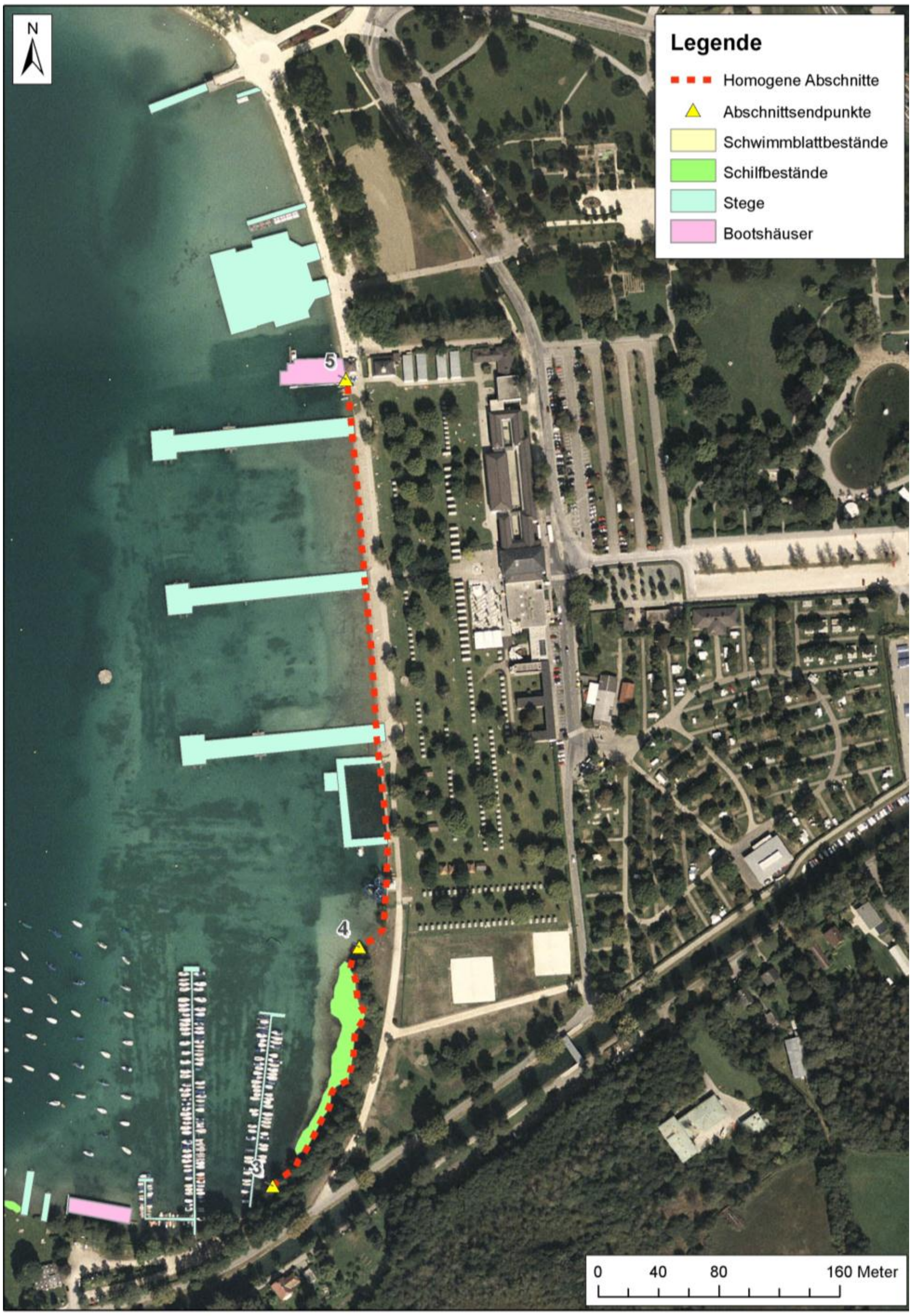

Abb. 2: zwei homogene Abschnitte - Beispiel

Die beiden Abschnitte liegen am Ostufer des Wörthersees, im Bereich des Klagenfurter Strandbades. Die unterschiedlich ausgeprägte Uferstruktur ist für die Ausweisung als zwei getrennte homogene Abschnitte verantwortlich. Während der Abschnitt „4_5" im

Strandbadgelände liegt und durch die starke Badenutzung, keine natürliche bzw. naturnahe Ufervegetation vorhanden ist, weist der angrenzende Abschnitt „3_4“ einen, wenn auch sehr schmalen Ufervegetationsstreifen auf. Dieser Streifen ist durch die parallel verlaufende, circa 30 Meter von der Uferlinie entfernt liegende Straße begrenzt. Uferverbauungen sind keine ersichtlich, auch ein Bestand natürlich wachsender Gräser ist nicht vorhanden (gepflegter Rasen weist kaum Pufferfunktionen vor, sodass er als „kahler Boden“ klassifiziert wird). Der prozentuelle Anteil der Unterbrechungen im schmalen Ufervegetationsstreifen ist mit größer als 22 % beziffert, sowie das Vorkommen des Schilfgürtels. Den Zweigen des Klassifizierungsbaumes folgend stößt man letztendlich auf Blatt Nr. 16, der diesem Abschnitt mit einer 83 %-igen Wahrscheinlichkeit die guten Funktionalitätsklasse zuweist.

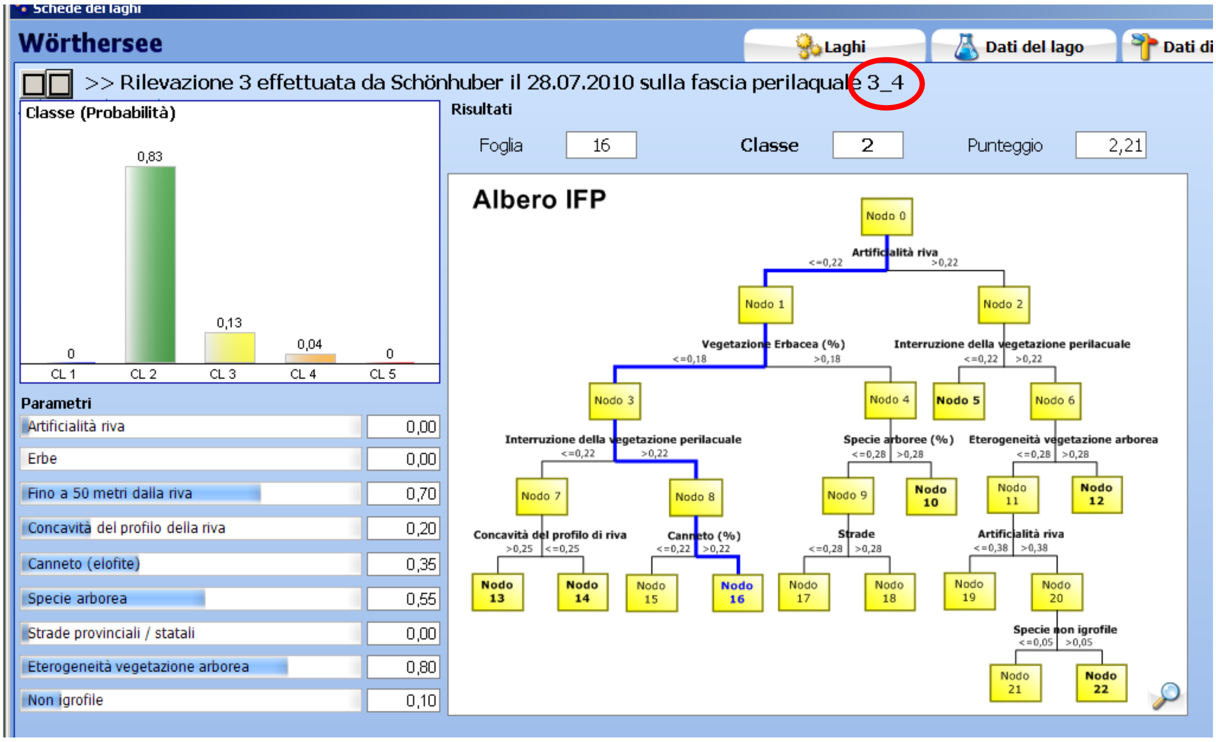

Abb. 3: Bewertung des Abschnittes „3_4“

Der Abschnitt „4_5“ weist hingegen eine anthropogen stark beeinflusste Uferlinie vor. Zwar handelt es sich meistens nicht um hart verbaute Uferabschnitte, jedoch verhindert die Badenutzung das Aufkommen von natürlicher Ufervegetation. Der Methodik zur Folge wird die Breite des Ufervegetationsstreifens mit 0 Metern bewertet. Dementsprechend prozentuell hoch fallen auch die Unterbrechungen im UVS aus: da de facto kein UVS vorhanden ist, gilt hier der Wert „1“ [= 100 %]. Die Vegetationsheterogenität ist nicht gegeben, prozentuell hoch sind dagegen jene die Uferabschnitte, die durch die anthropogene Nutzung als verbaut anzusehen sind. Durch das Fehlen des UVS wird der Methodik zur Folge den nicht-hygrophilen Arten der Wert „1“ zugeteilt, sodass im Klassifizierungsbaum das Blatt Nr. 22 ermittelt wird. Die Wahrscheinlichkeit, dass der Abschnitt in die Zustandsklassen „schlecht“

bzw. „unbefriedigend“ fällt, liegt bei 76 % bzw. 21 %, seine Pufferfunktion wird durch die starke menschliche Nutzung des Ufers und des dahinterliegenden Uferstreifens als sehr gering bewertet.

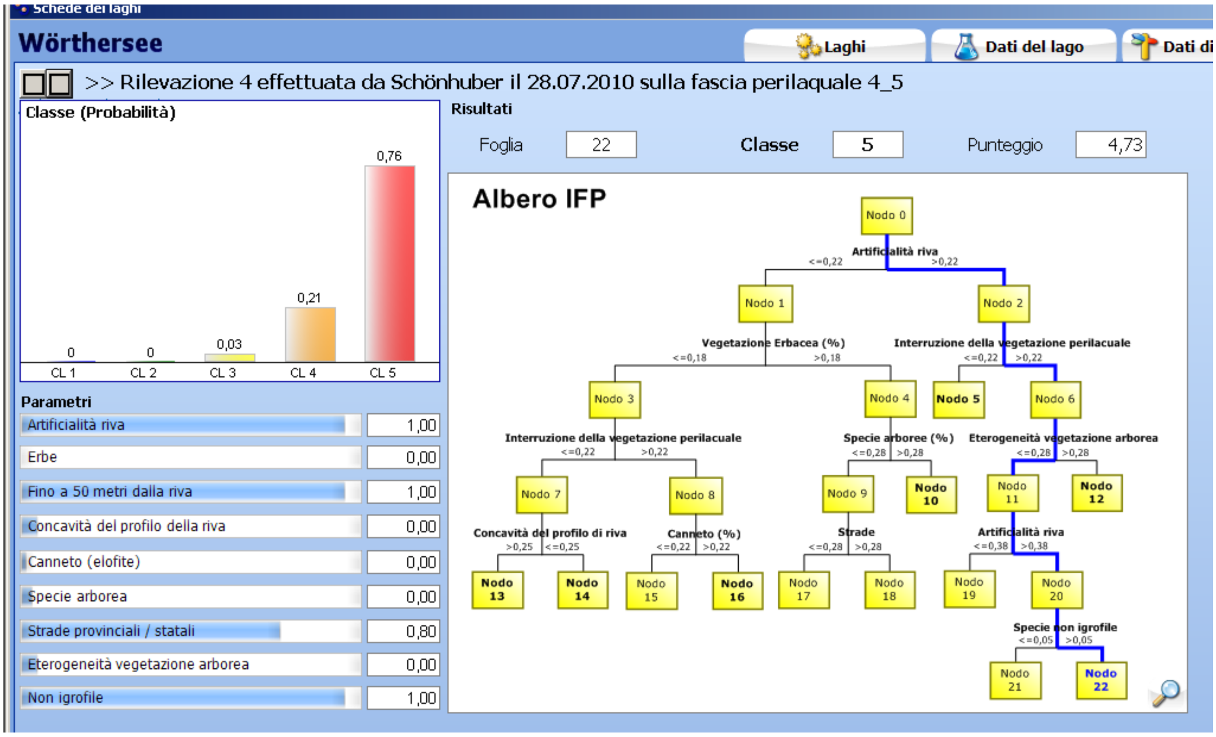

Abb. 4: Bewertung des Abschnittes „4_5“

Abb. 5: kartographische Darstellung der Ergebnisse

5 Ergebnisse

5.1 Millstätter See

Die Bewertungen der Ufer des Millstätter Sees nach dem Lake Shorezone Functionality Index erfolgten Anfang August 2010, Nachbesserungen wurden im August 2011 vorgenommen. Neben den technischen Hilfsmitteln (Videoaufnahmen) konnten bei einer zusätzlichen Bootsbefahrung am 02.08.2010 weitere, für die Bewertung wichtige Eindrücke gewonnen werden.

Die bewertete Uferlänge des Millstätter Sees beträgt insgesamt 26.856 m, in welcher 25 homogene Abschnitte (Ufervegetationsstreifen) ausgemacht werden konnten. Der kürzeste Streifen betrug ca. 93 m, der längste Abschnitt dagegen ca. 4.140 m.

Tab. 3: Verortung der Abschnittsendpunkte (BMN M31)

See	Abschnitt_ID	Rechtswert	Hochwert
Millstätter See	1	473705	181420
Millstätter See	2	473342	181815
Millstätter See	3	473084	181805
Millstätter See	4	472386	182289
Millstätter See	5	472181	182504
Millstätter See	6	471084	183570
Millstätter See	7	470432	184143
Millstätter See	8	470088	183966
Millstätter See	9	469716	184235
Millstätter See	10	469026	184618
Millstätter See	11	467524	185376
Millstätter See	12	465344	186249
Millstätter See	13	465015	186128
Millstätter See	14	464836	186157
Millstätter See	15	463920	186041
Millstätter See	16	463737	186024
Millstätter See	17	464622	185393
Millstätter See	18	467696	184033
Millstätter See	19	468468	183552
Millstätter See	20	469934	182561
Millstätter See	21	469868	182156
Millstätter See	22	470135	181948
Millstätter See	23	470242	181849
Millstätter See	24	473854	180804
Millstätter See	25	473736	181379

Abb. 6: Abschnitte des Millstätter Sees

Der Mündungsbereich des Riegerbaches war der Ausgangspunkt der Bewertung, die abschnittsweise gegen den Uhrzeigersinn vorgenommen wurde. Anthropologische Eingriffe sind besonders entlang des Nordufers zu erkennen (im Bereich der Siedlungsgebiete bzw. entlang der Millstätter Bundesstrasse), sodass dort nur Abschnitte mit mäßig bis schlechten Zustand festgestellt werden konnten. Das Südufer hingegen ist hauptsächlich durch natürlich belassene Vegetation gekennzeichnet, anthropogen bedingte Veränderungen begrenzen sich auf punktuelle Siedlungseinheiten bzw. forstliche Nutzung der vorhandenen Waldflächen. Hier ist der Zustand der Uferabschnitte größtenteils mit sehr gut auszuweisen.

Tab. 4: Ergebnisse der SFI-Bewertung

Millstätter See			
Umfang (m)	26856		
Anzahl der homogenen Abschnitte	25		
Abschnitt mit geringster Länge (m)	93		
Abschnitt mit größter Länge (m)	4142		
Durchschnittslänge der Abschnitte (m)	1074		
Medianwert der Abschnittslängen (m)	799		
Sehr guter Zustand	Abschnitte	Anzahl	5
		Länge (m)	10111
Guter Zustand	Abschnitte	Anzahl	2
		Länge (m)	285
Mäßiger Zustand	Abschnitte	Anzahl	10
		Länge (m)	6755
Unbefriedigender Zustand	Abschnitte	Anzahl	-
		Länge (m)	-
Schlechter Zustand	Abschnitte	Anzahl	9
		Länge (m)	9705
Zustand (gewichtetes Mittel)	**3,0 (mäßig)**		

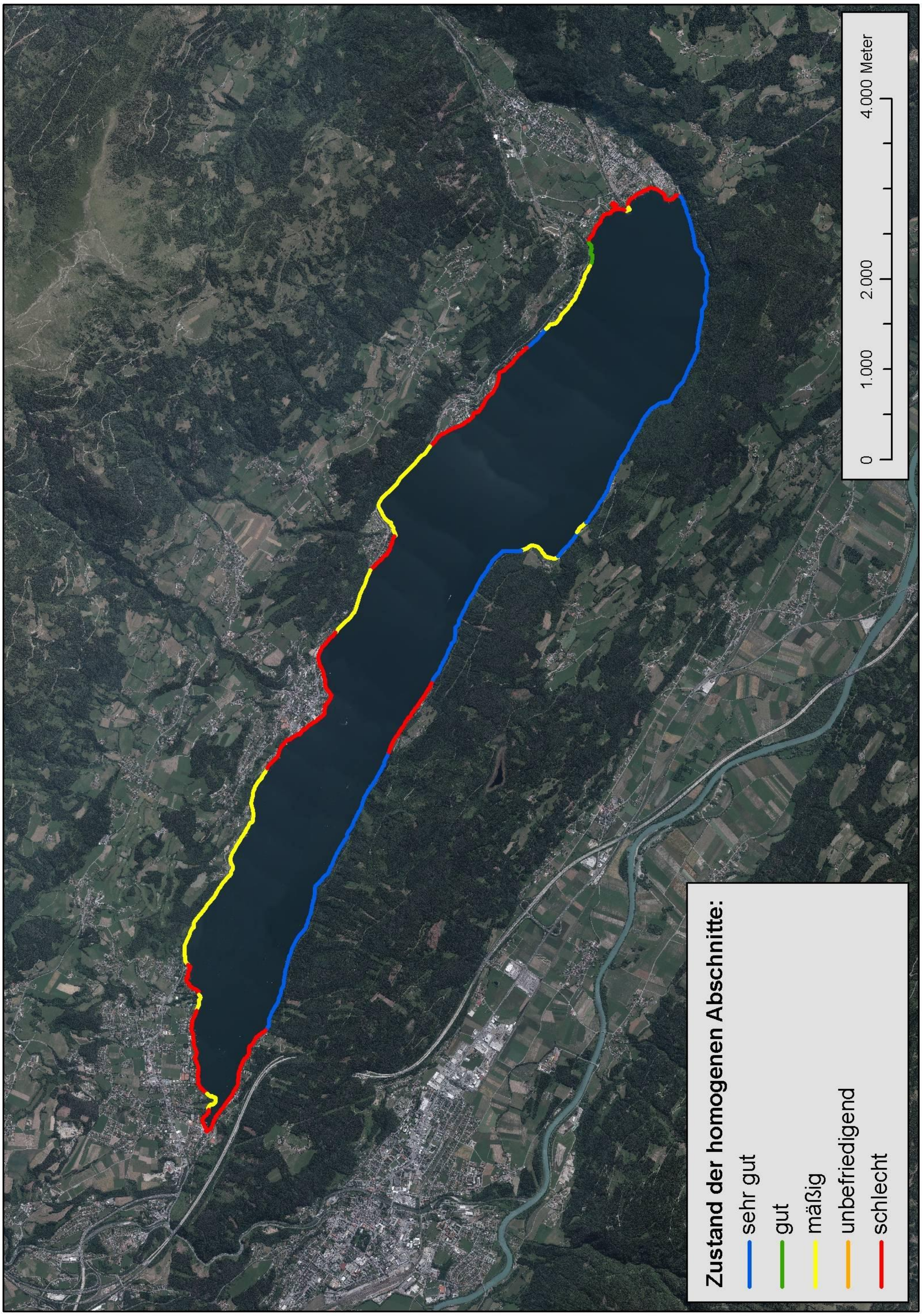

Abb. 7: Kartographische Darstellung der Ergebnisse am Millstätter See

5.2 *Wörthersee*

Der Zustand der Ufer des Wörthersees wurde Ende Juli 2010 bewertet, wobei hauptsächlich auf die Videoaufnahmen zurückgegriffen wurde. Die Ergebnisse wurden im September 2011, nach Veröffentlichung der neuen Version, nachgebessert. Vor Ort Besichtigungen erfolgten lediglich im Laufe des drei-tägigen Workshops Mitte Juli.

Am Wörthersee wurden insgesamt 46.352 Meter, wobei im Laufe der Bewertung vom Bearbeiter 42 unterschiedliche Ufervegetationsabschnitte ausgewiesen wurden. Der kürzeste Abschnitt betrug lediglich 165 m, der längste war mit über 3.900 m mehr als 20-mal so lang.

Tab. 5: Verortung der Abschnittsendpunkte (BMN M31)

See	Abschnitt_ID	Rechtswert	Hochwert
Wörthersee	1	520311	164317
Wörthersee	2	520305	164461
Wörthersee	3	520531	164460
Wörthersee	4	520588	164618
Wörthersee	5	520579	164994
Wörthersee	6	520417	165268
Wörthersee	7	519181	165732
Wörthersee	8	516214	164569
Wörthersee	9	515665	164639
Wörthersee	10	514745	165358
Wörthersee	11	513674	165673
Wörthersee	12	513294	166078
Wörthersee	13	512249	166098
Wörthersee	14	512129	165795
Wörthersee	15	511094	166678
Wörthersee	16	508881	165896
Wörthersee	17	508631	165789
Wörthersee	18	507923	165503
Wörthersee	19	506811	165104
Wörthersee	20	504528	164159
Wörthersee	21	505863	163738
Wörthersee	22	506139	163797
Wörthersee	23	506619	163737
Wörthersee	24	507216	163937
Wörthersee	25	507653	164136
Wörthersee	26	509231	164877
Wörthersee	27	510077	165127
Wörthersee	28	511183	165127
Wörthersee	29	511272	165007
Wörthersee	30	512227	164978
Wörthersee	31	512338	164849
Wörthersee	32	513778	164545
Wörthersee	33	513582	164467
Wörthersee	34	514902	163969
Wörthersee	35	514986	163813
Wörthersee	36	515666	163464

Wörthersee	37	516361	163726
Wörthersee	38	518008	163817
Wörthersee	39	518209	163821
Wörthersee	40	519829	164027
Wörthersee	41	520384	164188
Wörthersee	42	520391	164223

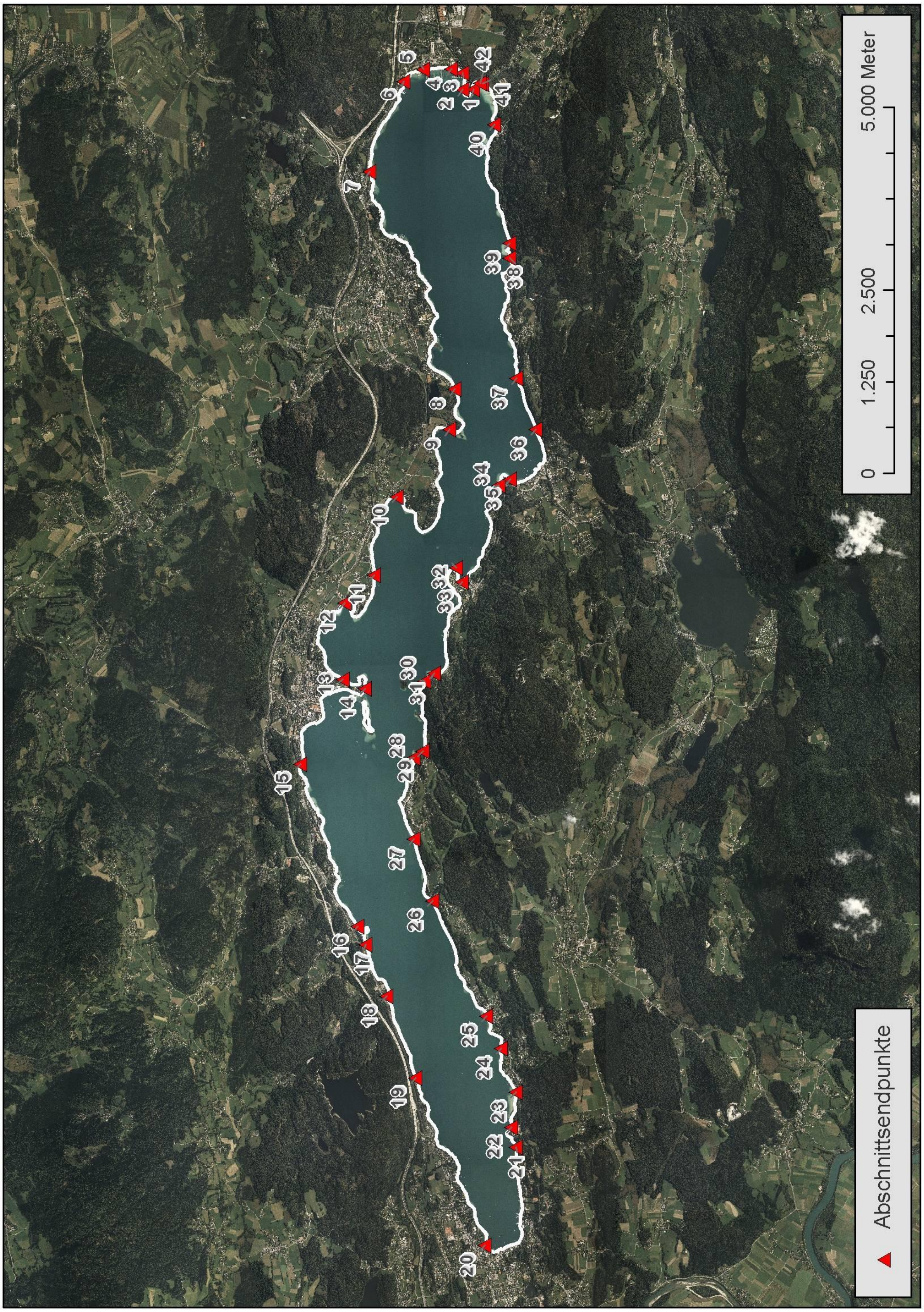

Abb. 8: Abschnitte des Wörthersees

Die SFI - Bewertung erfolgte gegen den Uhrzeigersinn, ausgehend vom Abfluss des Wörthersees. Natürliche oder naturnahe Abschnitte konnten entlang der Ufer des Wörthersees nur im geringen Ausmaß ausgemacht werden (Natura-2000-Gebiet „Lendspitz-Maiernigg“, Naturschutzgebiet „Walterskirchen“). Durch die fast kontinuierliche Verbauung der Uferbereiche (Bundesstraßen, Siedlungsgebiete, Stege, etc.), sowie Eingriffe in die Ufervegetation sind mehr als 80 % des Wörtherseeufers als mäßigen oder schlechter zubewerten. Abschnitte mit der Zustandsklasse 5 („schlecht“) machten fast die Hälfte des Wörtherseeufers aus.

Tab. 6: Ergebnisse der SFI-Bewertung

Wörthersee			
Umfang (m)	46300		
Anzahl der homogenen Abschnitte	42		
Abschnitt mit geringster Länge (m)	165		
Abschnitt mit größter Länge (m)	3967		
Durchschnittslänge der Abschnitte (m)	1102		
Medianwert der Abschnittslängen (m)	919		
Sehr guter Zustand	Abschnitte	Anzahl	8
		Länge (m)	5269
Guter Zustand	Abschnitte	Anzahl	6
		Länge (m)	2294
Mäßiger Zustand	Abschnitte	Anzahl	13
		Länge (m)	17136
Unbefriedigender Zustand	Abschnitte	Anzahl	-
		Länge (m)	-
Schlechter Zustand	Abschnitte	Anzahl	15
		Länge (m)	21601
Zustand (gewichtetes Mittel)	**3,7 (unbefriedigend)**		

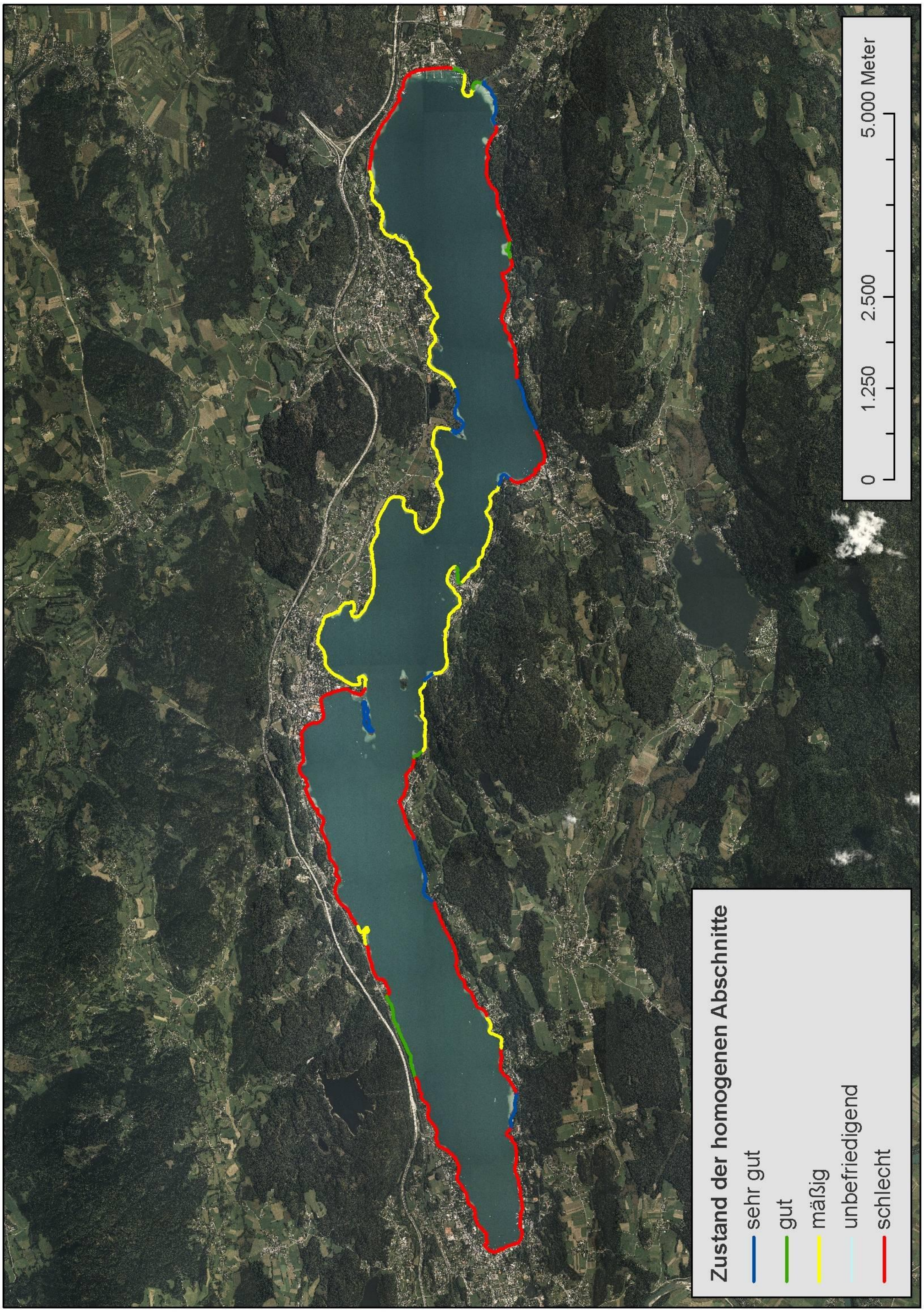

Abb. 9: Kartographische Darstellung der Ergebnisse am Wörthersee

6 Diskussion

Wie aus den Ergebnissen der Bewertung gemäß dem Lake Shorezone Functionality Index (SFI) ersichtlich liegen die Ufer des Wörthersees als auch des Millstätter Sees zum größten Teil in jenen Zustandsklassen, bei denen man von einer großen Abweichung von den erwarteten Grundzuständen ausgeht.

Am Wörthersee konnten lediglich noch 16 % als gut oder besser ausgewiesen werden, während der Prozentsatz am Millstätter See noch bei 38 % lag. Durch die starken anthropogenen Belastungen war die „schlechte“ Zustandsklasse jene, der meisten Seeufermeter zugeteilt wurden.

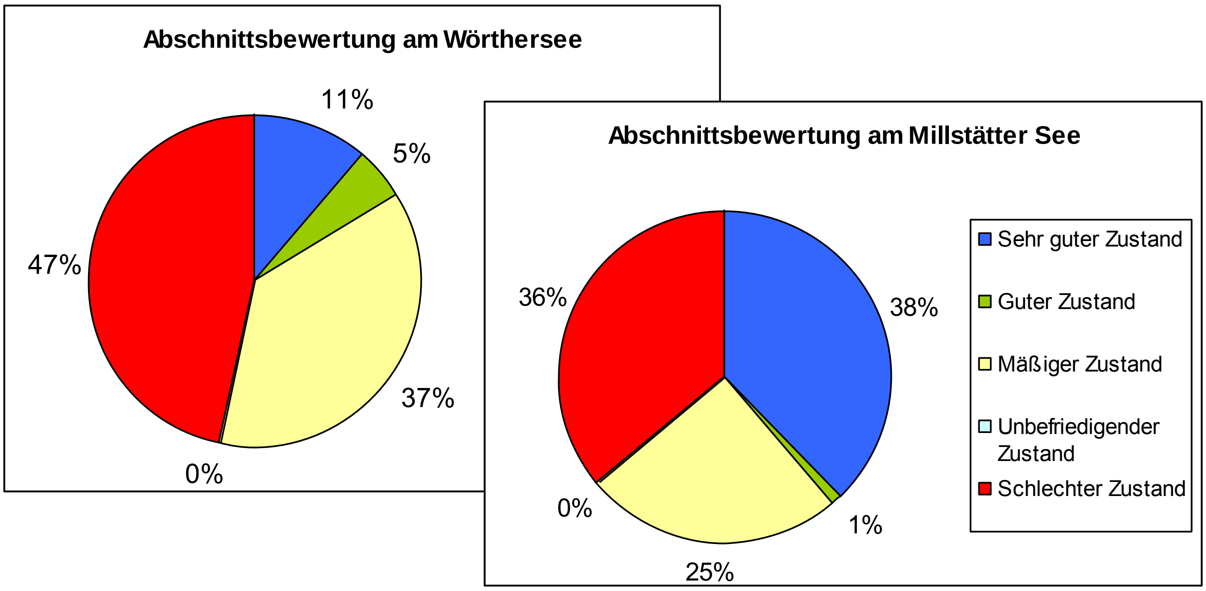

Abb. 10: Darstellung der Ergebnisse in Tortendiagrammen

Beurteilt man den Gesamtzustand der Seen unter Anwendung gewichteter Mittelwerte (eine Prozedur, die in der Methodik allerdings nicht vorgesehen ist), erhält man auch hier Ergebnisse die auf einen „nicht mehr guten“ Zustand der Seen hinweisen. Kann der Millstätter See noch als „mäßig“ bewertet werden, liegt der Wörthersee schon in Bereich des „unbefriedigenden“ Zustands.

Tab. 7: Zusammenfassung der Ergebnisse

	Wörthersee		**Millstätter See**	
Umfang (m)	46300		26856	
Anzahl der homogenen Abschnitte	42		25	
Abschnitt mit geringster Länge (m)	165		93	
Abschnitt mit größter Länge (m)	3967		4142	
Durchschnittslänge der Abschnitte (m)	1102		1074	
Medianwert der Abschnittslängen (m)	919		799	
Abschnitte im sehr guten Zustand	Anzahl	8	Anzahl	5
	Länge (m)	5269	Länge (m)	10111
Abschnitte im guten Zustand	Anzahl	6	Anzahl	1
	Länge (m)	2294	Länge (m)	285
Abschnitte im mäßigen Zustand	Anzahl	13	Anzahl	10
	Länge (m)	17136	Länge (m)	6755
Abschnitte im unbefriedigenden Zustand	Anzahl	0	Anzahl	0
	Länge (m)	0	Länge (m)	0
Abschnitte im schlechten Zustand	Anzahl	15	Anzahl	9
	Länge (m)	21601	Länge (m)	9705
Zustand (gewichtetes Mittel)	**3,7 (unbefriedigend)**		**3,0 (mäßig)**	

Allerdings muss angemerkt werden, dass die Einstufung der Parameter für die einzelnen Uferabschnitten nicht immer klar bzw. eindeutig war und die Fachmeinung der Sachbearbeiter teils deutlich variieren kann.

Darüber hinaus wurden im Bewertungsprozess Umstände angetroffen, in denen die Methodik teils unbefriedigende bzw. nach Meinung des Bearbeiters nicht plausible Resultate lieferte. Auf diese Punkte wird nachfolgend kurz eingegangen:

1) Die Parameter „Konkavität“ bzw. „Konvexität“ der Uferlinie fließen in der Methodik hauptsächlich wegen der Kumulierung bzw. Verteilung von (diffusen und punktuelle) Nährstoffeinträgen aus dem Hinterland in den See ein. Für den Bearbeiter ist es allerdings nicht nachvollziehbar, warum allein die Einbuchtung der Uferlinie automatisch ein Verschlechterung bedeutet, egal ob und welche Nährstoffeinträge aus dem Hinterland zu erwarten sind. Hinzu kommt, dass die Kanalisierung von Straßen- bzw. Haushaltsabwässern nicht in die Methodik einfließt. Der Diskussionsprozess über eine Methodikverbesserungen mit den Autoren ist derzeit noch im laufen.

2) Der Parameter „Breite des Ufervegetationsstreifens“ ist nicht direkt von Bedeutung und fließt nur indirekt in die Bewertung ein. Wir denken aber, da der

Ufervegetationsstreifen eine signifikante Funktions- bzw. Pufferfähigkeit besitzt, seine Ausdehnung sehr wohl direkt in das Bewertungsschema einfließen sollte. Die Autoren (Siligardi et al.) meinen, dass dies ausreichend, wenn auch indirekt über die Parameter „Unterbrechungen“, „Verbauungsgrad der Uferlinie“ und „Präsenz von Straßen“ berücksichtigt wird. Unseren Erachtens ist dies nicht immer befriedigend, eine Anpassung der Methodik erscheint uns notwendig.

3) Des Weiteren sind wir der Ansicht, dass das Bewertungssystem den Parameter „Unterbrechungen“ im Ufervegetationsstreifen (UVS) im Vergleich zu seiner effektiven Ausdehnung überbewertet. Zum Beispiel, ein durch eine Bundesstraße stark geschmälerter UVS wird zum Teil besser bewertet als ein weit breiterer UVS, in dem einige wenige Unterbrechungen, wie einzelne Häuser mit Gärten oder Parkplätze, anzutreffen sind. Auch in diesem Fall erscheinen uns Nachjustierungen des Bewertungssystems sinnvoll.

Im August 2011 wurde eine neue Version der Software veröffentlicht, bei der im Vordergrund aber eher Korrekturen von Programmierungsfehler standen. Veränderungen gab es lediglich beim Parameter „Konkavität“ und der Bewertung der „sehr guten“/ „guten“ Zustandsklassen. Die vollzogenen Änderungen betreffen aber nicht den oben diskutierten Punkt 1), sondern Korrekturen eines Programmierungsfehlers der Software, der uns im Laufe der Auswertungen aufgefallen ist.

Eine Überarbeitung der Methodik mit Neuberechnung des Klassifizierungsbaumes anhand aller bisher erhobenen SFI Datensätzen soll demnächst erfolgen.

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SILIGARDI, M., BERNABI, S., CAPPELLETTI, C., CIUTTI, F., DALLAFIOR, V., DALMIGLIO, A., FABIANI, C., MANCINI, L., MONAUNI, C., POZZI, S., SCARDI, M., TANCIONI, L. & B. ZENNARO: (2010): Lake Shorezone Functionality Index (SFI) – A tool for the definition of ecological quality as indicated by Directive 2000/60/CE. – ISPRA (Istituto Superiore per la Protezione e la Ricerca Ambientale), 73 pp., Trento

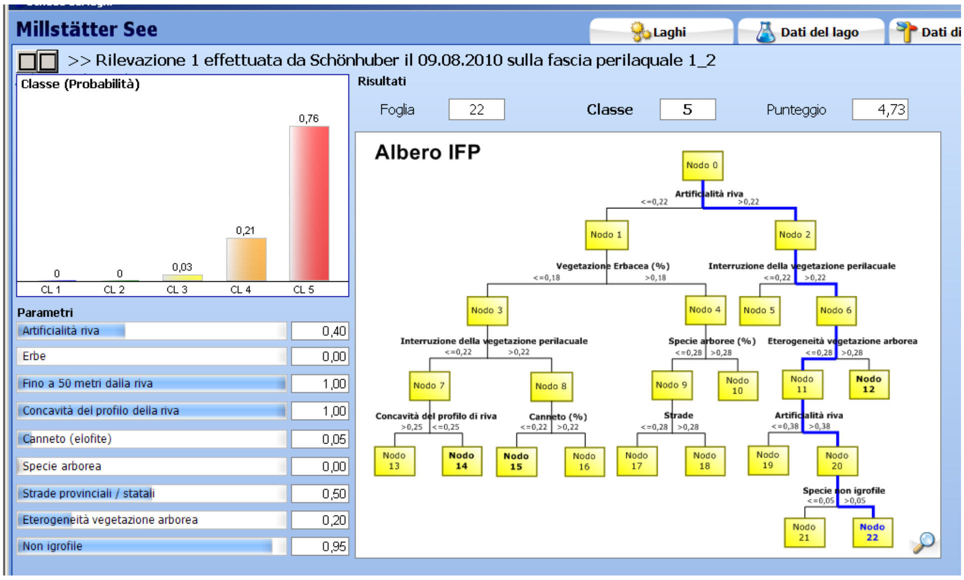
8 Tabellenverzeichnis

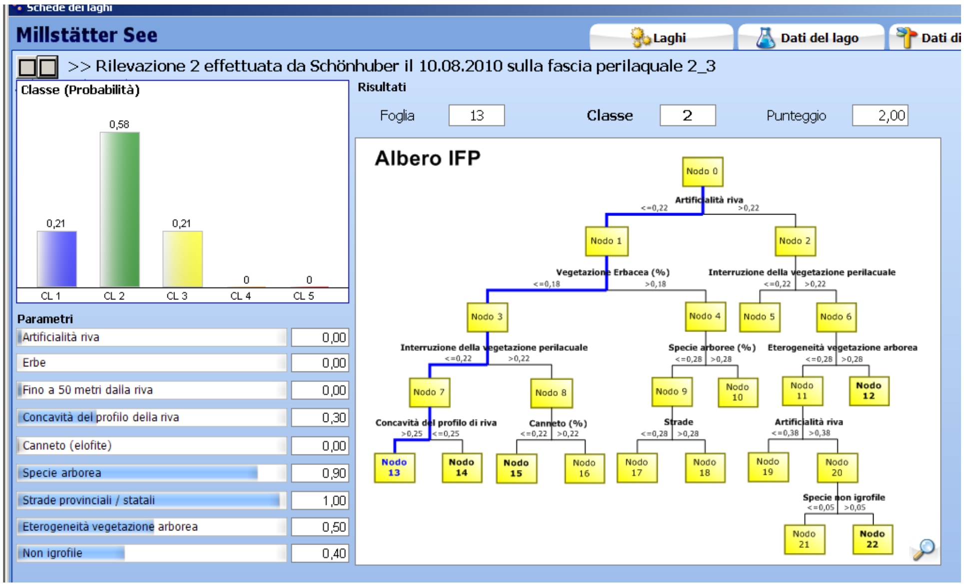
9 Abbildungsverzeichnis

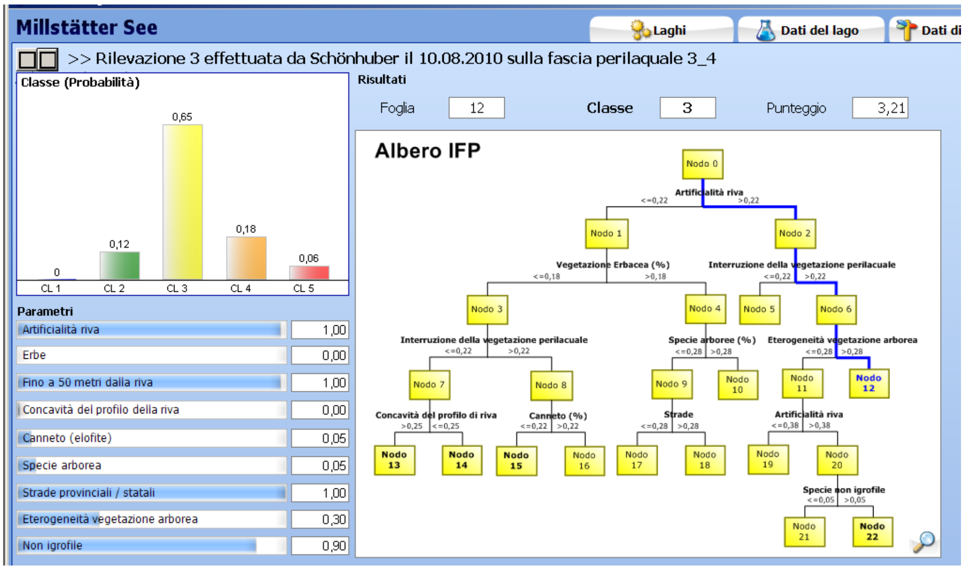
10 Anhang

10.1 Ergebnisblätter

10.1.1 Millstätter See



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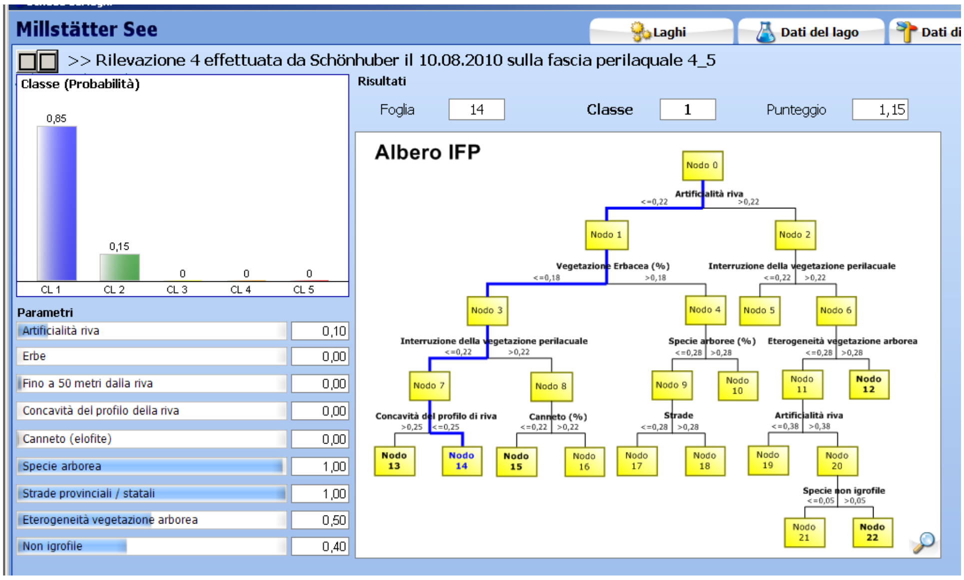
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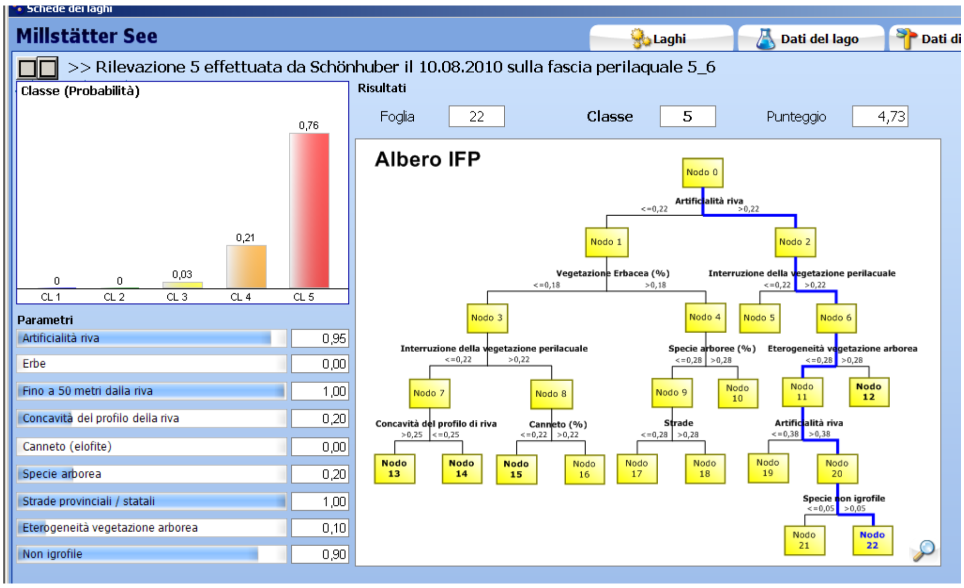
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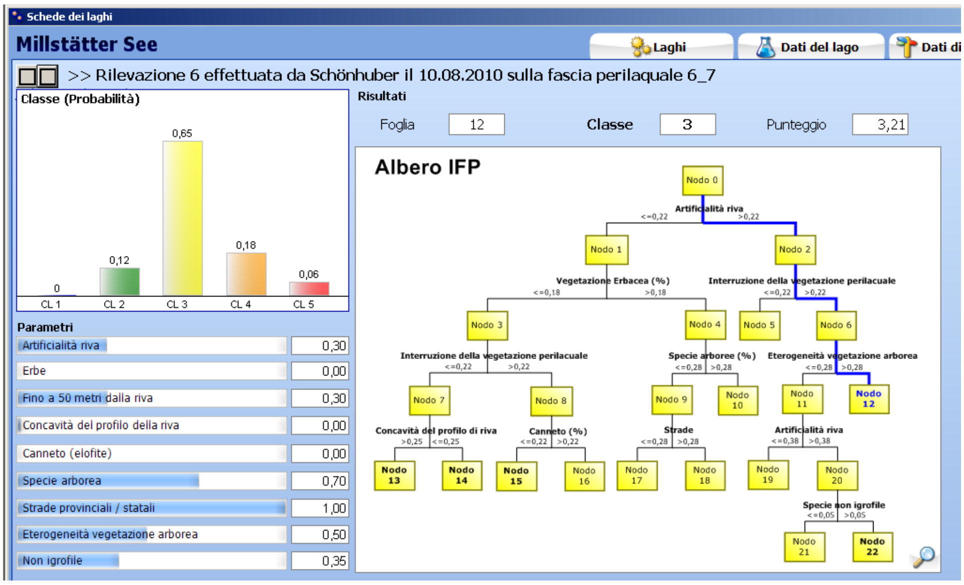
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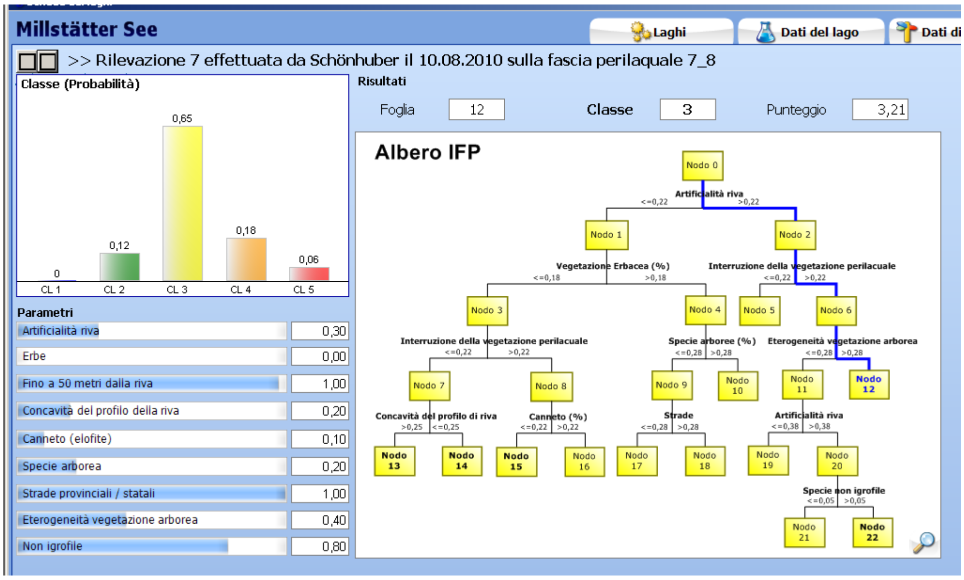
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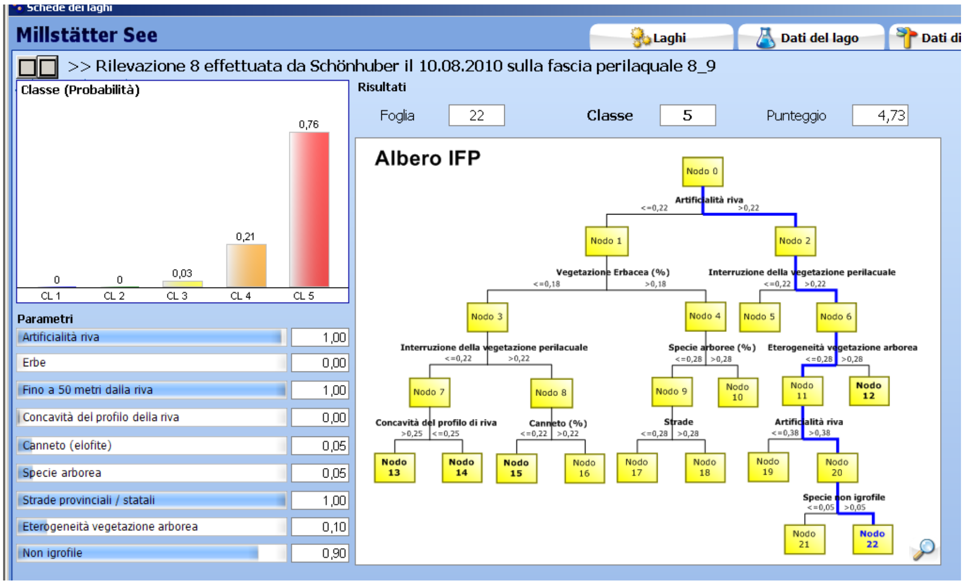
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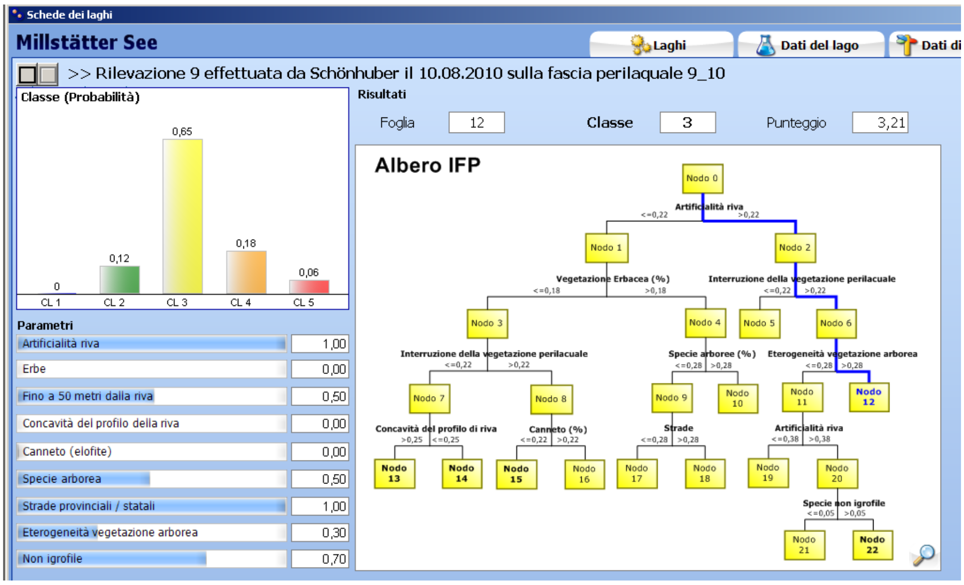
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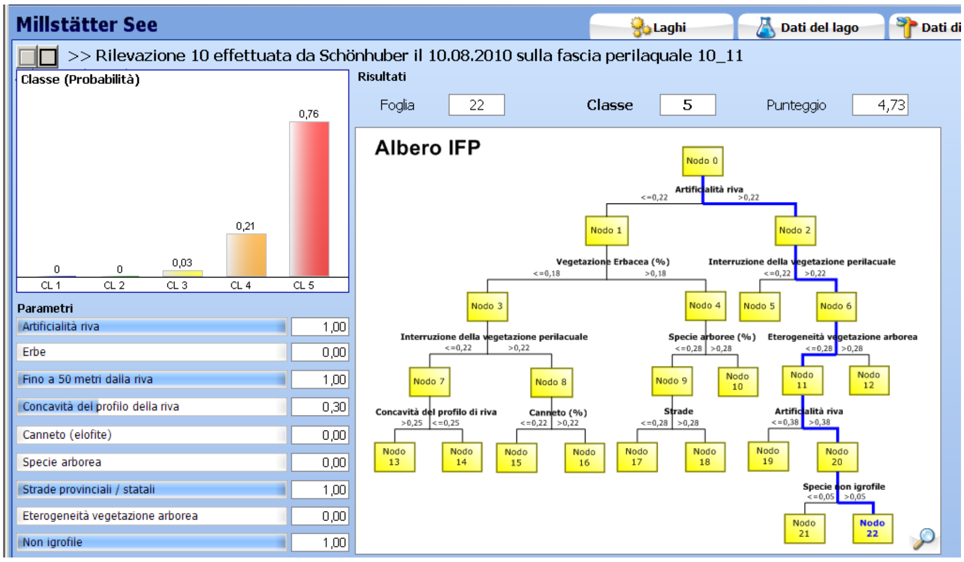
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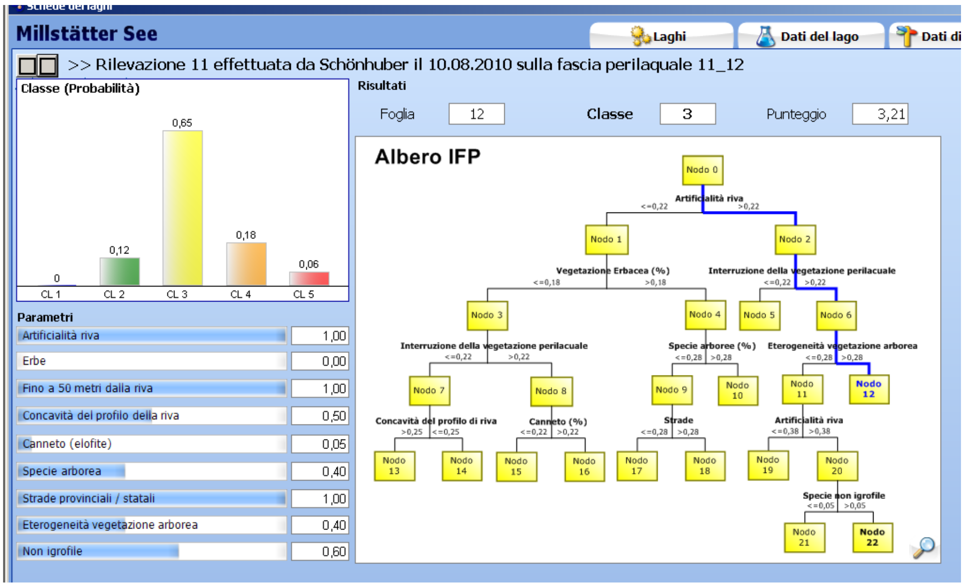
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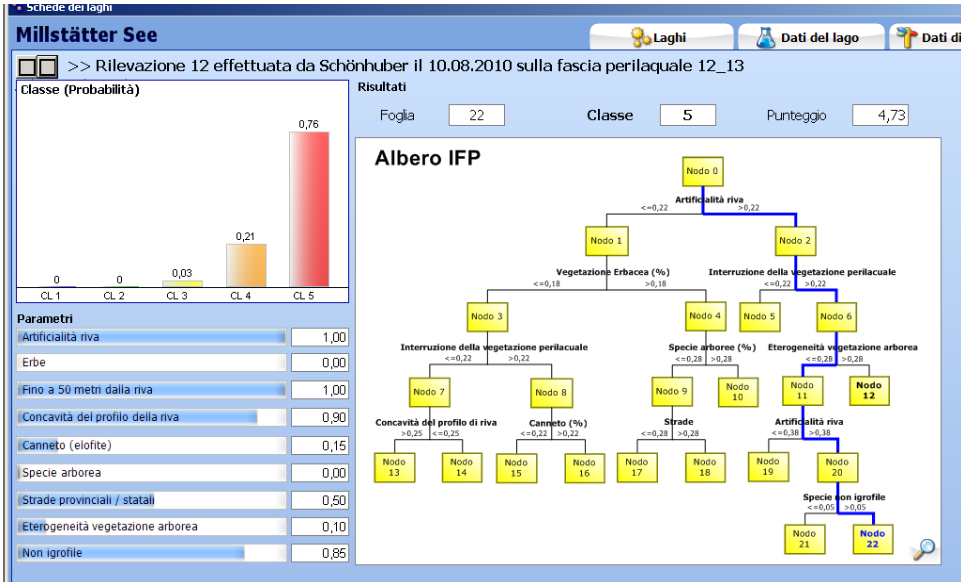
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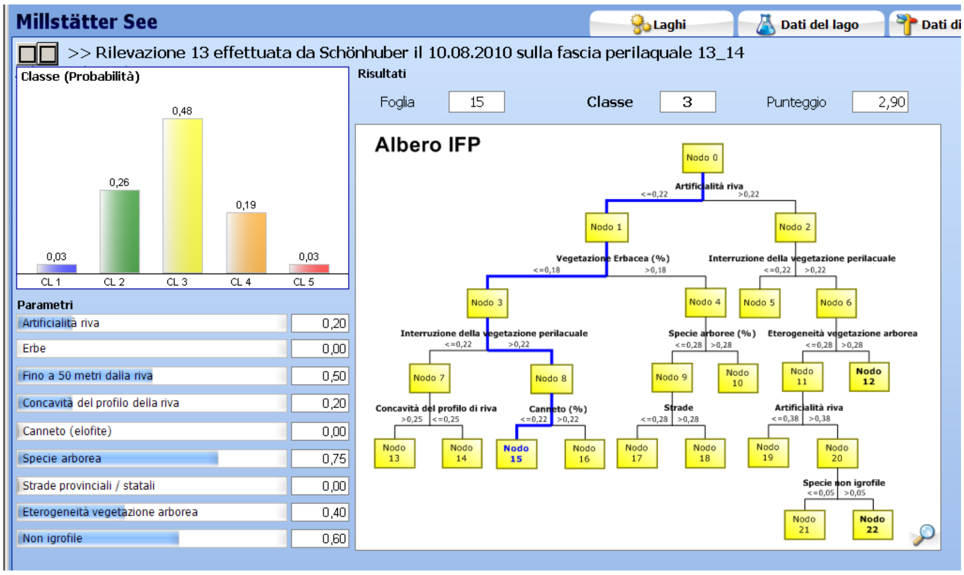
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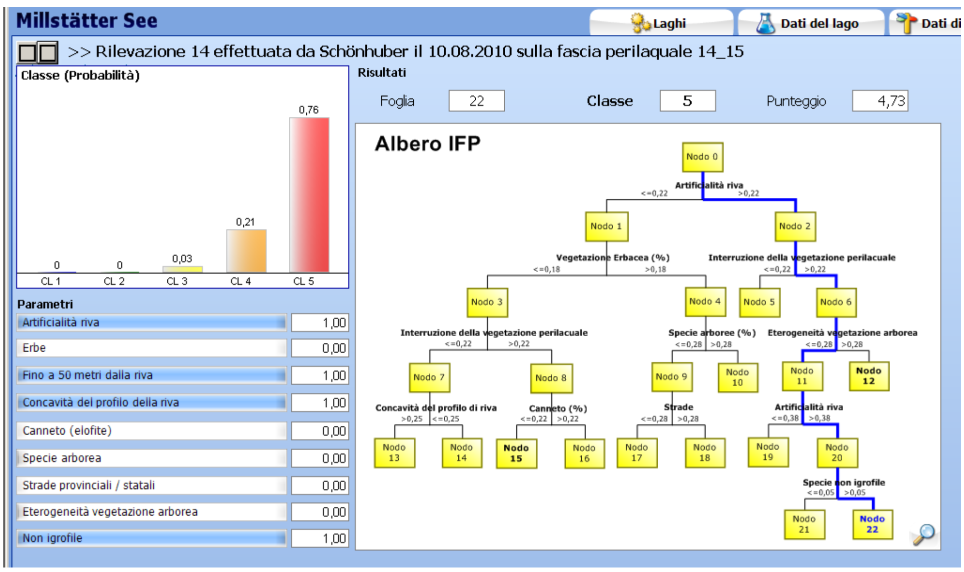
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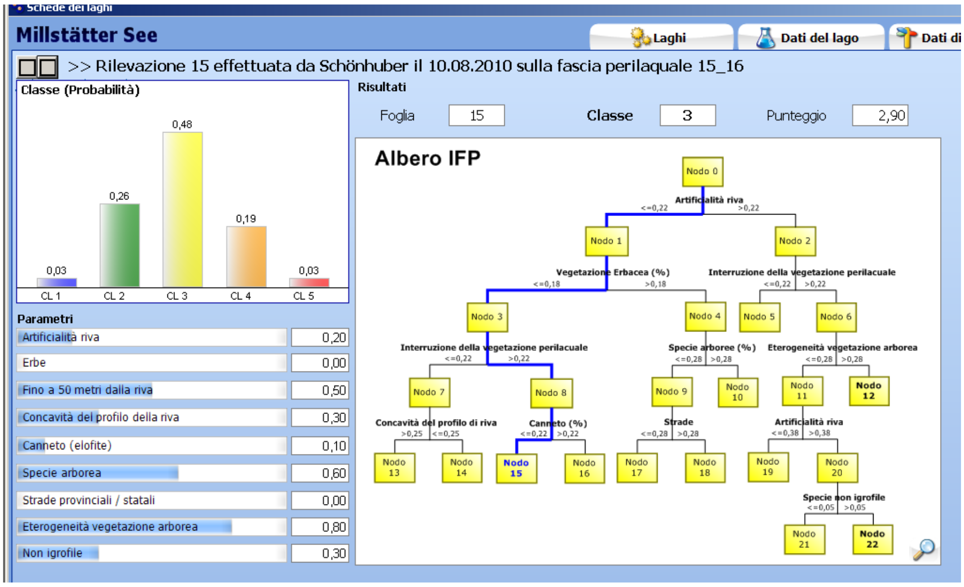
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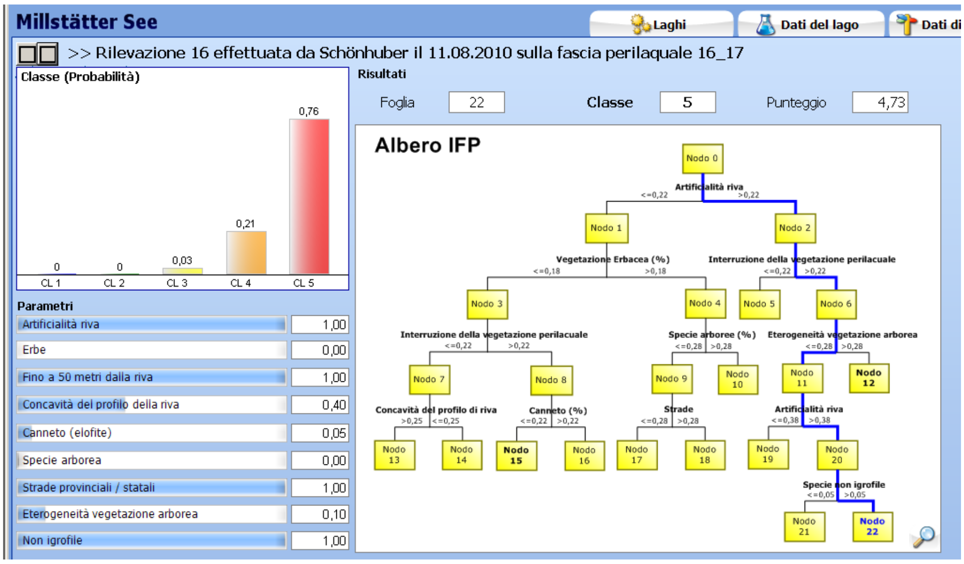
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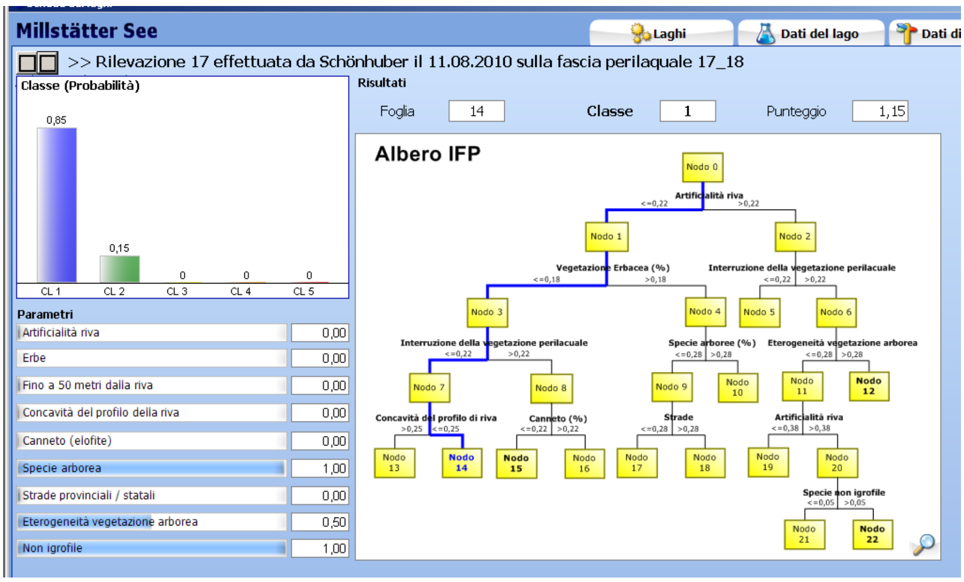
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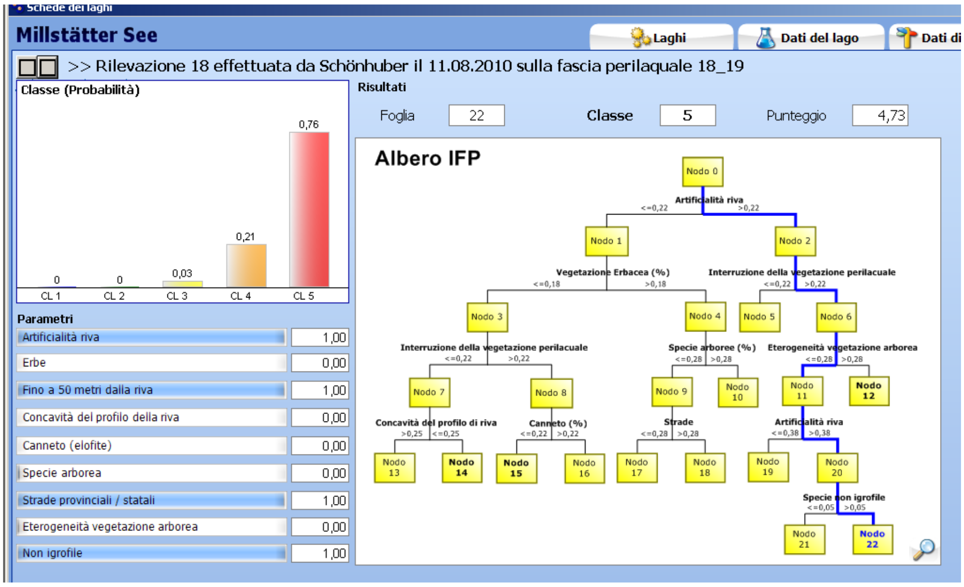
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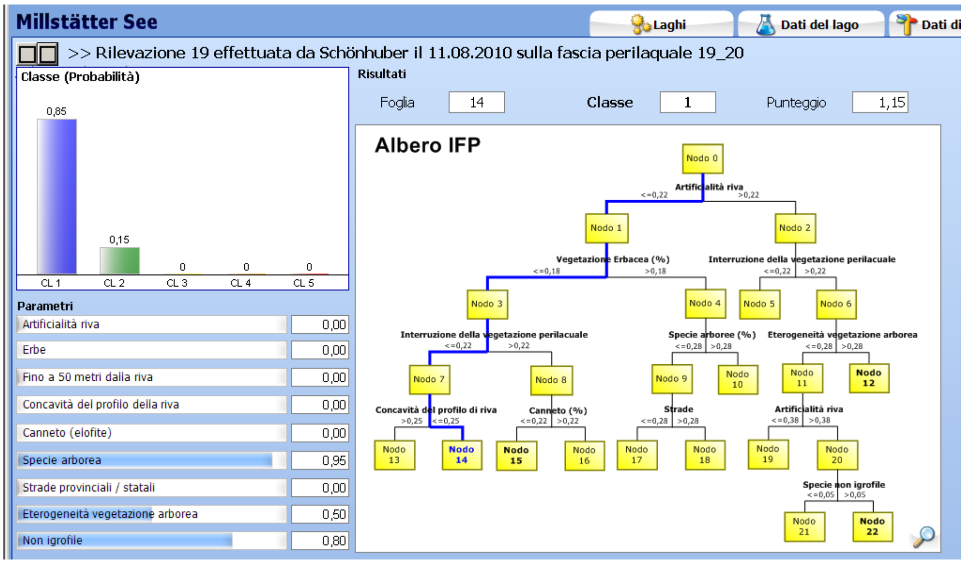
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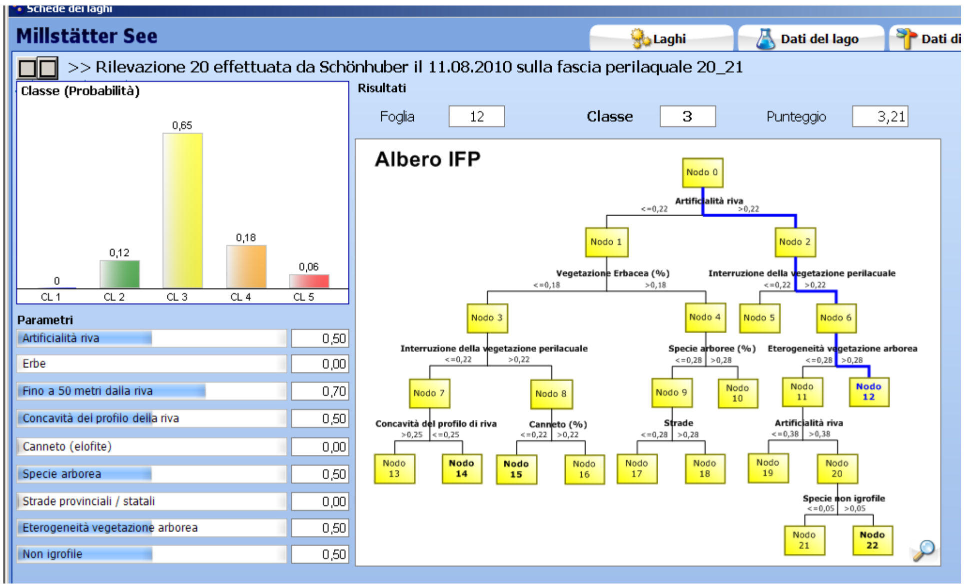
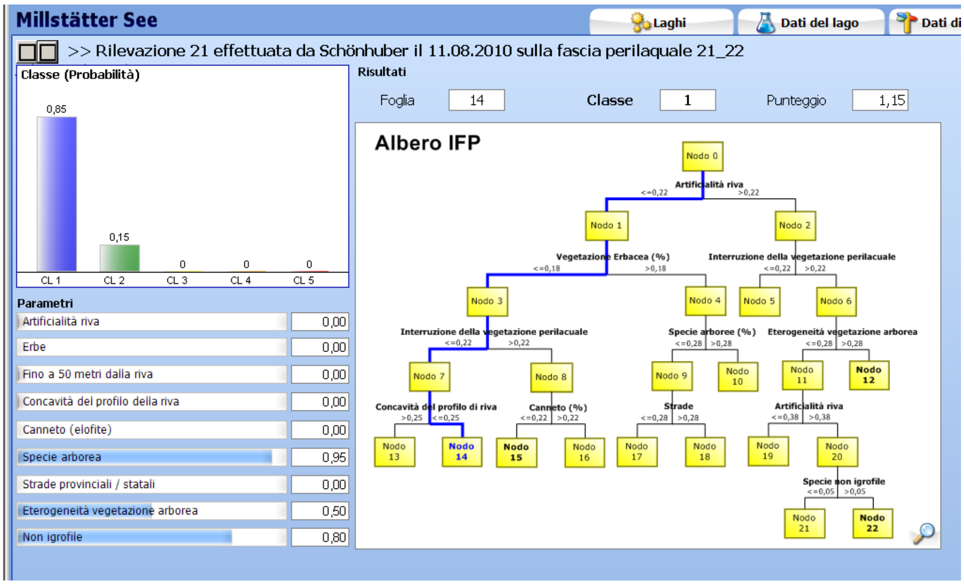
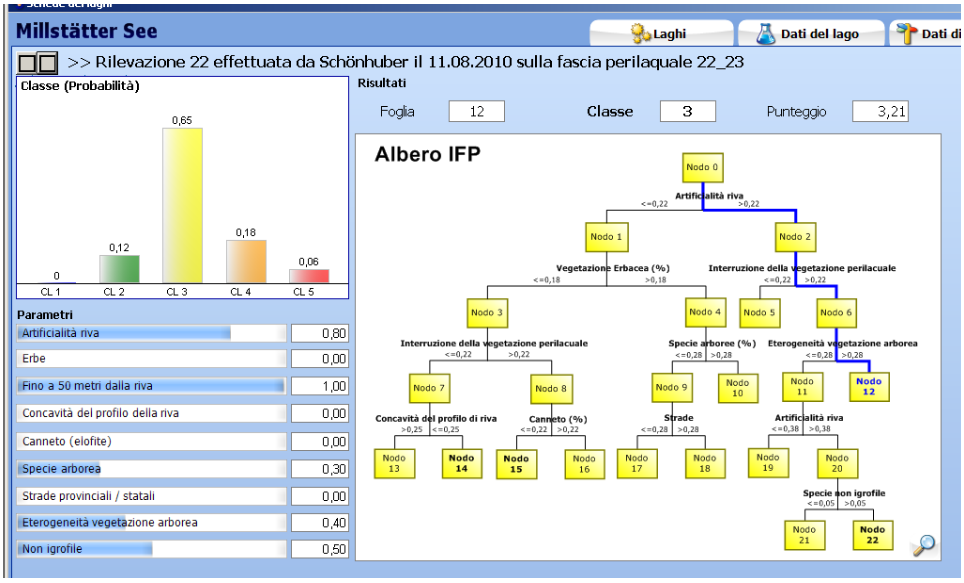
Punteggio 1,15
Albero IFP

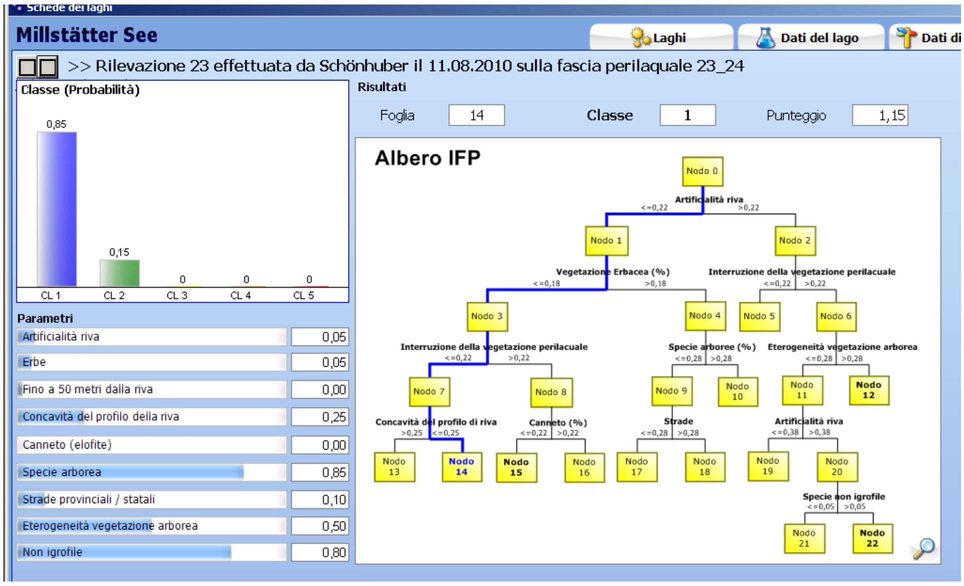

Schede dei laghi
Millstätter See
Laghi
Dati del lago
Dati di
>> Rilevazione 20 effettuata da Schönhuber il 11.08.2010 sulla fascia perilaquale 20_21
Classe (Probabilità)
0
0,12
0,65
0,18
0,06
CL 1
CL 2
CL 3
CL 4
CL 5
Parametri
Artificialità riva 0,50
Erbe 0,00
Fino a 50 metri dalla riva 0,70
Concavità del profilo della riva 0,50
Canneto (elofite) 0,00
Specie arborea 0,50
Strade provinciali / statali 0,00
Eterogeneità vegetazione arborea 0,50
Non igrofile 0,50
Risultati
Foglia 12
Classe 3
Punteggio 3,21
Albero IFP



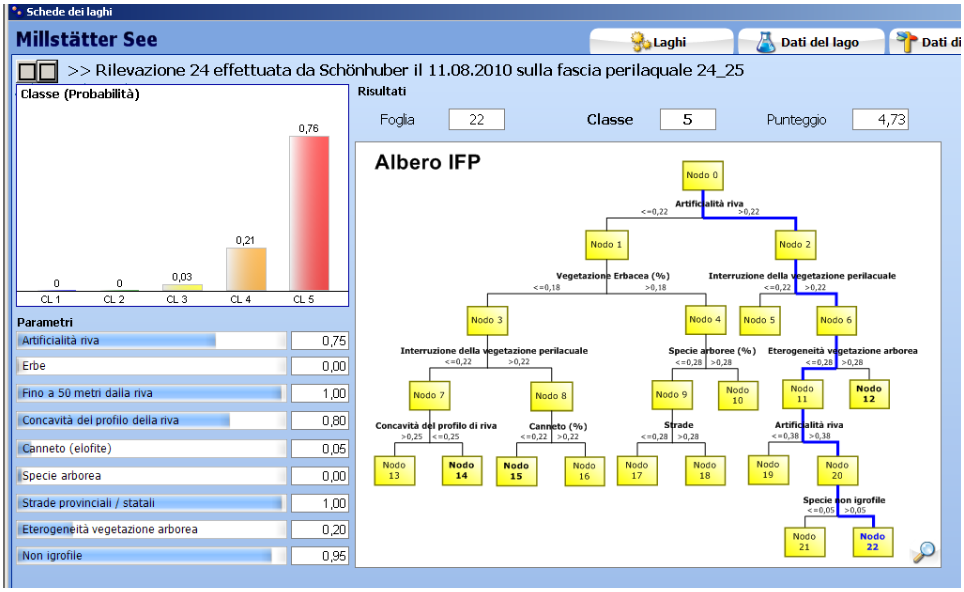
Millstätter See
Laghi
Dati del lago
>> Rilevazione 21 effettuata da Schönhuber il 11.08.2010 sulla fascia perilaquale 21_22
Classe (Probabilità)
0,85
0,15
0
0
0
CL 1
CL 2
CL 3
CL 4
CL 5
Risultati
Foglia 14
Classe 1
Punteggio 1,15
Albero IFP
Parametri
Artificialità riva 0,00
Erbe 0,00
Fino a 50 metri dalla riva 0,00
Concavità del profilo della riva 0,00
Canneto (elofite) 0,00
Specie arboree 0,95
Strade provinciali / statali 0,00
Eterogeneità vegetazione arborea 0,50
Non igrofile 0,80

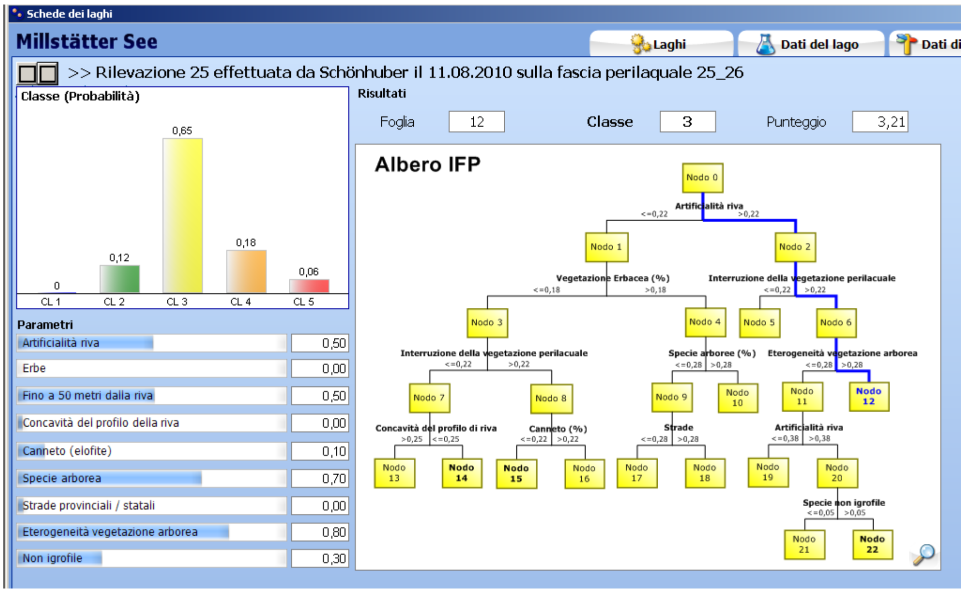


Millstätter See
Laghi
Dati del lago
>> Rilevazione 22 effettuata da Schönhuber il 11.08.2010 sulla fascia perilaquale 22_23
Classe (Probabilità)
0
0,12
0,65
0,18
0,06
CL 1
CL 2
CL 3
CL 4
CL 5
Risultati
Foglia 12
Classe 3
Punteggio 3,21
Albero IFP
Parametri
Artificialità riva 0,80
Erbe 0,00
Fino a 50 metri dalla riva 1,00
Concavità del profilo della riva 0,00
Canneto (elofite) 0,00
Specie arboree 0,30
Strade provinciali / statali 0,00
Eterogeneità vegetazione arborea 0,40
Non igrofile 0,50

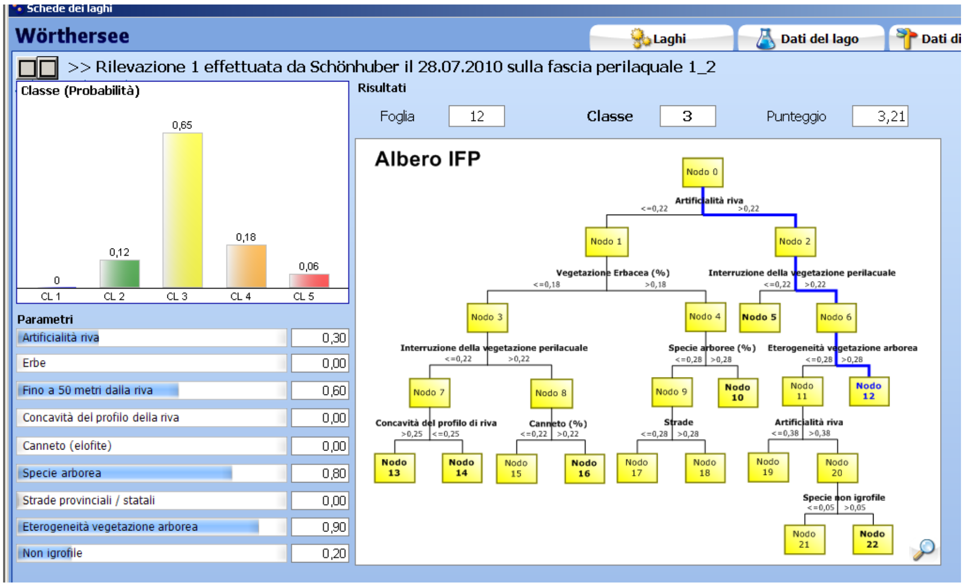


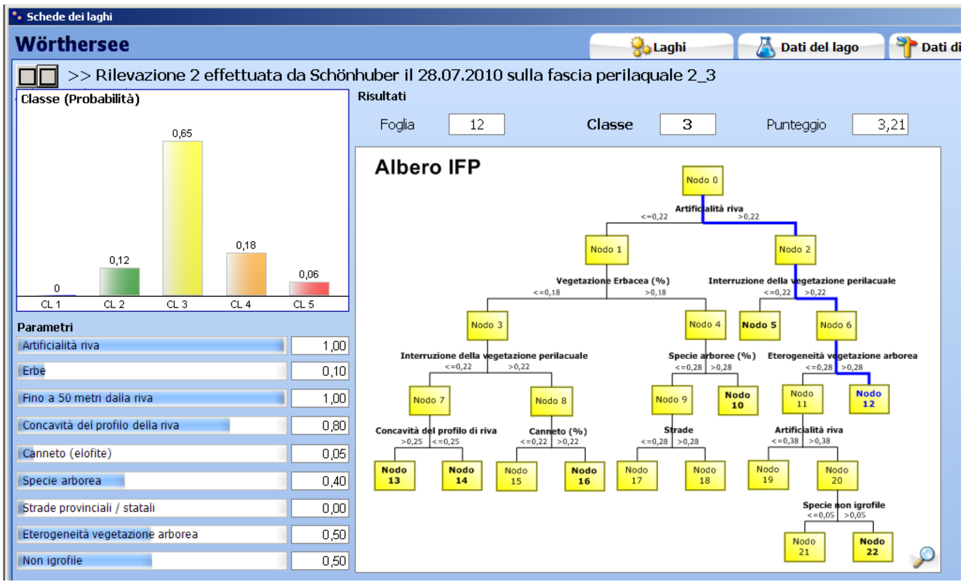
Schede dei laghi
Millstätter See
Laghi
Dati del lago
>> Rilevazione 23 effettuata da Schönhuber il 11.08.2010 sulla fascia perilaquale 23_24
Classe (Probabilità)
0,85
0,15
0
0
0
CL 1
CL 2
CL 3
CL 4
CL 5
Risultati
Foglia 14
Classe 1
Punteggio 1,15
Albero IFP
Parametri
Artificialità riva 0,05
Erbe 0,05
Fino a 50 metri dalla riva 0,00
Concavità del profilo della riva 0,25
Canneto (elofite) 0,00
Specie arboree 0,85
Strade provinciali / statali 0,10
Eterogeneità vegetazione arborea 0,50
Non igrofile 0,80

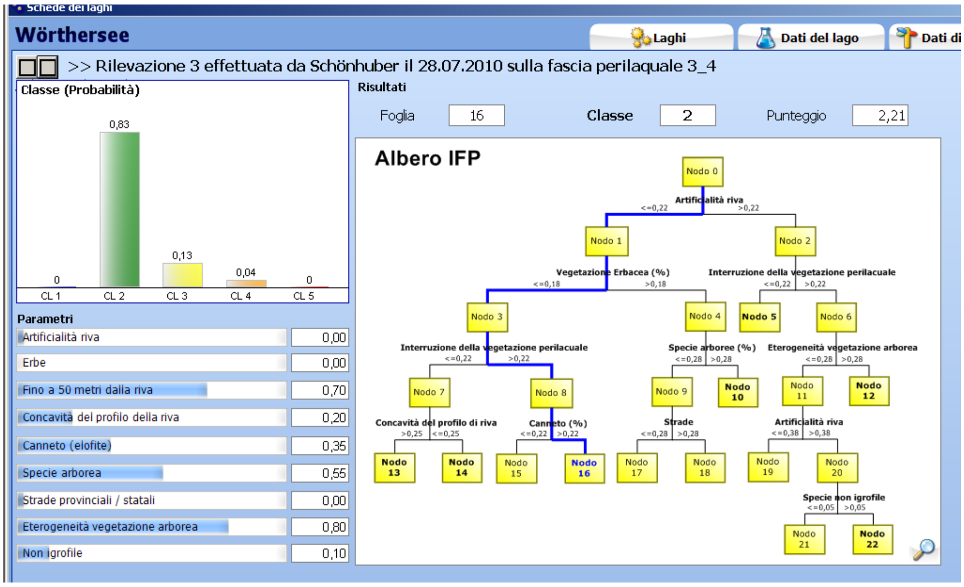

Schede dei laghi
Millstätter See
Laghi
Dati del lago
Dati di
>> Rilevazione 24 effettuata da Schönhuber il 11.08.2010 sulla fascia perilaquale 24_25
Classe (Probabilità)
0
0
0,03
0,21
0,76
CL 1
CL 2
CL 3
CL 4
CL 5
Parametri
Artificialità riva 0,75
Erbe 0,00
Fino a 50 metri dalla riva 1,00
Concavità del profilo della riva 0,80
Canneto (elofite) 0,05
Specie arborea 0,00
Strade provinciali / statali 1,00
Eterogeneità vegetazione arborea 0,20
Non igrofile 0,95
Risultati
Foglia 22
Classe 5
Punteggio 4,73
Albero IFP
Artificialità riva
Vegetazione Erbacea (%)
Interruzione della vegetazione perilacuale
Specie arboree (%)
Eterogeneità vegetazione arborea
Concavità del profilo di riva
Canneto (%)
Strade
Specie non igrofile

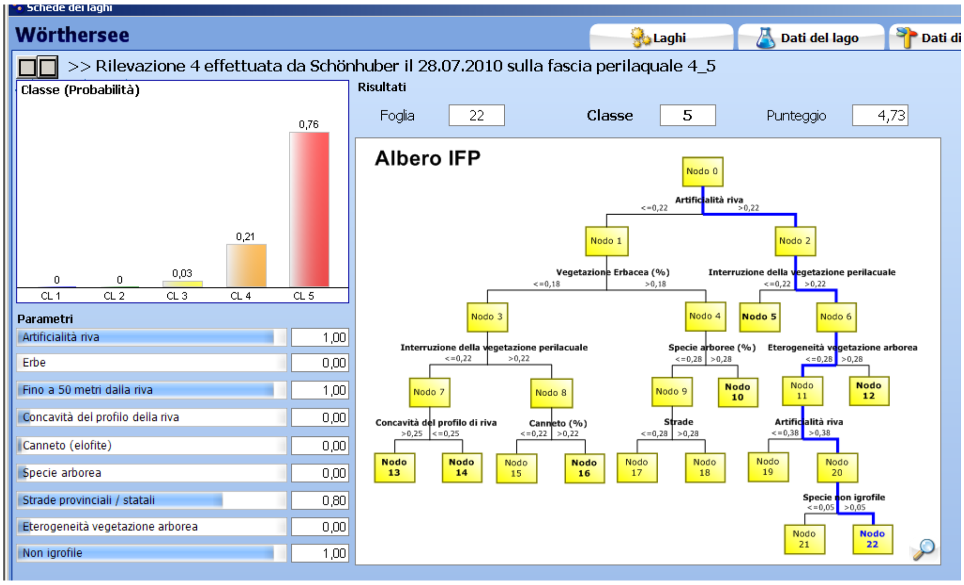

Schede dei laghi
Millstätter See
Laghi
Dati del lago
Dati di
>> Rilevazione 25 effettuata da Schönhuber il 11.08.2010 sulla fascia perilaquale 25_26
Classe (Probabilità)
0
0,12
0,65
0,18
0,06
CL 1
CL 2
CL 3
CL 4
CL 5
Parametri
Artificialità riva 0,50
Erbe 0,00
Fino a 50 metri dalla riva 0,50
Concavità del profilo della riva 0,00
Canneto (elofite) 0,10
Specie arborea 0,70
Strade provinciali / statali 0,00
Eterogeneità vegetazione arborea 0,80
Non igrofile 0,30
Risultati
Foglia 12
Classe 3
Punteggio 3,21
Albero IFP
Artificialità riva
Vegetazione Erbacea (%)
Interruzione della vegetazione perilacuale
Specie arboree (%)
Eterogeneità vegetazione arborea
Concavità del profilo di riva
Canneto (%)
Strade
Specie non igrofile

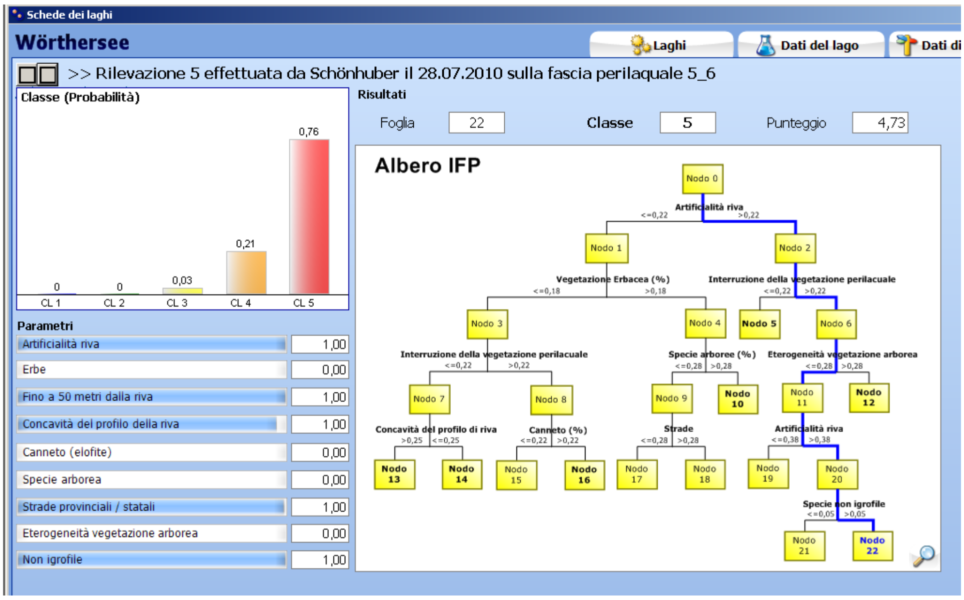
10.1.2 Wörthersee

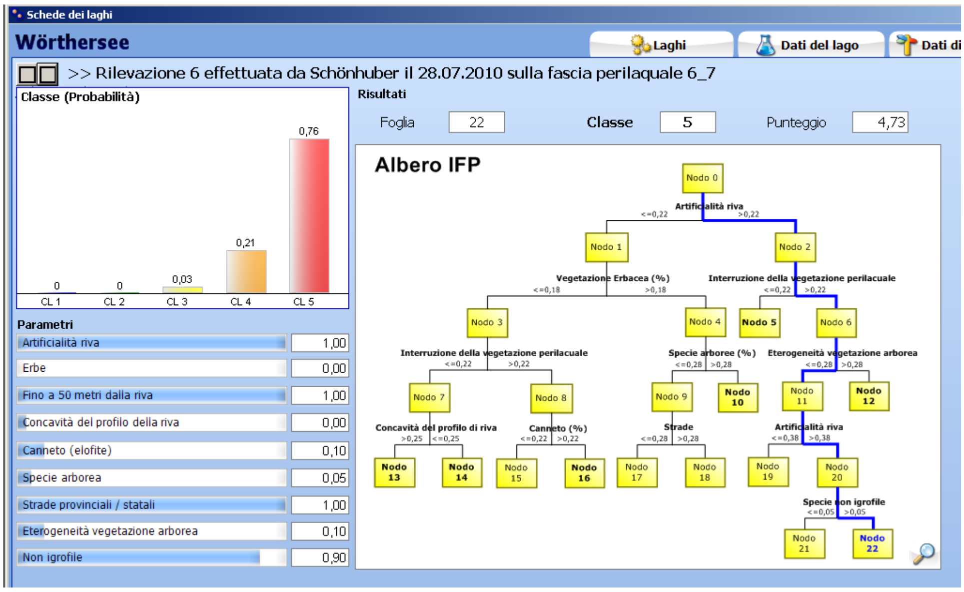


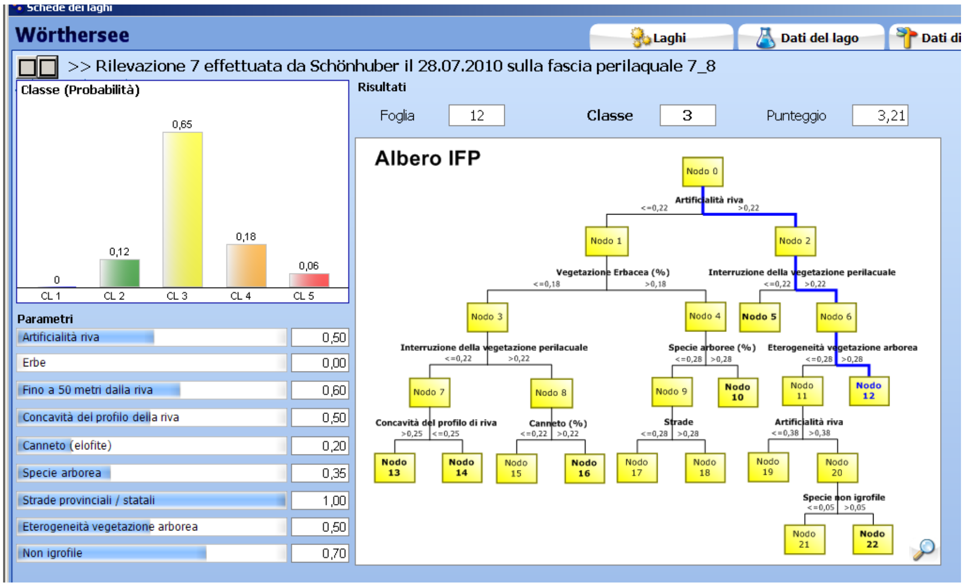


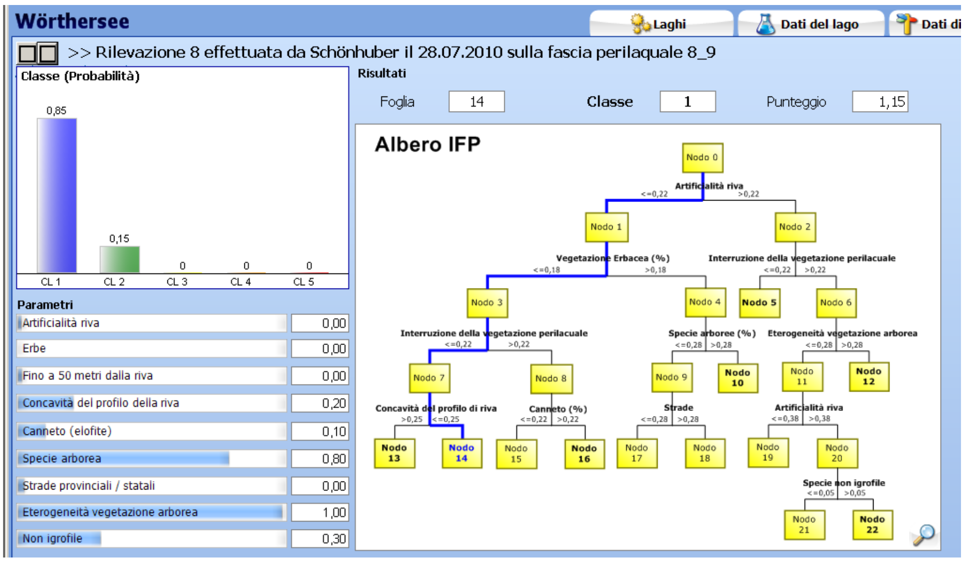

Schede dei laghi
Wörthersee
Laghi
Dati del lago
Dati di
>> Rilevazione 3 effettuata da Schönhuber il 28.07.2010 sulla fascia perilaquale 3_4
Classe (Probabilità)
0,83
0,13
0,04
0
0
CL 1
CL 2
CL 3
CL 4
CL 5
Risultati
Foglia 16
Classe 2
Punteggio 2,21
Albero IFP
Parametri
Artificialità riva 0,00
Erbe 0,00
Fino a 50 metri dalla riva 0,70
Concavità del profilo della riva 0,20
Canneto (elofite) 0,35
Specie arborea 0,55
Strade provinciali / statali 0,00
Eterogeneità vegetazione arborea 0,80
Non igrofile 0,10

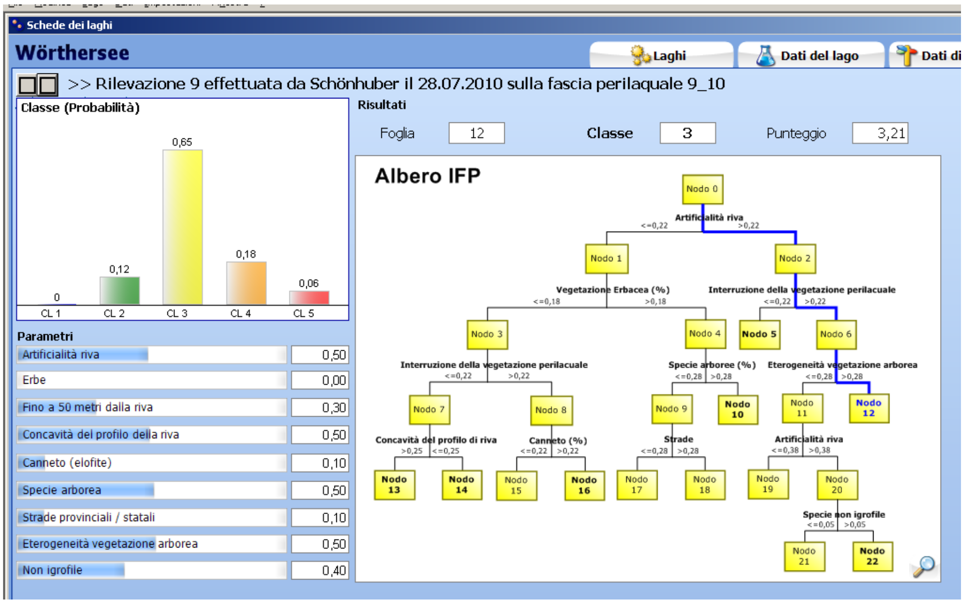

Schede dei laghi
Wörthersee
Laghi
Dati del lago
Dati di
>> Rilevazione 4 effettuata da Schönhuber il 28.07.2010 sulla fascia perilaquale 4_5
Classe (Probabilità)
0
0
0,03
0,21
0,76
CL 1
CL 2
CL 3
CL 4
CL 5
Risultati
Foglia 22
Classe 5
Punteggio 4,73
Albero IFP
Parametri
Artificialità riva 1,00
Erbe 0,00
Fino a 50 metri dalla riva 1,00
Concavità del profilo della riva 0,00
Canneto (elofite) 0,00
Specie arborea 0,00
Strade provinciali / statali 0,80
Eterogeneità vegetazione arborea 0,00
Non igrofile 1,00

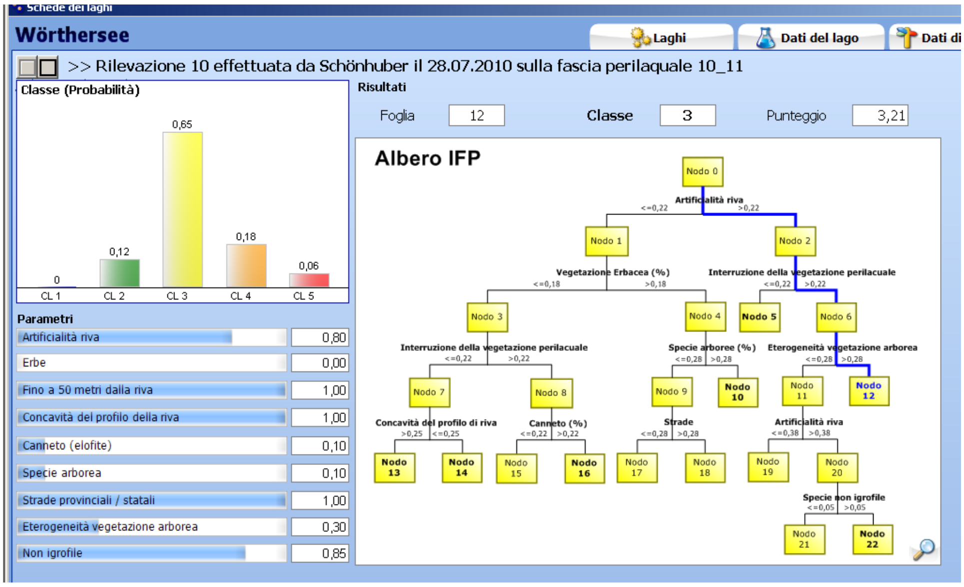

Schede dei laghi
Wörthersee
Laghi
Dati del lago
Dati di
>> Rilevazione 5 effettuata da Schönhuber il 28.07.2010 sulla fascia perilaquale 5_6
Classe (Probabilità)
0
0
0,03
0,21
0,76
CL 1
CL 2
CL 3
CL 4
CL 5
Risultati
Foglia 22
Classe 5
Punteggio 4,73
Albero IFP
Parametri
Artificialità riva 1,00
Erbe 0,00
Fino a 50 metri dalla riva 1,00
Concavità del profilo della riva 1,00
Canneto (elofite) 0,00
Specie arborea 0,00
Strade provinciali / statali 1,00
Eterogeneità vegetazione arborea 0,00
Non igrofile 1,00

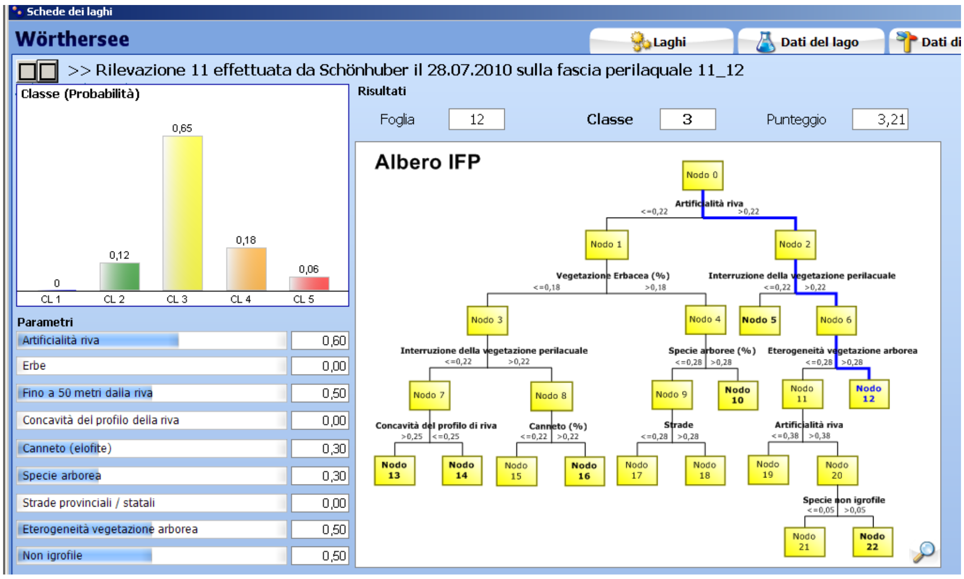

Schede dei laghi
Wörthersee
Laghi
Dati del lago
>> Rilevazione 6 effettuata da Schönhuber il 28.07.2010 sulla fascia perilaquale 6_7
Classe (Probabilità)
0
0
0,03
0,21
0,76
CL 1
CL 2
CL 3
CL 4
CL 5
Risultati
Foglia 22
Classe 5
Punteggio 4,73
Albero IFP
Parametri
Artificialità riva 1,00
Erbe 0,00
Fino a 50 metri dalla riva 1,00
Concavità del profilo della riva 0,00
Canneto (elofite) 0,10
Specie arborea 0,05
Strade provinciali / statali 1,00
Eterogeneità vegetazione arborea 0,10
Non igrofile 0,90

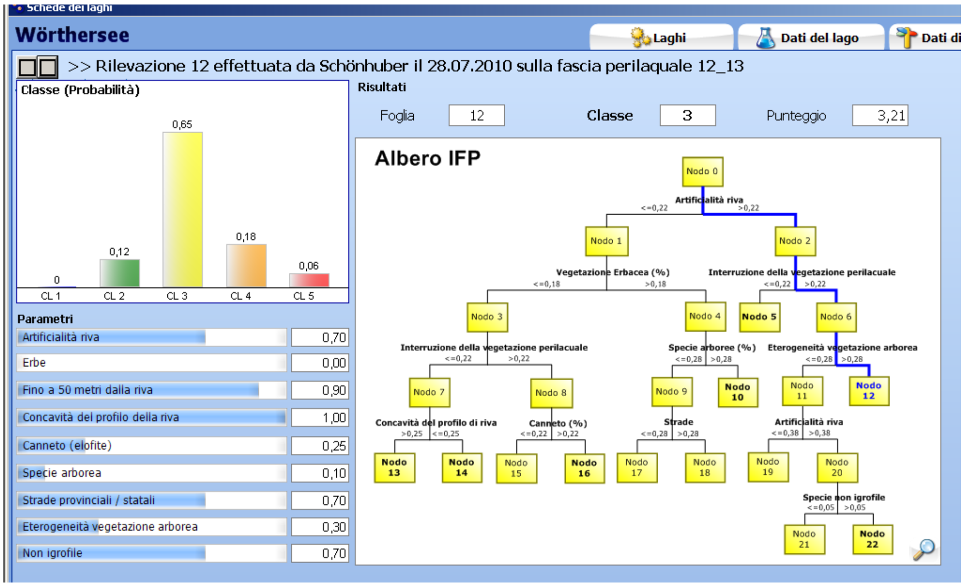

Schede dei laghi
Wörthersee
Laghi
Dati del lago
>> Rilevazione 7 effettuata da Schönhuber il 28.07.2010 sulla fascia perilaquale 7_8
Classe (Probabilità)
0
0,12
0,65
0,18
0,06
CL 1
CL 2
CL 3
CL 4
CL 5
Risultati
Foglia 12
Classe 3
Punteggio 3,21
Albero IFP
Parametri
Artificialità riva 0,50
Erbe 0,00
Fino a 50 metri dalla riva 0,60
Concavità del profilo della riva 0,50
Canneto (elofite) 0,20
Specie arborea 0,35
Strade provinciali / statali 1,00
Eterogeneità vegetazione arborea 0,50
Non igrofile 0,70

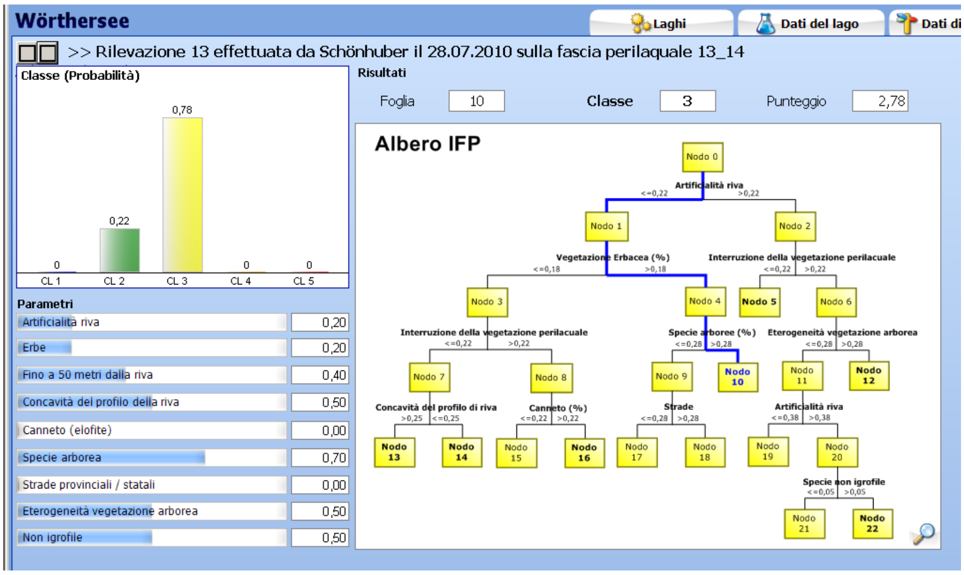

Wörthersee
Laghi
Dati del lago
>> Rilevazione 8 effettuata da Schönhuber il 28.07.2010 sulla fascia perilaquale 8_9
Classe (Probabilità)
0,85
0,15
0
0
0
CL 1
CL 2
CL 3
CL 4
CL 5
Risultati
Foglia 14
Classe 1
Punteggio 1,15
Albero IFP
Parametri
Artificialità riva 0,00
Erbe 0,00
Fino a 50 metri dalla riva 0,00
Concavità del profilo della riva 0,20
Canneto (elofite) 0,10
Specie arborea 0,80
Strade provinciali / statali 0,00
Eterogeneità vegetazione arborea 1,00
Non igrofile 0,30

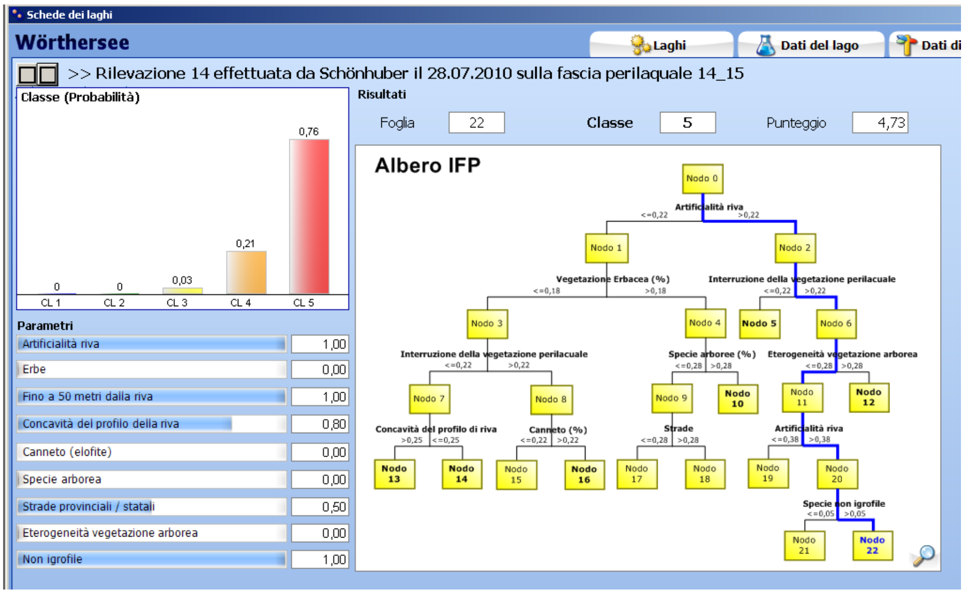

Schede dei laghi
Wörthersee
Laghi
Dati del lago
Dati di
>> Rilevazione 9 effettuata da Schönhuber il 28.07.2010 sulla fascia perilaquale 9_10
Classe (Probabilità)
0
0,12
0,65
0,18
0,06
CL 1
CL 2
CL 3
CL 4
CL 5
Risultati
Foglia 12
Classe 3
Punteggio 3,21
Albero IFP
Parametri
Artificialità riva 0,50
Erbe 0,00
Fino a 50 metri dalla riva 0,30
Concavità del profilo della riva 0,50
Canneto (elofite) 0,10
Specie arboree 0,50
Strade provinciali / statali 0,10
Eterogeneità vegetazione arborea 0,50
Non igrofile 0,40

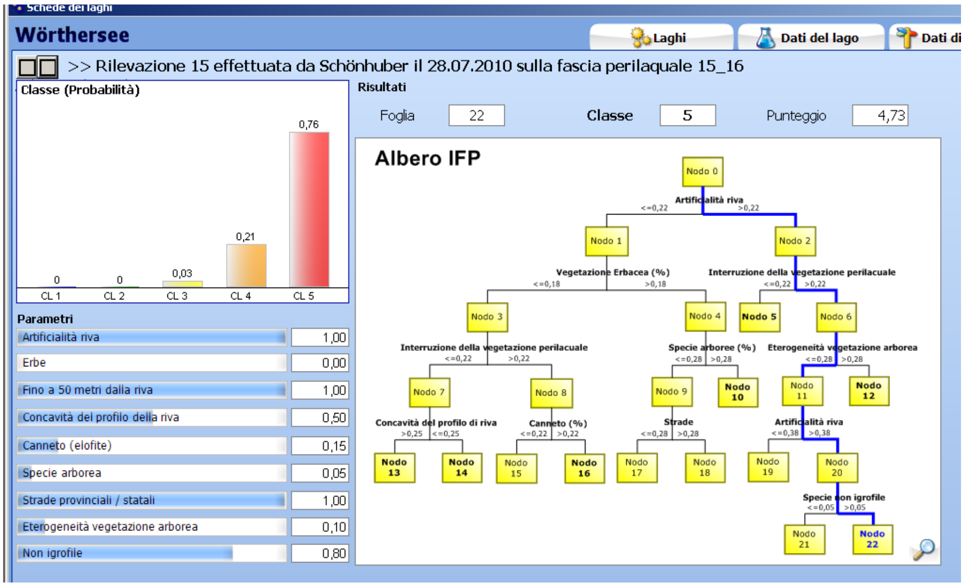

Schede dei laghi
Wörthersee
Laghi
Dati del lago
Dati di
>> Rilevazione 10 effettuata da Schönhuber il 28.07.2010 sulla fascia perilaquale 10_11
Classe (Probabilità)
0
0,12
0,65
0,18
0,06
CL 1
CL 2
CL 3
CL 4
CL 5
Risultati
Foglia 12
Classe 3
Punteggio 3,21
Albero IFP
Parametri
Artificialità riva 0,80
Erbe 0,00
Fino a 50 metri dalla riva 1,00
Concavità del profilo della riva 1,00
Canneto (elofite) 0,10
Specie arboree 0,10
Strade provinciali / statali 1,00
Eterogeneità vegetazione arborea 0,30
Non igrofile 0,85

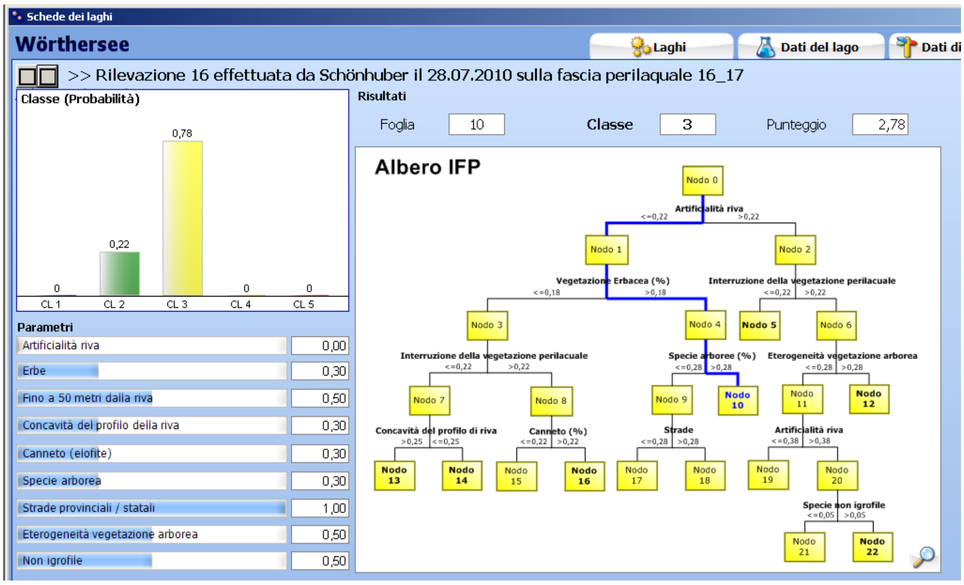

Schede dei laghi
Wörthersee
Laghi
Dati del lago
Dati di
>> Rilevazione 11 effettuata da Schönhuber il 28.07.2010 sulla fascia perilaquale 11_12
Classe (Probabilità)
0
0,12
0,65
0,18
0,06
CL 1
CL 2
CL 3
CL 4
CL 5
Risultati
Foglia 12
Classe 3
Punteggio 3,21
Albero IFP
Parametri
Artificialità riva 0,60
Erbe 0,00
Fino a 50 metri dalla riva 0,50
Concavità del profilo della riva 0,00
Canneto (elofite) 0,30
Specie arboree 0,30
Strade provinciali / statali 0,00
Eterogeneità vegetazione arborea 0,50
Non igrofile 0,50

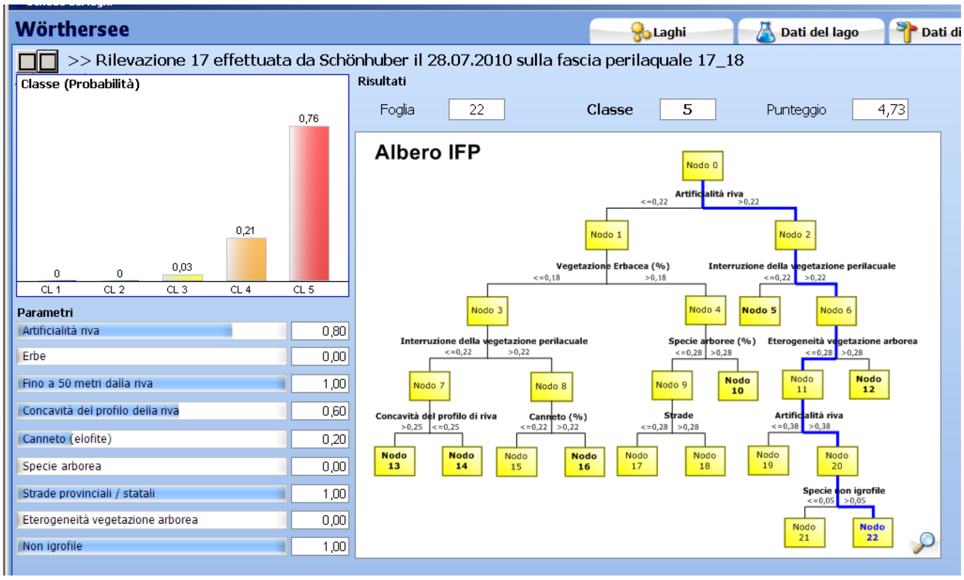

Schede dei laghi
Wörthersee
Laghi
Dati del lago
Dati di
>> Rilevazione 12 effettuata da Schönhuber il 28.07.2010 sulla fascia perilaquale 12_13
Classe (Probabilità)
0
0,12
0,65
0,18
0,06
CL 1
CL 2
CL 3
CL 4
CL 5
Risultati
Foglia 12
Classe 3
Punteggio 3,21
Albero IFP
Parametri
Artificialità riva 0,70
Erbe 0,00
Fino a 50 metri dalla riva 0,90
Concavità del profilo della riva 1,00
Canneto (elofite) 0,25
Specie arborea 0,10
Strade provinciali / statali 0,70
Eterogeneità vegetazione arborea 0,30
Non igrofile 0,70

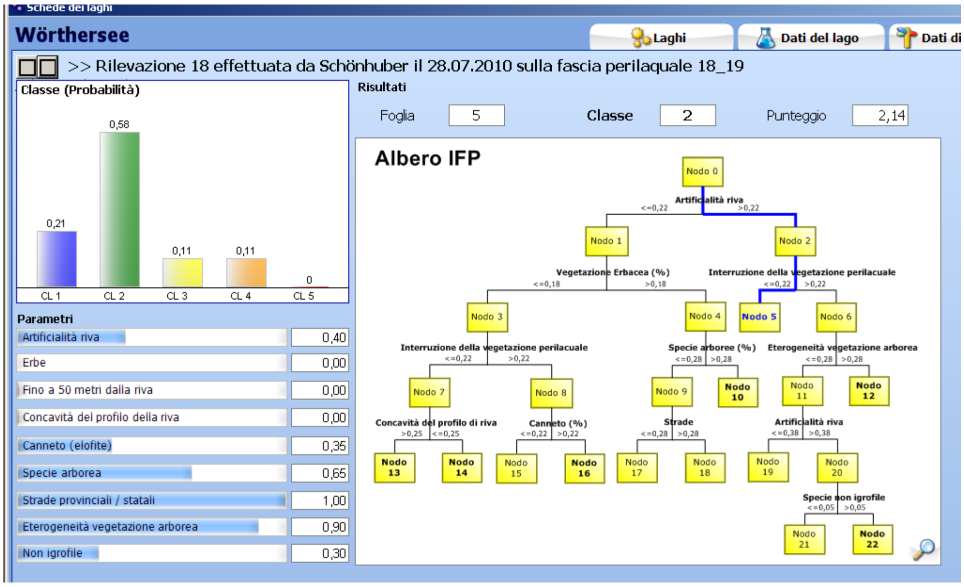

Wörthersee
Laghi
Dati del lago
Dati di
>> Rilevazione 13 effettuata da Schönhuber il 28.07.2010 sulla fascia perilaquale 13_14
Classe (Probabilità)
0
0,22
0,78
0
0
CL 1
CL 2
CL 3
CL 4
CL 5
Risultati
Foglia 10
Classe 3
Punteggio 2,78
Albero IFP
Parametri
Artificialità riva 0,20
Erbe 0,20
Fino a 50 metri dalla riva 0,40
Concavità del profilo della riva 0,50
Canneto (elofite) 0,00
Specie arborea 0,70
Strade provinciali / statali 0,00
Eterogeneità vegetazione arborea 0,50
Non igrofile 0,50

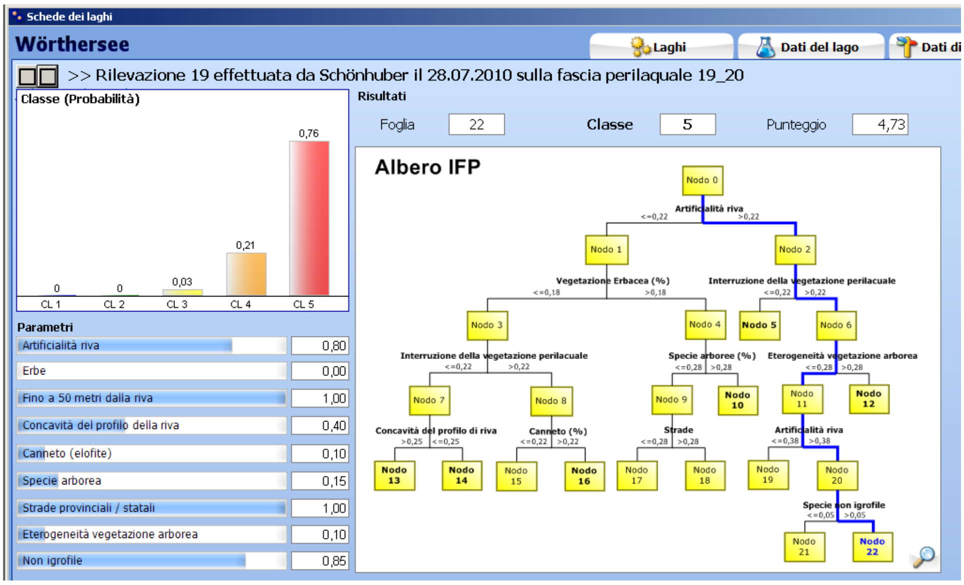

Schede dei laghi
Wörthersee
Laghi
Dati del lago
Dati di
>> Rilevazione 14 effettuata da Schönhuber il 28.07.2010 sulla fascia perilaquale 14_15
Classe (Probabilità)
0
0
0,03
0,21
0,76
CL 1
CL 2
CL 3
CL 4
CL 5
Risultati
Foglia 22
Classe 5
Punteggio 4,73
Albero IFP
Parametri
Artificialità riva 1,00
Erbe 0,00
Fino a 50 metri dalla riva 1,00
Concavità del profilo della riva 0,80
Canneto (elofite) 0,00
Specie arborea 0,00
Strade provinciali / statali 0,50
Eterogeneità vegetazione arborea 0,00
Non igrofile 1,00

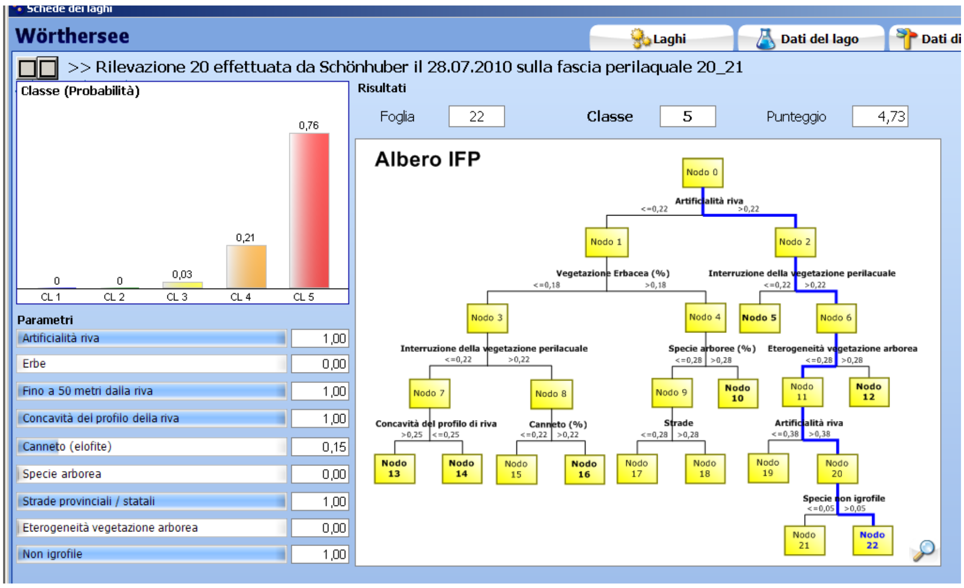

Wörthersee
Laghi
Dati del lago
Dati di
>> Rilevazione 15 effettuata da Schönhuber il 28.07.2010 sulla fascia perilaquale 15_16
Classe (Probabilità)
0 0 0,03 0,21 0,76
CL 1 CL 2 CL 3 CL 4 CL 5
Risultati
Foglia 22
Classe 5
Punteggio 4,73
Albero IFP
Parametri
Artificialità riva 1,00
Erbe 0,00
Fino a 50 metri dalla riva 1,00
Concavità del profilo della riva 0,50
Canneto (elofite) 0,15
Specie arborea 0,05
Strade provinciali / statali 1,00
Eterogeneità vegetazione arborea 0,10
Non igrofile 0,80

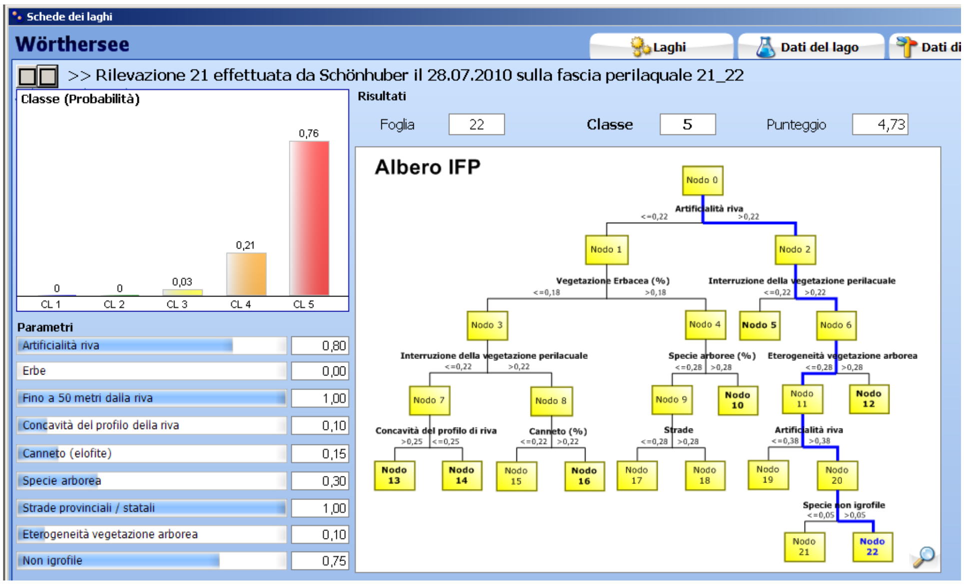

Schede dei laghi
Wörthersee
Laghi
Dati del lago
Dati di
>> Rilevazione 16 effettuata da Schönhuber il 28.07.2010 sulla fascia perilaquale 16_17
Classe (Probabilità)
0 0,22 0,78 0 0
CL 1 CL 2 CL 3 CL 4 CL 5
Risultati
Foglia 10
Classe 3
Punteggio 2,78
Albero IFP
Parametri
Artificialità riva 0,00
Erbe 0,30
Fino a 50 metri dalla riva 0,50
Concavità del profilo della riva 0,30
Canneto (elofite) 0,30
Specie arborea 0,30
Strade provinciali / statali 1,00
Eterogeneità vegetazione arborea 0,50
Non igrofile 0,50

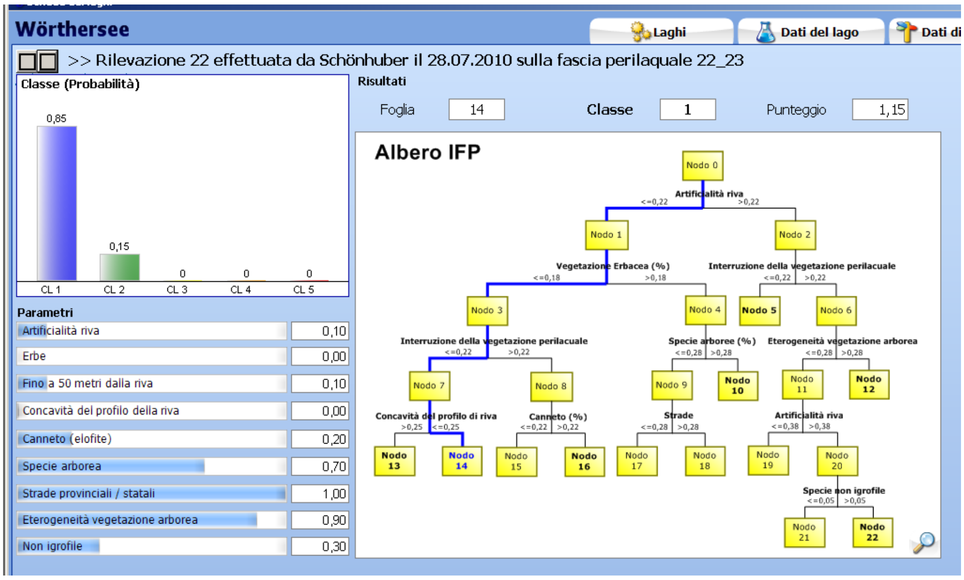

Wörthersee
Laghi
Dati del lago
Dati di
>> Rilevazione 17 effettuata da Schönhuber il 28.07.2010 sulla fascia perilaquale 17_18
Classe (Probabilità)
0 0 0,03 0,21 0,76
CL 1 CL 2 CL 3 CL 4 CL 5
Risultati
Foglia 22
Classe 5
Punteggio 4,73
Albero IFP
Parametri
Artificialità riva 0,80
Erbe 0,00
Fino a 50 metri dalla riva 1,00
Concavità del profilo della riva 0,60
Canneto (elofite) 0,20
Specie arborea 0,00
Strade provinciali / statali 1,00
Eterogeneità vegetazione arborea 0,00
Non igrofile 1,00

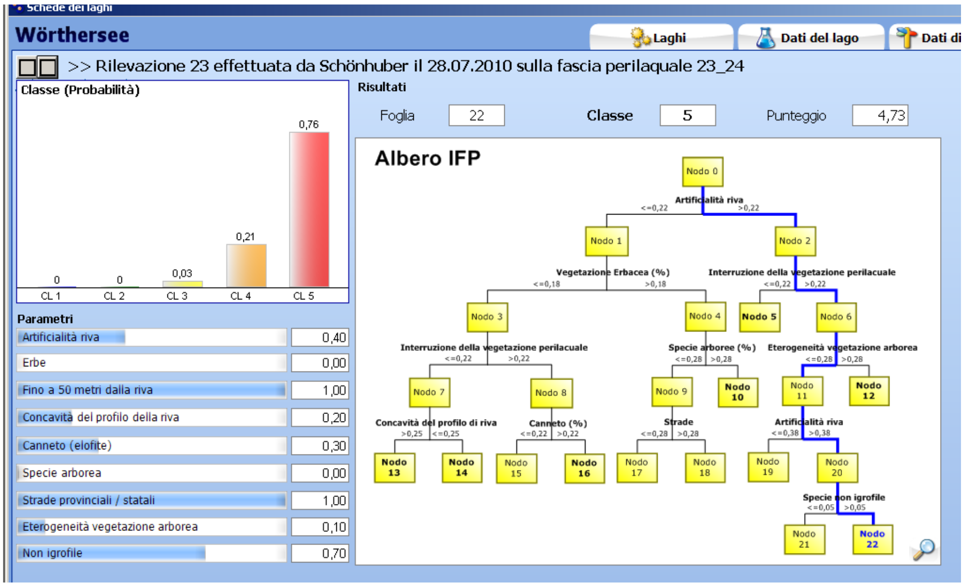

Schede dei laghi
Wörthersee
Laghi
Dati del lago
Dati di
>> Rilevazione 18 effettuata da Schönhuber il 28.07.2010 sulla fascia perilaquale 18_19
Classe (Probabilità)
0,21
0,58
0,11
0,11
0
CL 1
CL 2
CL 3
CL 4
CL 5
Risultati
Foglia 5
Classe 2
Punteggio 2,14
Albero IFP
Parametri
Artificialità riva 0,40
Erbe 0,00
Fino a 50 metri dalla riva 0,00
Concavità del profilo della riva 0,00
Canneto (elofite) 0,35
Specie arborea 0,65
Strade provinciali / statali 1,00
Eterogeneità vegetazione arborea 0,90
Non igrofile 0,30

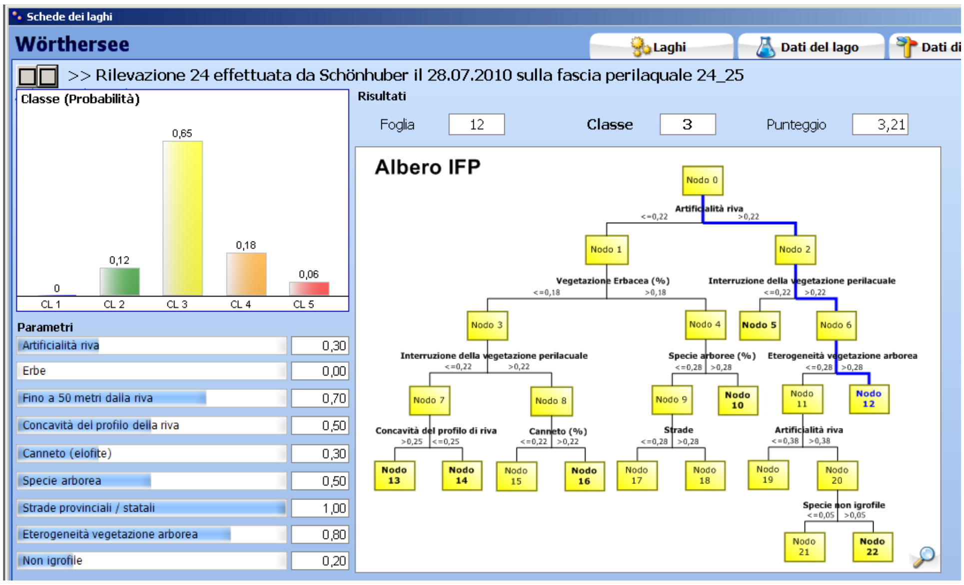

Schede dei laghi
Wörthersee
Laghi
Dati del lago
Dati di
>> Rilevazione 19 effettuata da Schönhuber il 28.07.2010 sulla fascia perilaquale 19_20
Classe (Probabilità)
0
0
0,03
0,21
0,76
CL 1
CL 2
CL 3
CL 4
CL 5
Risultati
Foglia 22
Classe 5
Punteggio 4,73
Albero IFP
Parametri
Artificialità riva 0,80
Erbe 0,00
Fino a 50 metri dalla riva 1,00
Concavità del profilo della riva 0,40
Canneto (elofite) 0,10
Specie arborea 0,15
Strade provinciali / statali 1,00
Eterogeneità vegetazione arborea 0,10
Non igrofile 0,85

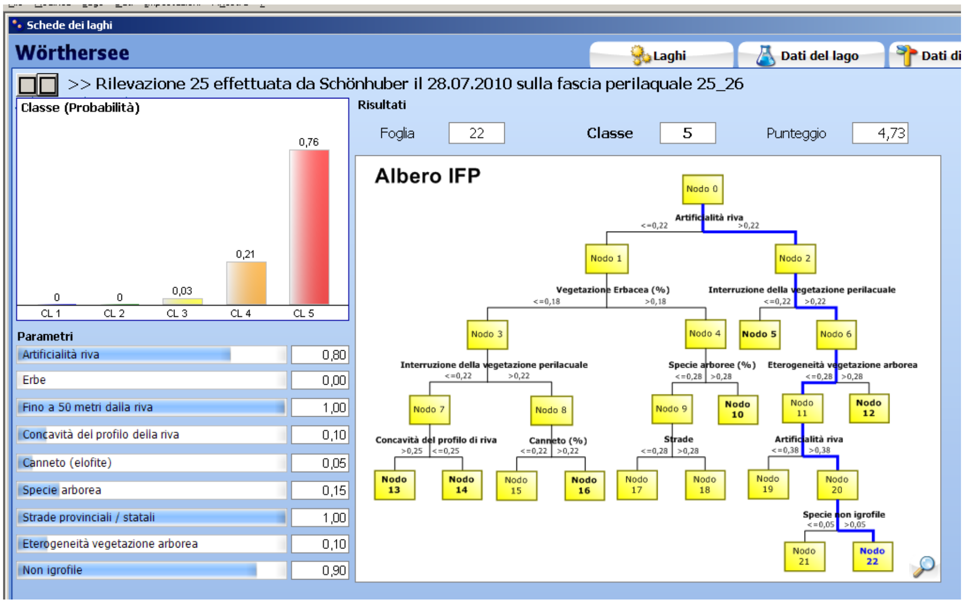

Schede dei laghi
Wörthersee
Laghi
Dati del lago
Dati di
>> Rilevazione 20 effettuata da Schönhuber il 28.07.2010 sulla fascia perilaquale 20_21
Classe (Probabilità)
0
0
0,03
0,21
0,76
CL 1
CL 2
CL 3
CL 4
CL 5
Risultati
Foglia 22
Classe 5
Punteggio 4,73
Albero IFP
Parametri
Artificialità riva 1,00
Erbe 0,00
Fino a 50 metri dalla riva 1,00
Concavità del profilo della riva 1,00
Canneto (elofite) 0,15
Specie arborea 0,00
Strade provinciali / statali 1,00
Eterogeneità vegetazione arborea 0,00
Non igrofile 1,00

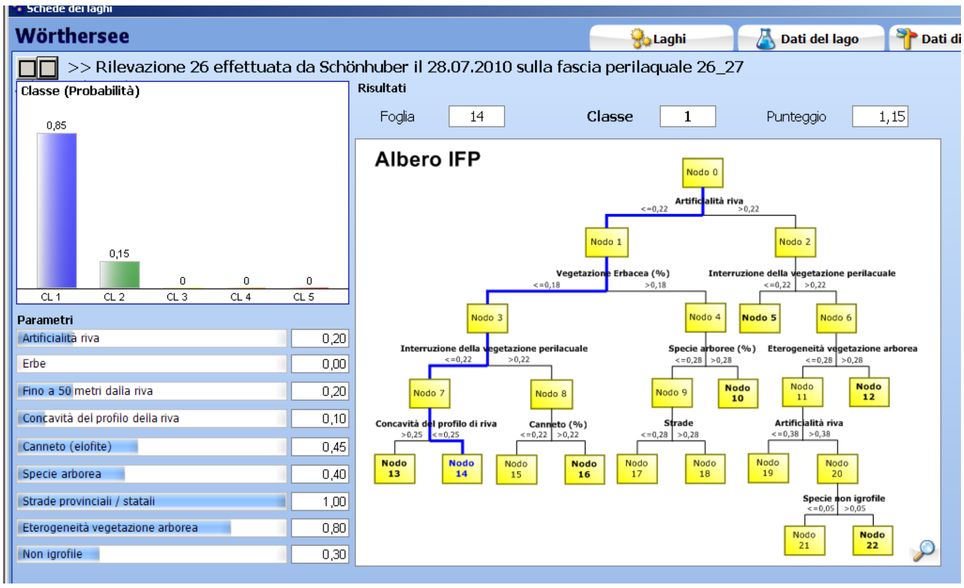

Schede dei laghi
Wörthersee
Laghi
Dati del lago
>> Rilevazione 21 effettuata da Schönhuber il 28.07.2010 sulla fascia perilaquale 21_22
Classe (Probabilità)
0 0 0,03 0,21 0,76
CL 1 CL 2 CL 3 CL 4 CL 5
Risultati
Foglia 22
Classe 5
Punteggio 4,73
Albero IFP
Parametri
Artificialità riva 0,80
Erbe 0,00
Fino a 50 metri dalla riva 1,00
Concavità del profilo della riva 0,10
Canneto (elofite) 0,15
Specie arborea 0,30
Strade provinciali / statali 1,00
Eterogeneità vegetazione arborea 0,10
Non igrofile 0,75

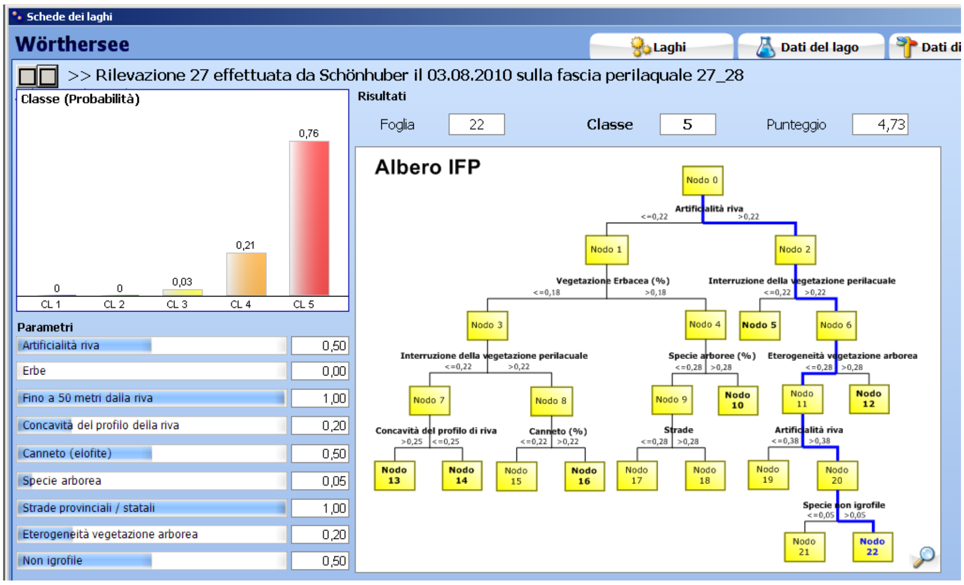

Wörthersee
Laghi
Dati del lago
>> Rilevazione 22 effettuata da Schönhuber il 28.07.2010 sulla fascia perilaquale 22_23
Classe (Probabilità)
0,85 0,15 0 0 0
CL 1 CL 2 CL 3 CL 4 CL 5
Risultati
Foglia 14
Classe 1
Punteggio 1,15
Albero IFP
Parametri
Artificialità riva 0,10
Erbe 0,00
Fino a 50 metri dalla riva 0,10
Concavità del profilo della riva 0,00
Canneto (elofite) 0,20
Specie arborea 0,70
Strade provinciali / statali 1,00
Eterogeneità vegetazione arborea 0,90
Non igrofile 0,30

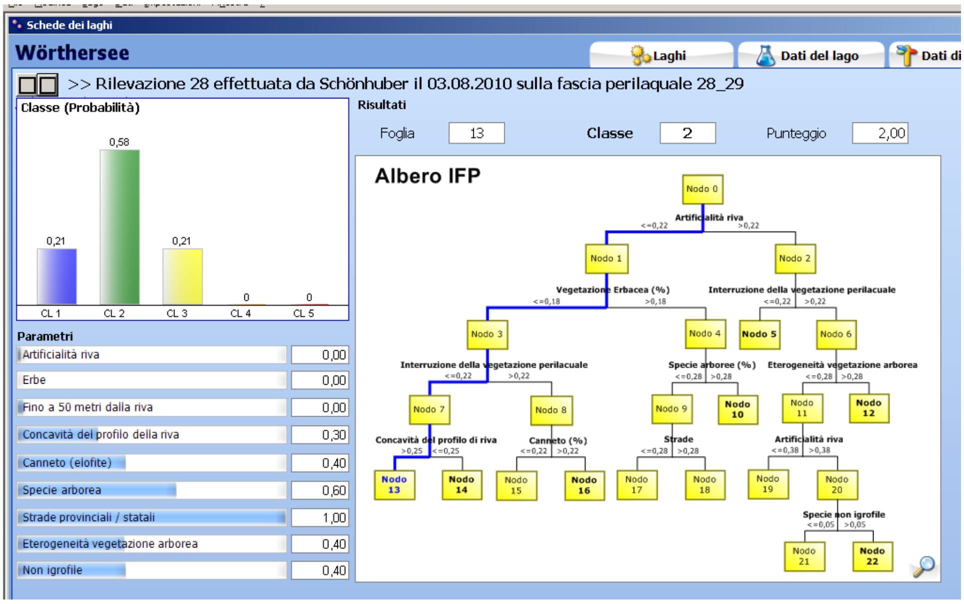

Schede dei laghi
Wörthersee
Laghi
Dati del lago
>> Rilevazione 23 effettuata da Schönhuber il 28.07.2010 sulla fascia perilaquale 23_24
Classe (Probabilità)
0 0 0,03 0,21 0,76
CL 1 CL 2 CL 3 CL 4 CL 5
Risultati
Foglia 22
Classe 5
Punteggio 4,73
Albero IFP
Parametri
Artificialità riva 0,40
Erbe 0,00
Fino a 50 metri dalla riva 1,00
Concavità del profilo della riva 0,20
Canneto (elofite) 0,30
Specie arborea 0,00
Strade provinciali / statali 1,00
Eterogeneità vegetazione arborea 0,10
Non igrofile 0,70

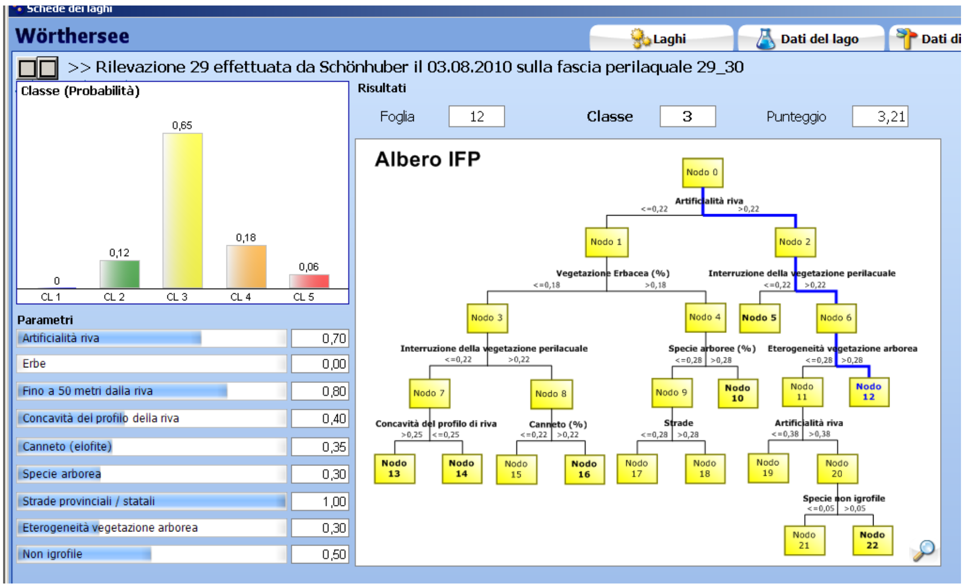

Schede dei laghi
Wörthersee
Laghi
Dati del lago
>> Rilevazione 24 effettuata da Schönhuber il 28.07.2010 sulla fascia perilaquale 24_25
Classe (Probabilità)
0 0,12 0,65 0,18 0,06
CL 1 CL 2 CL 3 CL 4 CL 5
Risultati
Foglia 12
Classe 3
Punteggio 3,21
Albero IFP
Parametri
Artificialità riva 0,30
Erbe 0,00
Fino a 50 metri dalla riva 0,70
Concavità del profilo della riva 0,50
Canneto (elofite) 0,30
Specie arboree 0,50
Strade provinciali / statali 1,00
Eterogeneità vegetazione arborea 0,80
Non igrofile 0,20

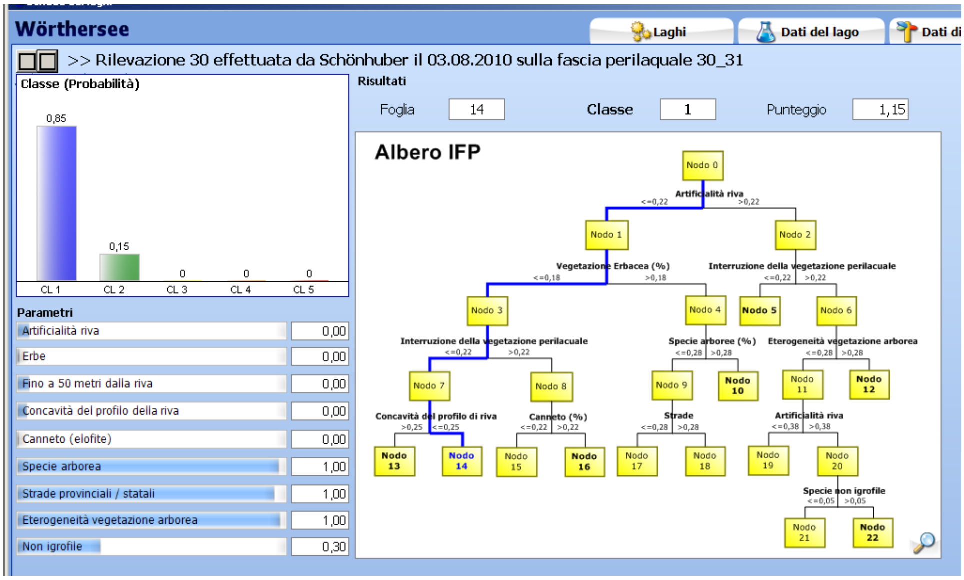

Schede dei laghi
Wörthersee
Laghi
Dati del lago
>> Rilevazione 25 effettuata da Schönhuber il 28.07.2010 sulla fascia perilaquale 25_26
Classe (Probabilità)
0 0 0,03 0,21 0,76
CL 1 CL 2 CL 3 CL 4 CL 5
Risultati
Foglia 22
Classe 5
Punteggio 4,73
Albero IFP
Parametri
Artificialità riva 0,80
Erbe 0,00
Fino a 50 metri dalla riva 1,00
Concavità del profilo della riva 0,10
Canneto (elofite) 0,05
Specie arborea 0,15
Strade provinciali / statali 1,00
Eterogeneità vegetazione arborea 0,10
Non igrofile 0,90

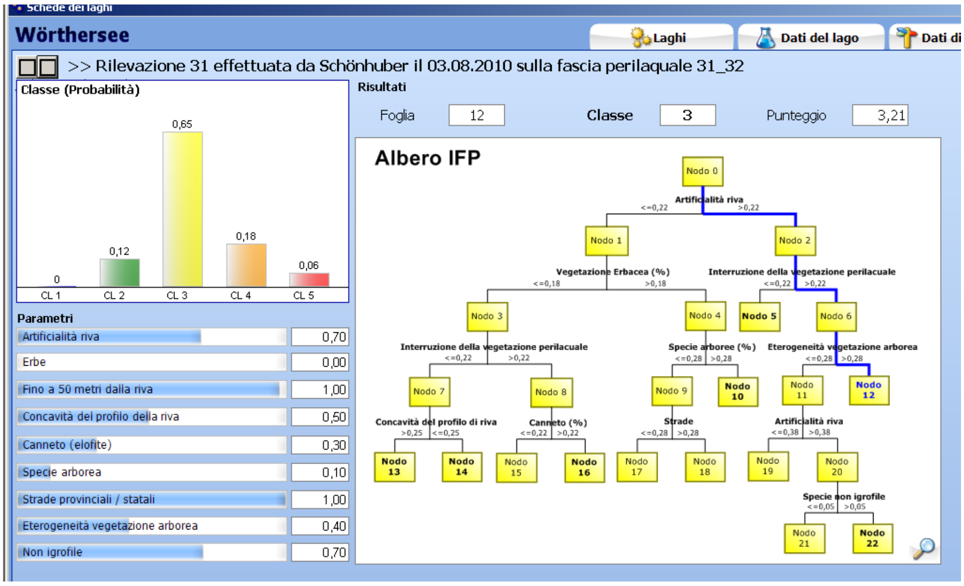

Schede dei laghi
Wörthersee
Laghi
Dati del lago
>> Rilevazione 26 effettuata da Schönhuber il 28.07.2010 sulla fascia perilaquale 26_27
Classe (Probabilità)
0,85 0,15 0 0 0
CL 1 CL 2 CL 3 CL 4 CL 5
Risultati
Foglia 14
Classe 1
Punteggio 1,15
Albero IFP
Parametri
Artificialità riva 0,20
Erbe 0,00
Fino a 50 metri dalla riva 0,20
Concavità del profilo della riva 0,10
Canneto (elofite) 0,45
Specie arborea 0,40
Strade provinciali / statali 1,00
Eterogeneità vegetazione arborea 0,80
Non igrofile 0,30

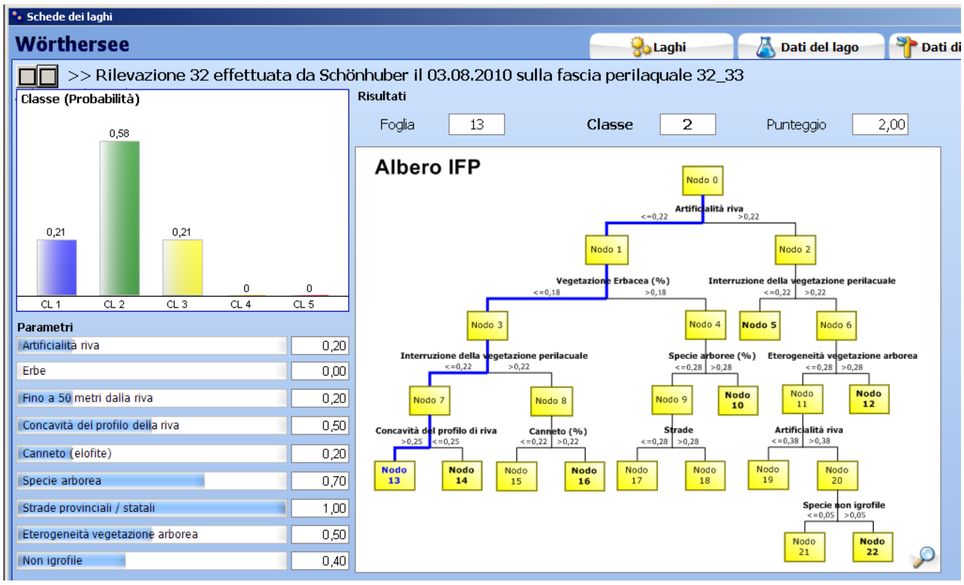

Schede dei laghi
Wörthersee
Laghi
Dati del lago
>> Rilevazione 27 effettuata da Schönhuber il 03.08.2010 sulla fascia perilaquale 27_28
Classe (Probabilità)
Risultati
Foglia 22
Classe 5
Punteggio 4,73
Albero IFP
Parametri
Artificialità riva 0,50
Erbe 0,00
Fino a 50 metri dalla riva 1,00
Concavità del profilo della riva 0,20
Canneto (elofite) 0,50
Specie arborea 0,05
Strade provinciali / statali 1,00
Eterogeneità vegetazione arborea 0,20
Non igrofile 0,50

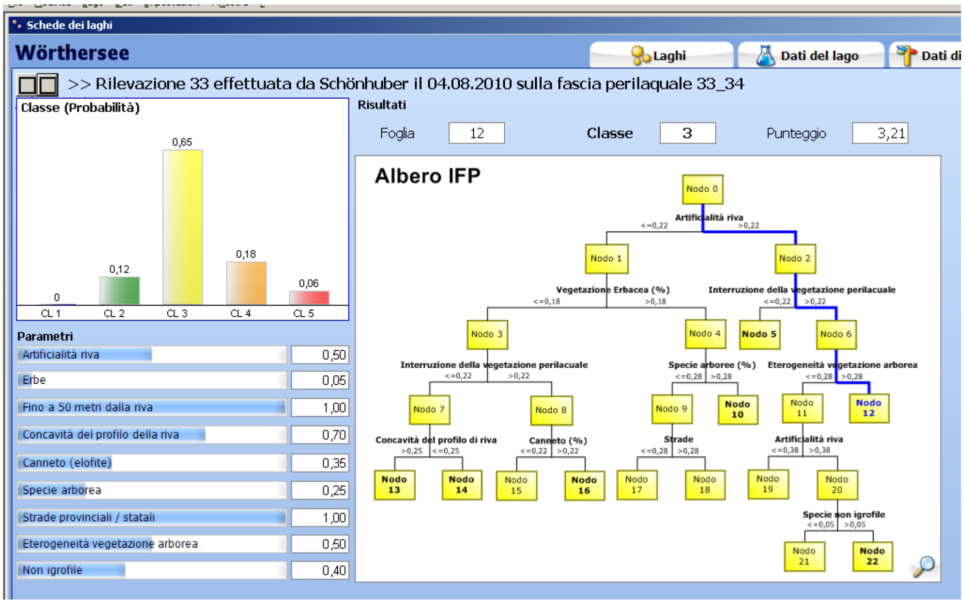

Schede dei laghi
Wörthersee
Laghi
Dati del lago
>> Rilevazione 28 effettuata da Schönhuber il 03.08.2010 sulla fascia perilaquale 28_29
Classe (Probabilità)
Risultati
Foglia 13
Classe 2
Punteggio 2,00
Albero IFP
Parametri
Artificialità riva 0,00
Erbe 0,00
Fino a 50 metri dalla riva 0,00
Concavità del profilo della riva 0,30
Canneto (elofite) 0,40
Specie arborea 0,60
Strade provinciali / statali 1,00
Eterogeneità vegetazione arborea 0,40
Non igrofile 0,40

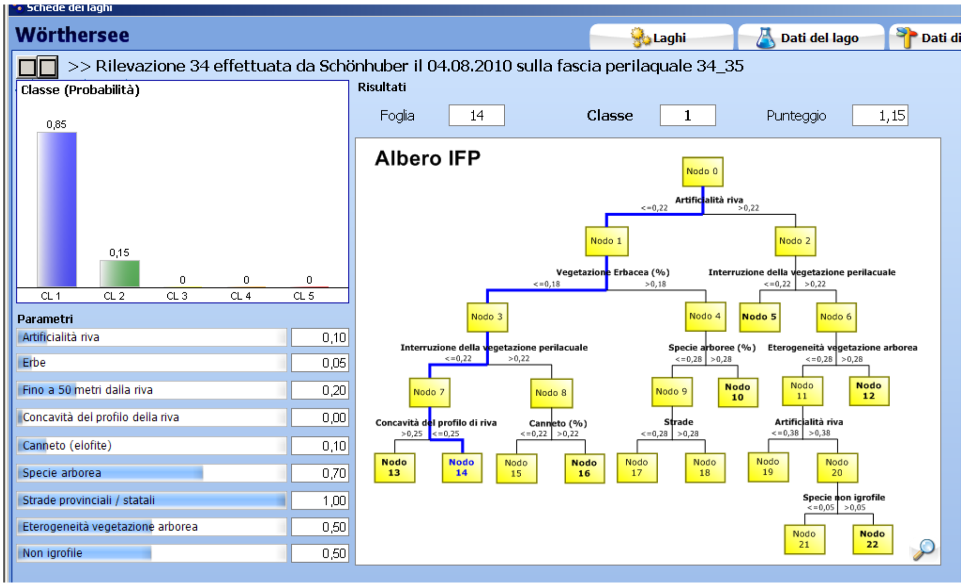

Schede dei laghi
Wörthersee
Laghi
Dati del lago
>> Rilevazione 29 effettuata da Schönhuber il 03.08.2010 sulla fascia perilaquale 29_30
Classe (Probabilità)
Risultati
Foglia 12
Classe 3
Punteggio 3,21
Albero IFP
Parametri
Artificialità riva 0,70
Erbe 0,00
Fino a 50 metri dalla riva 0,80
Concavità del profilo della riva 0,40
Canneto (elofite) 0,35
Specie arborea 0,30
Strade provinciali / statali 1,00
Eterogeneità vegetazione arborea 0,30
Non igrofile 0,50

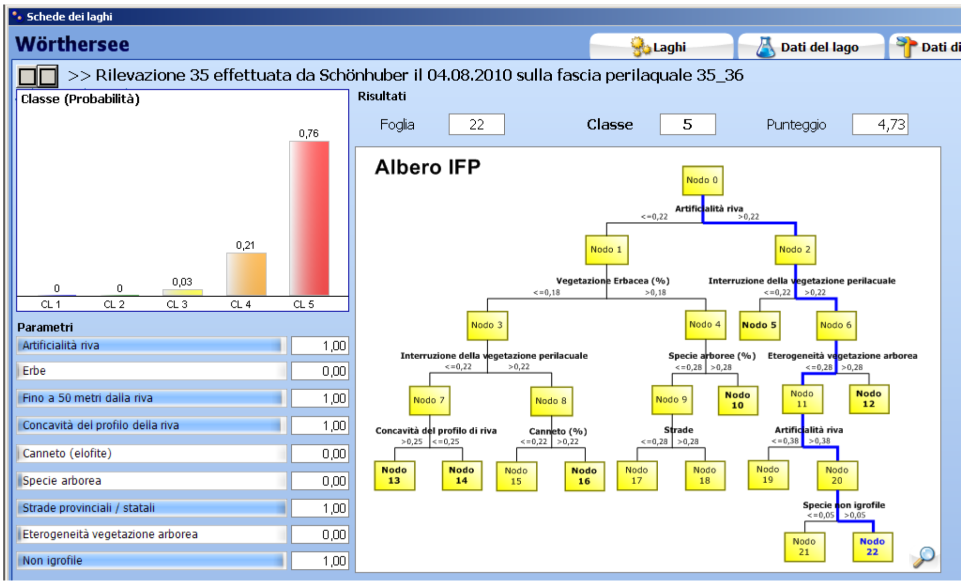

Wörthersee
Laghi
Dati del lago
Dati di
>> Rilevazione 30 effettuata da Schönhuber il 03.08.2010 sulla fascia perilaquale 30_31
Classe (Probabilità)
0,85
0,15
0
0
0
CL 1
CL 2
CL 3
CL 4
CL 5
Risultati
Foglia 14
Classe 1
Punteggio 1,15
Albero IFP
Parametri
Artificialità riva 0,00
Erbe 0,00
Fino a 50 metri dalla riva 0,00
Concavità del profilo della riva 0,00
Canneto (elofite) 0,00
Specie arboree 1,00
Strade provinciali / statali 1,00
Eterogeneità vegetazione arborea 1,00
Non igrofile 0,30

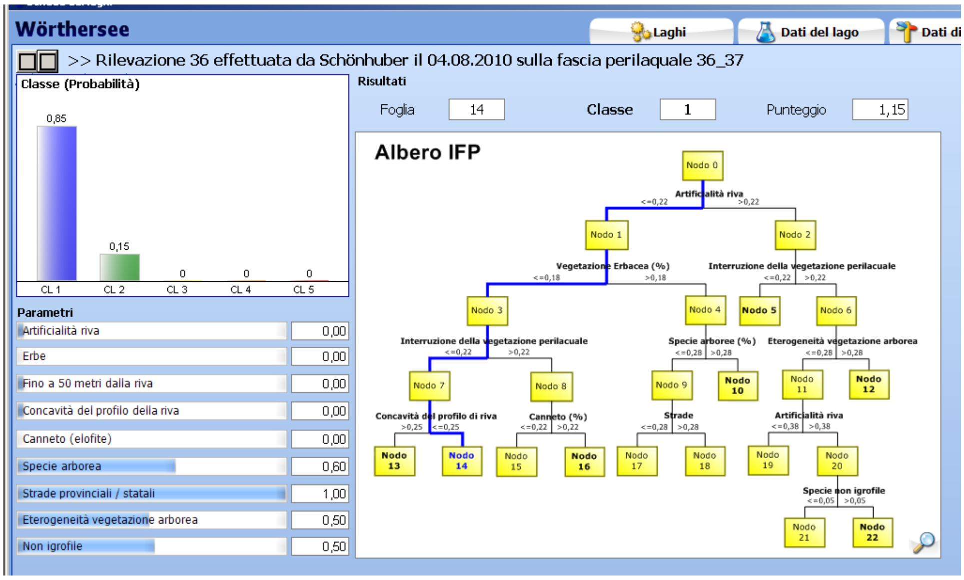

Schede dei laghi
Wörthersee
Laghi
Dati del lago
Dati di
>> Rilevazione 31 effettuata da Schönhuber il 03.08.2010 sulla fascia perilaquale 31_32
Classe (Probabilità)
0
0,12
0,65
0,18
0,06
CL 1
CL 2
CL 3
CL 4
CL 5
Risultati
Foglia 12
Classe 3
Punteggio 3,21
Albero IFP
Parametri
Artificialità riva 0,70
Erbe 0,00
Fino a 50 metri dalla riva 1,00
Concavità del profilo della riva 0,50
Canneto (elofite) 0,30
Specie arboree 0,10
Strade provinciali / statali 1,00
Eterogeneità vegetazione arborea 0,40
Non igrofile 0,70

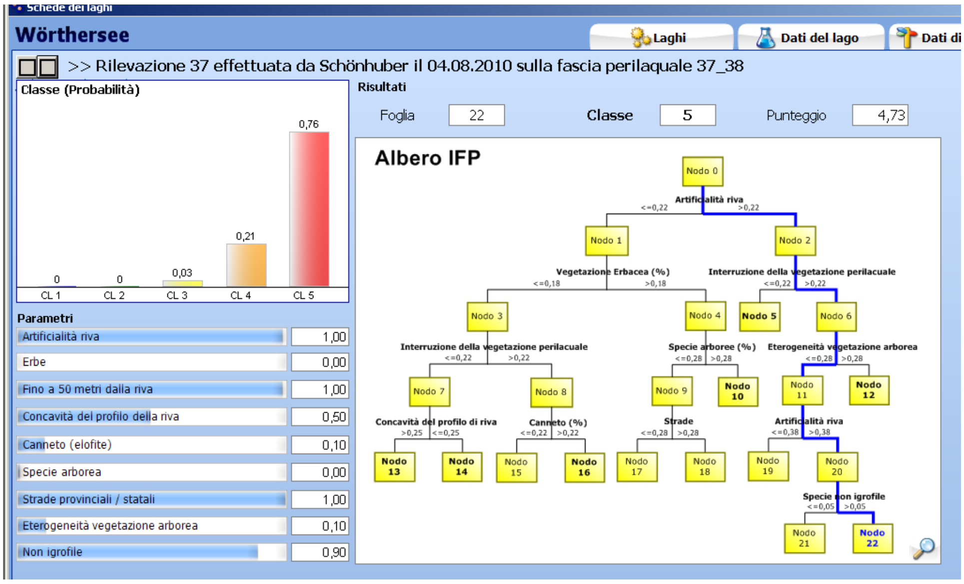

Schede dei laghi
Wörthersee
Laghi
Dati del lago
Dati di
>> Rilevazione 32 effettuata da Schönhuber il 03.08.2010 sulla fascia perilaquale 32_33
Classe (Probabilità)
0,21
0,58
0,21
0
0
CL 1
CL 2
CL 3
CL 4
CL 5
Risultati
Foglia 13
Classe 2
Punteggio 2,00
Albero IFP
Parametri
Artificialità riva 0,20
Erbe 0,00
Fino a 50 metri dalla riva 0,20
Concavità del profilo della riva 0,50
Canneto (elofite) 0,20
Specie arboree 0,70
Strade provinciali / statali 1,00
Eterogeneità vegetazione arborea 0,50
Non igrofile 0,40

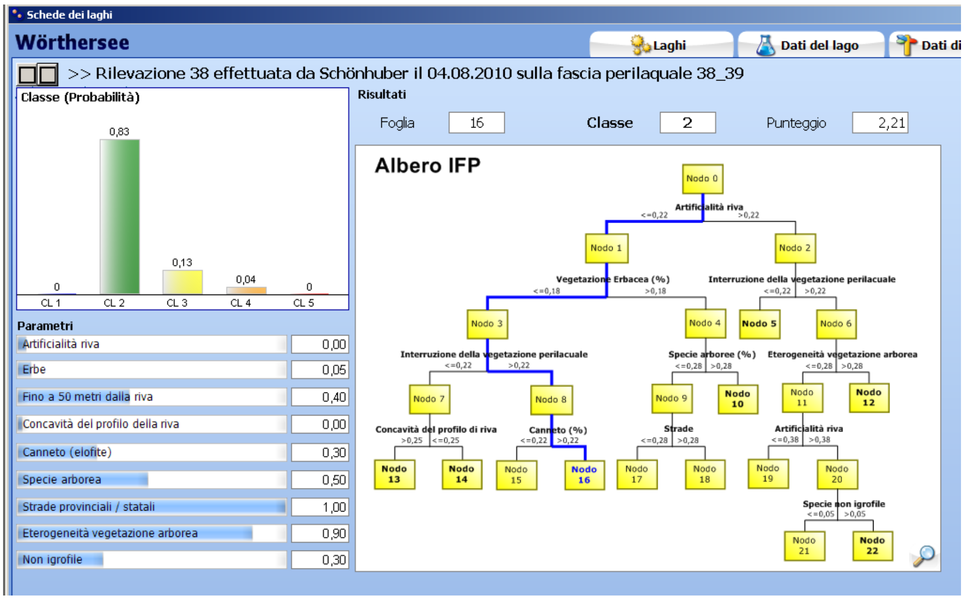

Schede dei laghi
Wörthersee
Laghi
Dati del lago
>> Rilevazione 33 effettuata da Schönhuber il 04.08.2010 sulla fascia perilaquale 33_34
Classe (Probabilità)
0
0,12
0,65
0,18
0,06
CL 1
CL 2
CL 3
CL 4
CL 5
Risultati
Foglia 12
Classe 3
Punteggio 3,21
Albero IFP
Parametri
Artificialità riva 0,50
Erbe 0,05
Fino a 50 metri dalla riva 1,00
Concavità del profilo della riva 0,70
Canneto (elofite) 0,35
Specie arborea 0,25
Strade provinciali / statali 1,00
Eterogeneità vegetazione arborea 0,50
Non igrofile 0,40

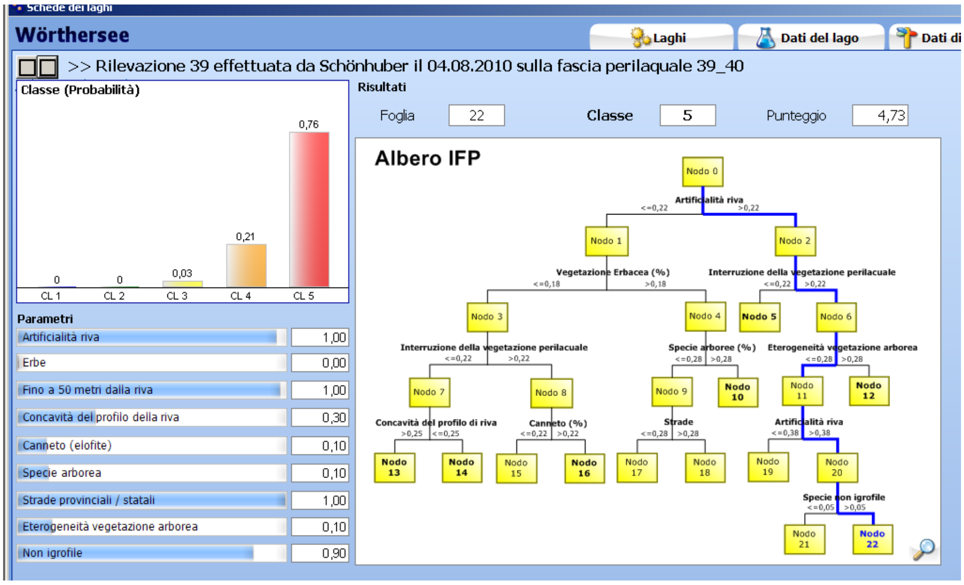

Schede dei laghi
Wörthersee
Laghi
Dati del lago
>> Rilevazione 34 effettuata da Schönhuber il 04.08.2010 sulla fascia perilaquale 34_35
Classe (Probabilità)
0,85
0,15
0
0
0
CL 1
CL 2
CL 3
CL 4
CL 5
Risultati
Foglia 14
Classe 1
Punteggio 1,15
Albero IFP
Parametri
Artificialità riva 0,10
Erbe 0,05
Fino a 50 metri dalla riva 0,20
Concavità del profilo della riva 0,00
Canneto (elofite) 0,10
Specie arborea 0,70
Strade provinciali / statali 1,00
Eterogeneità vegetazione arborea 0,50
Non igrofile 0,50

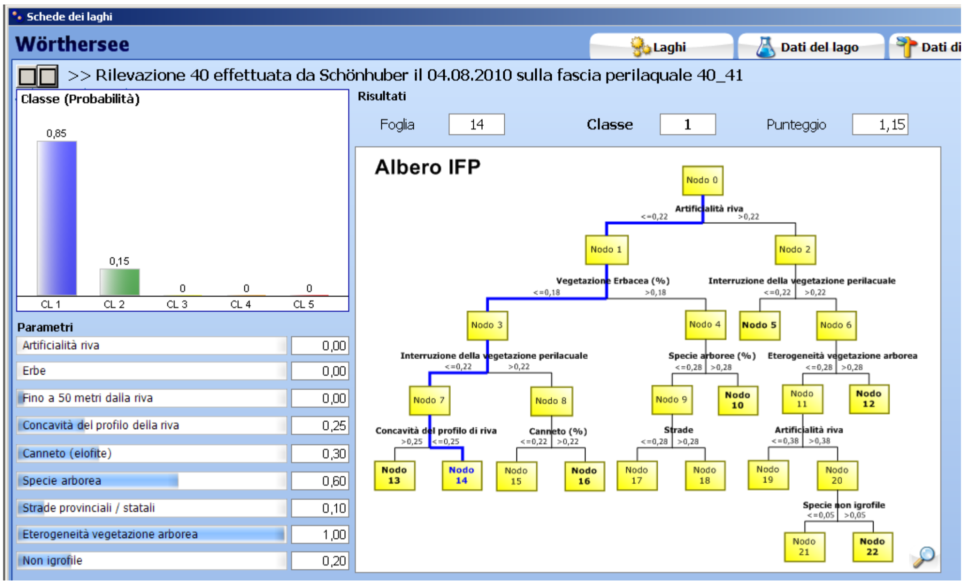

Schede dei laghi
Wörthersee
Laghi
Dati del lago
>> Rilevazione 35 effettuata da Schönhuber il 04.08.2010 sulla fascia perilaquale 35_36
Classe (Probabilità)
0
0
0,03
0,21
0,76
CL 1
CL 2
CL 3
CL 4
CL 5
Risultati
Foglia 22
Classe 5
Punteggio 4,73
Albero IFP
Parametri
Artificialità riva 1,00
Erbe 0,00
Fino a 50 metri dalla riva 1,00
Concavità del profilo della riva 1,00
Canneto (elofite) 0,00
Specie arborea 0,00
Strade provinciali / statali 1,00
Eterogeneità vegetazione arborea 0,00
Non igrofile 1,00

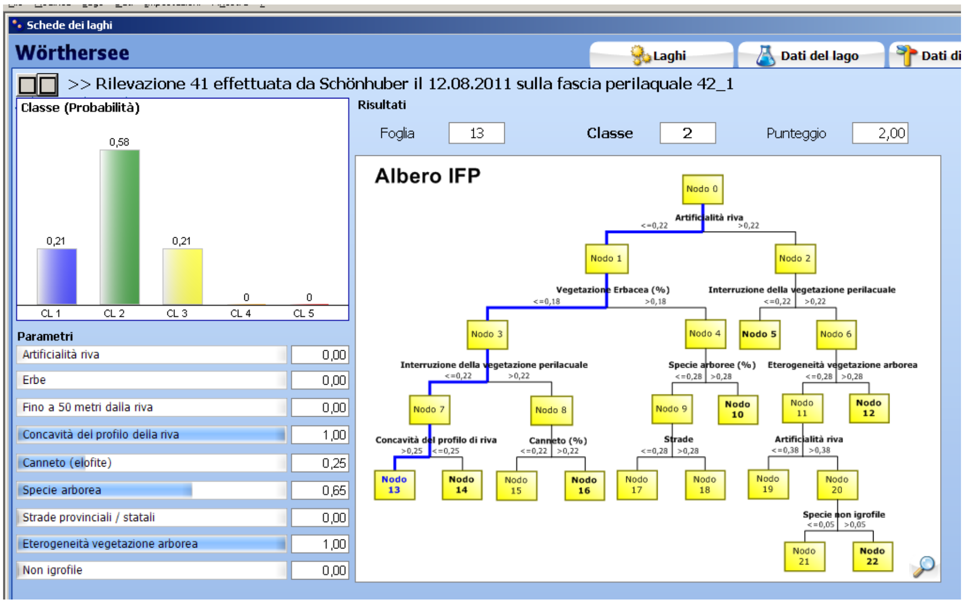

Wörthersee
Laghi
Dati del lago
Dati di
>> Rilevazione 36 effettuata da Schönhuber il 04.08.2010 sulla fascia perilaquale 36_37
Classe (Probabilità)
0,85
0,15
0
0
0
CL 1
CL 2
CL 3
CL 4
CL 5
Risultati
Foglia 14
Classe 1
Punteggio 1,15
Albero IFP
Parametri
Artificialità riva 0,00
Erbe 0,00
Fino a 50 metri dalla riva 0,00
Concavità del profilo della riva 0,00
Canneto (elofite) 0,00
Specie arborea 0,60
Strade provinciali / statali 1,00
Eterogeneità vegetazione arborea 0,50
Non igrofile 0,50
Artificialità riva
Vegetazione Erbacea (%)
Interruzione della vegetazione perilacuale
Specie arboree (%)
Eterogeneità vegetazione arborea
Concavità del profilo di riva
Canneto (%)
Strade
Specie non igrofile

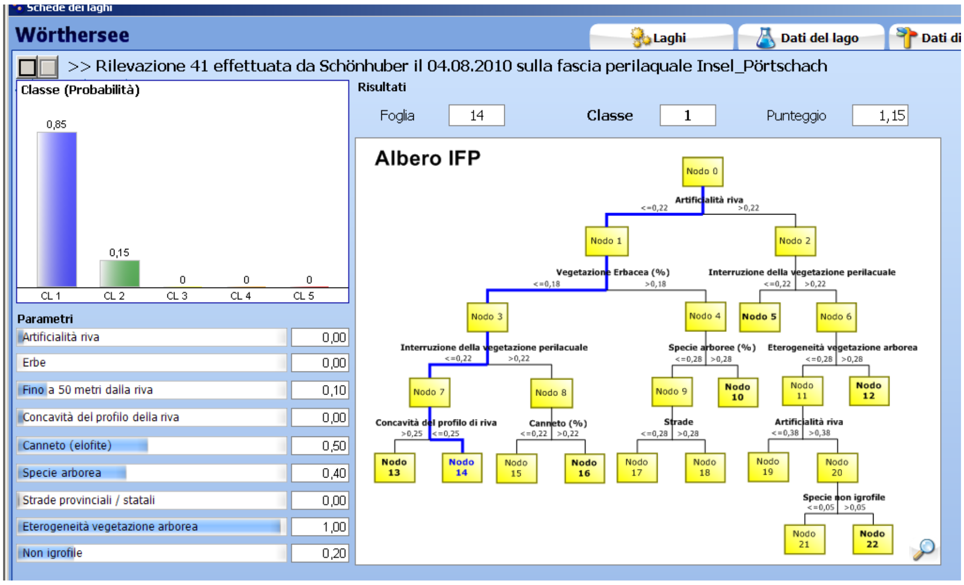

Schede dei laghi
Wörthersee
Laghi
Dati del lago
Dati di
>> Rilevazione 37 effettuata da Schönhuber il 04.08.2010 sulla fascia perilaquale 37_38
Classe (Probabilità)
0
0
0,03
0,21
0,76
CL 1
CL 2
CL 3
CL 4
CL 5
Risultati
Foglia 22
Classe 5
Punteggio 4,73
Albero IFP
Parametri
Artificialità riva 1,00
Erbe 0,00
Fino a 50 metri dalla riva 1,00
Concavità del profilo della riva 0,50
Canneto (elofite) 0,10
Specie arborea 0,00
Strade provinciali / statali 1,00
Eterogeneità vegetazione arborea 0,10
Non igrofile 0,90


Schede dei laghi
Wörthersee
Laghi
Dati del lago
Dati di
>> Rilevazione 38 effettuata da Schönhuber il 04.08.2010 sulla fascia perilaquale 38_39
Classe (Probabilità)
0
0,83
0,13
0,04
0
CL 1
CL 2
CL 3
CL 4
CL 5
Risultati
Foglia 16
Classe 2
Punteggio 2,21
Albero IFP
Parametri
Artificialità riva 0,00
Erbe 0,05
Fino a 50 metri dalla riva 0,40
Concavità del profilo della riva 0,00
Canneto (elofite) 0,30
Specie arborea 0,50
Strade provinciali / statali 1,00
Eterogeneità vegetazione arborea 0,90
Non igrofile 0,30


Schede dei laghi
Wörthersee
Laghi
Dati del lago
>> Rilevazione 39 effettuata da Schönhuber il 04.08.2010 sulla fascia perilaquale 39_40
Classe (Probabilità)
0 0 0,03 0,21 0,76
CL 1 CL 2 CL 3 CL 4 CL 5
Risultati
Foglia 22
Classe 5
Punteggio 4,73
Albero IFP
Parametri
Artificialità riva 1,00
Erbe 0,00
Fino a 50 metri dalla riva 1,00
Concavità del profilo della riva 0,30
Canneto (elofite) 0,10
Specie arborea 0,10
Strade provinciali / statali 1,00
Eterogeneità vegetazione arborea 0,10
Non igrofile 0,90


Schede dei laghi
Wörthersee
Laghi
Dati del lago
>> Rilevazione 40 effettuata da Schönhuber il 04.08.2010 sulla fascia perilaquale 40_41
Classe (Probabilità)
0,85 0,15 0 0 0
CL 1 CL 2 CL 3 CL 4 CL 5
Risultati
Foglia 14
Classe 1
Punteggio 1,15
Albero IFP
Parametri
Artificialità riva 0,00
Erbe 0,00
Fino a 50 metri dalla riva 0,00
Concavità del profilo della riva 0,25
Canneto (elofite) 0,30
Specie arborea 0,60
Strade provinciali / statali 0,10
Eterogeneità vegetazione arborea 1,00
Non igrofile 0,20


Schede dei laghi
Wörthersee
Laghi
Dati del lago
>> Rilevazione 41 effettuata da Schönhuber il 12.08.2011 sulla fascia perilaquale 42_1
Classe (Probabilità)
0,21 0,58 0,21 0 0
CL 1 CL 2 CL 3 CL 4 CL 5
Risultati
Foglia 13
Classe 2
Punteggio 2,00
Albero IFP
Parametri
Artificialità riva 0,00
Erbe 0,00
Fino a 50 metri dalla riva 0,00
Concavità del profilo della riva 1,00
Canneto (elofite) 0,25
Specie arborea 0,65
Strade provinciali / statali 0,00
Eterogeneità vegetazione arborea 1,00
Non igrofile 0,00


Wörthersee
Laghi
Dati del lago
>> Rilevazione 41 effettuata da Schönhuber il 04.08.2010 sulla fascia perilaquale Insel_Pörtschach
Classe (Probabilità)
Risultati
Foglia 14
Classe 1
Punteggio 1,15
Albero IFP
Parametri
Artificialità riva 0,00
Erbe 0,00
Fino a 50 metri dalla riva 0,10
Concavità del profilo della riva 0,00
Canneto (elofite) 0,50
Specie arborea 0,40
Strade provinciali / statali 0,00
Eterogeneità vegetazione arborea 1,00
Non igrofile 0,20

10.2 Detaillierte Methodik

ISPRA

Istituto Superiore per la Protezione e la Ricerca Ambientale

PROVINCIA AUTONOMA DI TRENTO

Agenzia Provinciale Protezione Ambiente

INDEX of LAKESHORE ZONE FUNCTIONING (IFP)

Instrument for the definition of ecological quality

as indicated by Directive 2000/60/CE

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1. Introduction

In international literature there is a huge bibliography regarding riparian fluvial areas with contributions about vegetation, fauna, on the function of the buffer strip, on their ecological function, re-naturalization and reclamation, the planning value, consolidation actions etc. (Vidon & Hill, 2006; Hatterman et al., 2006; Naiman & Decamps, 1997; Naiman et al., 1993). These studies relative to the role of the repatian area of lakes do not have such a long tradition and often treated the functions of such component only marginally (Keddy & Fraser, 1983, 1984, 2000; Zhao et al., 2003; Hazelet et al., 2005; Marburg et al., 2006; Hwang et al., 2007; Ostojic et al., 2007).

The coastal habitat has many natural element*s that are intertwined with the* lake ecosystem to form an ecological net. The vegetation, the sediments and the detritus play an important role in the vital cycles of fish and coastal fauna. (McDonald et al., 2006; Dudgeon et al., 2006; Malm Renofalt et al., 2005).

The rivers are subject to receive the waters of the basin from which they flow bearing a load of chemicals that, in the case of nitrogen and phosphorus, actively affect in the trophic evolutionary processes of their waters. (Premazzi & Chiaudani, 1992; Chapman, 1996). Already secular classic limnology has produced numerous works without focusing the attention on the simple functionality of the lake riparian zone.

The role that the riparian strips have in the protection of the body of water from human activities is surely an element to guarantee the stopping of the degradation of the aquatic ecosystem (Cobourn, 2006). The use of the territory has often cause environmental stress caused by the elimination of the riparian and aquatic vegetation on the borders increasing diffuse pollution creating morphological alterations and habitat destruction (Schultz et al., 1993, 1995).

The studies by Osborne and Kovacic (1993) have shown that the riparian strips both herbaceous or shrub/arboreal types have a capacity to efficiently intercept the nutrients coming from nearby agricultural areas diminishing over 90% of the content of nitrogen and phosphorus in the superficial flowing water and some superficial that flows into the body of water.

The interests that concentrate around the river environments are various and heterogeneous. The waterfront owners often have a different opinion regarding the function of the constituents of the lakeshore zone: despite they are convinced that “natural” is better than “artificial”, there is anyway an attitude that pushes towards the exploitation of the resource. In fact a lake besides having a great naturalistic value guarantees numerous opportunities for water activities such as swimming and aesthetic satisfaction that can be exalted by management and protection policies of the lake ecosystem.

Such vision necessarily has as the creation of a system of indicators and thus indices that are able to guide us in the planning and management choices of the territory. Following the success of the IFF (index of fluvial functioning – Siligardi etal., 2007), the necessity spawned research for a model able to calibrate the efficiency of the lakeshore zone. It started with the examination of different descriptors present that are easily surveyed (Broocks et al., 1991; Keddy & Fraser, 2000; Lin et al., 2000; Dale & Beyele, 2001; Danz et al., 2005; Brazner et al., 2007). The need is strengthened by the request by the Water Framework Directive 2000/60/CE on the waters that worked the evaluations regarding the biological elements such as the hydro-morphological elements in support of a definition of the state of ecological quality.

2. Lakeshore environments Water Framework Directive 2000/60/CE

The Water Framework Directive 2000/60/CE defines the elements of quality (EQ) for the classification of the ecological state of the bodies of water of any typology. Among the elements of quality to be determined in support of the biological elements, there are hydro-morphological elements that in the case of lakes regard both the hydrological regime (with elements relative to the quantity and dynamics of the water flow the connections with the subterranean waters and the time of residency) as well as the morphology (with elements such as the variation of death the characteristics of the substrate don't have the structure of the river banks) (CIS, 2003). For that which concerns the lakeshore zone the document "The horizontal guidance document on the low roles of wetlands" in framework directive (CIS wetlands WG 2003) is the most important reference to article 1 of the Water Framework Directive in which the wetlands are cited as elements on the ecosystem of internal superficial bodies of water as are the lakes.

The ecosystem of the Lakeshore zone closest to the water is commonly called Wetland or an area that has characterized its self as a Lakeshore eco-tone with a gradient that goes from the surrounding territory to the aquatic environment and that can depend on the constant and periodic increase of the lake level with or with out flooding. The CIS document is clear in considering the Lakeshore zone as associated to the wetlands in the directive and anyhow as integral part of a lake able to influence the relative ecological status. The many of the objectives and obligations of WFD be linked to the body of water can encompass also the Lakeshore zone (CIS Wetlands WG 2003, page 10 to 13).

However the directive does not foresee environmental objectives for the wetlands and for such reason at the meeting in Copenhagen in November 2002 the member states defined that the tampering with the shoreline are considered as impacts also for the ecological state of the body of water. Thus the management of the wetlands or of the Lakeshore zone as in our case can be considered an integral part of the Basin Plans and the increase or conservation of the wetlands – Lakeshore zone may be the instrument to reach the objectives of the WFD. These considerations and assumptions not only have been received by the CEN Technical Committee 230/WG2 "Water Analysis" but also by the member states and others such as Switzerland.

The overlooking of the methods in use by the member states immediately demonstrated that they are no agreed upon or consistent methods in the EU for the determination and use of such elements of quality. Also there is no agreement regarding the definition and put into use of the measurement programs to be included in the Water Management Plans of the Hydro-geographical Districts with the aim to reach the environmental objectives defined by the WFD regarding environmental protection policy and sustainable use of the bodies of water.

The hydro-morphological elements of quality are of fundamental importance in the analysis of bodies of water at risk to not reach with in the established times by the Basin Programs the environmental objectives in particular those for bodies of water classified as highly modified water bodies (HMWB) or the artificial ones.

Therefore it is extremely important to develop and apply in the indices such as the IFP in the analogous IFF regarding rivers that can give an integrated response on the state and ecological potential of a body of water (Lake, River) for the hydro-morphological aspects.

3. Ecology and function of the lakeshore zone

The “Lakeshore zone” that extends around the lake with a defined width has various ecological functions. Many environmental factors contribute to determine ecological functioning of the Lakeshore zone.

The morphology and characteristics of the lakeshore have great importance as functional elements for the ecological dynamics of the bodies of water and biodiversity. The morphological characters, apparently not influential on the qualitative processes, in fact assume a high importance for the evaluation of the functionality of the coastal areas.

In addition, the topographical conformation of the territory adjacent to the body of lake can influence the exchanges between Lake – territory. In fact the greater the geometric complexity of the profile of the lakeshore is, minor is the influence of the amount of nutrients in the limnological processes in that the geometric complexity reduces the content of BOD, COD and TP (Hwang, 2007).

The Lakeshore riparian ecosystem, even though less obviously than the fluvial riparian one, guarantees a conspicuous amount of water that contributes to the growth and survival of plants, insects, animals, and microorganisms increasing biodiversity and consequentially, functionality (Giller, et al., 2004). Plants constitute a element of structural diversity and taxonomic able to moderate seasonal water flows storing water and regulating the amounts of sediment and nutrients (Smith and Hellmund, 1993).

Topography, climate and the geological composition of the soil greatly influence the structure and extension of the lake shore zone. Likewise the vegetation of the Lakeshore zone exerts a considerable control on the water flow of nutrients, sediments, and the diffusion of animal and vegetable species that calm from the surrounding territory and that move towards the lake (Malanson, 1993b; Naiman et.al., 1993). In fact the surrounding territory gives the lake different amounts of nutrients based on the use by the same territory be it agricultural, industrial, urban, uncultivated or other with differentiated amounts and especially diffuse whose control is rather difficult.

The band of vegetation along side the lake is thus considered a transition zone not only from a topographical point of view but also functionally between the surrounding territory and the body of water (Pinay et al., 1990; Smith & Hellmund, 1993; Malanson, 1993b; Vidon & Hill, 2006; Hazelet et al., 2005). The containment of the amount of nutrients of the basin to be lake must be done by the maintenance of a vegetated lakeshore zone capable to intercept water contributions be they superficial or subterranean and the nutrients that are contained within them (Burt et al., 2002; Van Geest et al., 2003).

The portion along the lake that is in contact with the shore where the macrophytes are at the bottom of a trophic web is not less important. The variation in factors such as depth, granulotry, and exposure to the waves combined with the variations and level affect the grade of biodiversity of the macrophyte community (Keddy & Reznicek, 1986; Keddy, 1990; Ostendorp, 1991; Wilcox & Meeker, 1992). The vegetation also has an important role in lakeshore protection (Maynard & Wilcox, 1997; Ostendorp, 1993).

Besides these ecological functions there is also a recreational function in which the coastal areas of lakes due to their natural conformation are highly attractive to tourists (Bragg *et al.*, 2003; Wilcox, 1995).

The following definitions of the IFP are used regarding the different portions of the Lakeshore zone:

- Shoreline: this is the portion of the riverbank that makes contact between water and soil that can be nude, herbaceous or constituted by vegetation elements more or less complex such as stumps, logs, branches, root systems, bed of reeds or other;

- Littoral zone: indicates that portion of the lake that correspondence to the euphotic (well illuminated) and in general coincides with the new limit of development of the submerged macrophytes; it often hosts characteristic phytobenthic communities and zoobenthos and furnishes a hideout for many aquatic and non-aquatic animals. It is an area of deposit and development of the eggs of some fish species (Baker, 1990; Doyle, 1990; Pollock *et al.*, 1998; Bratli *et al.*, 1999; Wetzel, 2001; Roth *et al.*, 2007);

- Riparian zone: it represents that part of the territory immediately adjacent to the lake that is capable to significantly affect the quality value and determined by other hydro-morphological, biological or physical elements and in return can be influenced by flooding and wave action. It is more or less indicated as that portion that has ecotonal functions constituted by habitats for both terrestrial and aquatic organisms and guarantees a high level of biodiversity (Wetzel, 2001);

- Lakeside zone is that portion of the territory that interacts with the lake environment; it does not have ecotonal structure and function but more a terrestrial one.

Expressions such as Lakeside zone, riparian zone, littoral zone, Shoreline do not completely reflect the significance of ecotonal zone and in the scientific world there is a lack of agreed-upon expressions to indicate the ecological functional zone. In fact there is no unanimous or shared agreement on the areas of the lake and their definitions; in fact in the same document of CIS Wetlands Group (CIS, 2003) to identify the littoral zone especially when the context refers to natural lakes, the term lakeshore is used that other authors differently, less geographically- morphologically but more ecological-functional (Schmeider, 2004). (Fig.1) Therefore the term lakeshore is used to indicate the transitional area (ecotone) that is in between the terrestrial environment and the pelagic one (Naiman & Decamps, 1997).

With the aim to apply the IFP method for **the lakeshore zone it is intended as a topographical zone situated around the lake that comprises part of the littoral zone up to a maximum depth of 1 m and extends up to 50 m from the shoreline.**

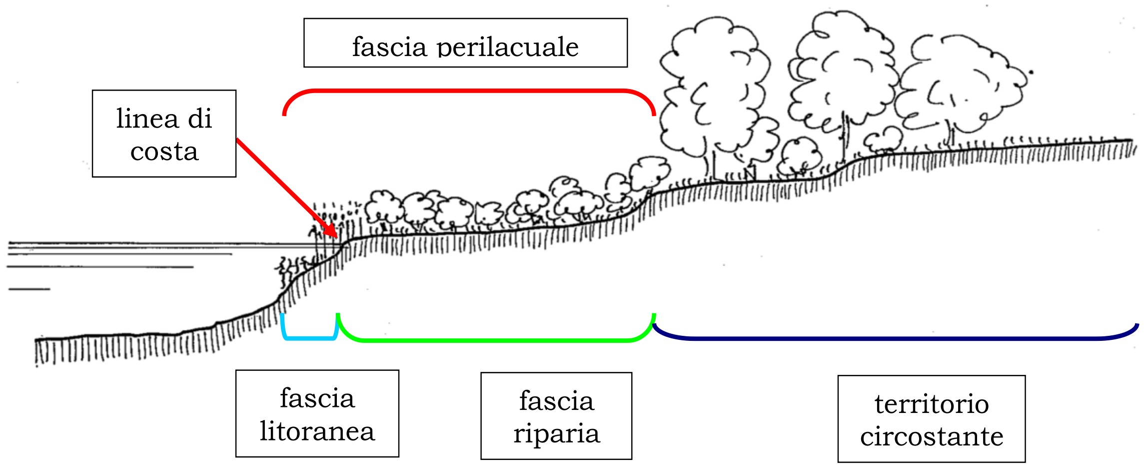


Figure 1 - scheme of the different lakeshore areas

The natural lake shores can have different characteristics that depend on the vegetation and geology of the rocks, genesis, age, depth and shape of the lake, geo-morphological processes, delta sedimentation and wave action and occurring changes in level. They efficiently carry out the role of eco-tone separating and at the same time putting in relation the terrestrial habitat with that of the lake and regulating the sink- source flow between the compartments that are in contact (Farina, 2001). Also they have many ecological functions such as filter for nutrients of diffuse origin, having a tampon effect and self depurative action of its own water zones (littoral and riparian) that compose it (Hatterman *et al.*, 2006; Cirmo & McDonnell, 1997; Krysanova & Becker, 2000; Lin *et al.*, 2002).

The Lakeshore zone is quite important for the different functions that it has for the lake ecosystem:

1) **Filter**: the rain and surface streams of water are slowed down by vegetation that favor the infiltration and processes of sediment and pollutant capture (Pinay *et al.*, 1990) (Fig. 2).

2) **Protection from erosion** –the tree roots hold the soil of the lakeshore impeding or slowing down the erosion process done by the natural wavy action or induced by swimmers (Heckman, 1984).

3) **Removal of nutrients** – nutrients such as nitrogen or phosphorus coming from a surrounding basin can be intercepted by the root systems of the lakeshore zone vegetation and metabolized and stored in leaves, trunks, and roots (Pinay *et al.*, 1990; Vanek, 1991; Vought *et al.*, 1993, 1994; Shultz *et al.*, 1995; Push *et al.*, 1998). Phosphorus is the main limiting nutrient of lakes and produces an acceleration of the eutrophication process in lake waters. Its removal can occur by three different solutions:

   a) deposited in river sediment

   b) absorption of the dissolved phosphorus such as ortho phosphate and its immobilization in particles of bottom sediment (Triska *et al.*, 1993; Vought, 1993);

   c) uptake of nitrogen and soluble orthophosphate phosphorous with suction operated by the root apparatus of the Lakeshore zone vegetation (Vought, 1993, 1994) (Fig. 2).

The efficiency of the tampon zone feels negatively the effect of the duration, intensity and period in which the water flows linked to the seasonal climatic activities; for example the lakeshore zone vegetation generally composed of deciduous plants, has a higher filtrate efficiency and removal of nutrients in the vegetative period with respect to the physiological dormancy (Mitsch & Grosselink, 1986).

4) **Temperature control** – By shade produced by the tree foliage one can have an attenuation of solar irradiation and a temperature control and the band of water in contact with the coast where more often you find the fauna and where egg deposition occurs (Gregory et al., 1991).

5) **Habitat** – The Lakeshore zone with vegetation is an ideal habitat for many species of animals (amphibians, reptiles, birds, mammals, insects, etc.) giving them a refuge and necessary food for survival and reproduction (Callow and Petts 1994). To this is associated also a value of the coastal zone as a habitat for fish and thus is an element to manage or reclaim also for the maintenance of the fishing resource.

6) **Anthropic value** - the Lakeshore zone with vegetation and trees has particular value when characterizing the Lake both by naturalistic and aesthetic points of view. At other times it assumes a cultural-historical-archaeological value due to the presence of manufactured items that are historically symbolic.

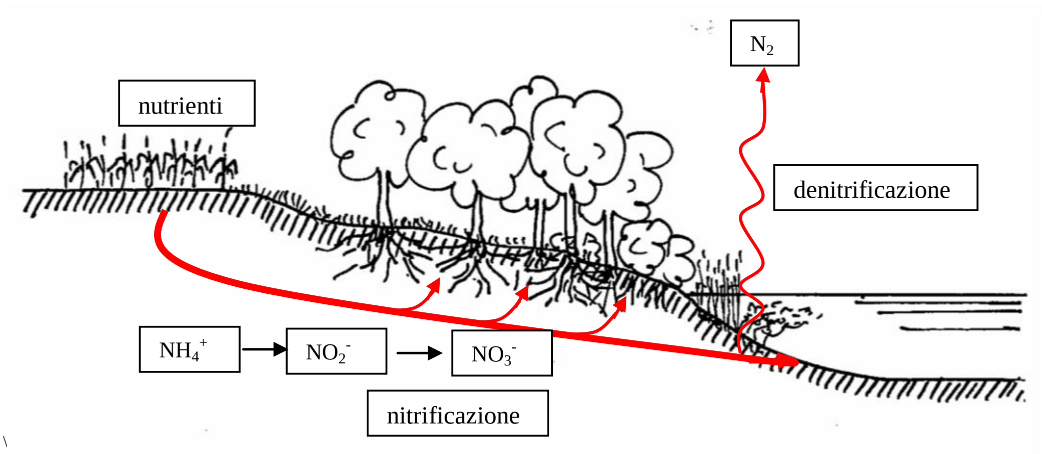


Figure 2 - Representation of the tampon function of the Lakeshore

4. IFP lakeshore functionality index: introduction

4.1 Methodologies

To satisfy the needs listed above regarding the necessity of indices for the evaluation of the functionality of the lakeshore zones it was officially instituted by APAT now ISPRA, a work group whose aim to propose a new method.

After a first classic approach to the problem based on consolidated experience of the IFF (index of fluvial functioning) (Siligardi et al., 2007) the workgroup thought about the necessity to widen bio-indicators to more modern and advanced conceptual models. They directed themselves towards an elaboration of approaches that could utilize potentialities of new generation methods such as for example those made from the area of machine learning, artificial intelligence or fuzzy logic as inspiration of the new ecosystem vision.

With the aim to define an evaluation criteria of the functioning of an important ecological structure, the integrity of a community or other characteristics of closely related entities only two approaches are possible:

- The first foresees the recognition of recurring typologies and successive interpretation of these with the attribution a posteriori of any quality number or any analogous classification not necessarily on an ordinal basis (or not necessarily following a scheme that distinguishes only that which is desirable from that which is not). This approach for example is that that was used for the development of the CAM algorithm (classification of marine waters) that was used for the evaluation of data furnished from monitoring the coastal marine waters coordinated by the environment directorate (www.minambiente.it).

- the second approach instead foresees an evaluation a priori of the quality or functionality of the observed entity furnished by technicians that survey the data and unequivocally link it to these. In practice they survey the values in a series of variables or attributes that are considered relevant and they are associated with a subjective score. Later this information can be used to develop a heuristic or codified type method formalized in a precise algorithm to associate a group of environmental measures or observations a grade the most conforming to that which would have been given in the case they were available the surveyors of the original data. This was done in a couple cases putting together more or less complex multi-metric biotic Indices but the possibilities of modern data analysis methods, machine learning or even artificial intelligence make it easier to use non-subjective approaches to this problem (Scardi et al, 2008).

In this area for the treatment of the data collected to create an Index of Lakeshore Functionality it was decided to use an approach based on a **classification tree** after having analyzed with different explorative techniques such as ordinance and hierarchy classifications and also self organizing maps. For an introduction to the ecological applications of the method please refer to Fielding (1999).

This solution allows to link unequivocally a group of observations on the structure of the Lakeshore zone to an evaluation of its potential functionality or of its apparent capacity to protect the body of water from non-point emissions coming from sections of the rainy basin stretched below the lakeshore zone under consideration. This method is immediately comprehensive for use by ecologists and naturalists as it generates a binary tree that has the same structure as the dychotomic tree for the identification of species.

The solution is not the only possible one and is not necessary in the most efficient and absolute but it was chosen because it was considered optimal with respect to the explorative nature of the work completed. In particular the main objective was to get an easily applicable method on the basis of a grouping of rather limited field observations.

The workgroup made a form for the collection of the largest number of parameters and indicators to identify the most significant information for the proposed objectives.

The form is divided into three groups of parameters:

1) general parameters
    a) Topographical
    b) Morphological
    c) Climactic
    d) Geological
    e) Others
2) ecological parameters
    a) vegetation type
    b) size
    c) continuity
    d) interruption
3) socio-economical parameters
    a) General
    b) use of territory
    c) infrastructure
    d) tourism
    e) tourist infrastructure
    f) productive activities

4.2 Characteristics of the classification trees

Any *classification tree* (a term sometimes translated in a time as "decisional tree" or "tree of decisions") is a binary tree that represents a group of rules that are applied to classify multi-variate observations. Each "leaf" of a *classification tree* represents a more or less frequent type of observation and more leaves can belong to the same class; it follows that these can be considered as a subgroup of the class is recognized by the system.

Once organized the *classification trees* can be used to classify objects or observations sequentially following the rules associated to each bifurcation of the tree to reach the leaves.

These can be more or less pure meaning that they can contain objects and observations classified in an incorrect way. In general obtaining pure leaves implies a reduced capacity to generalize from the tree (*overfitting*). In other words if the tree learns only to correctly classify the cases that are given it during training, the rules that are generated are associated too closely to these particular cases and are not useful when other slightly different cases must be classified. On the contrary if the tree structure and the rules that it contains are simple the probability that the tree can be used efficiently also in the classification of new cases is increased. It is for this reason why many cases and appropriate methods to trim the tree once it's developed are used so to reduce its complexity and to increase if possible it's capacity to generalize.

Among the *Machine Learning* techniques the *classification trees* represent the one that fits better to be used in easily understandable practical applications it can be used also by the non-technical public. In fact the complexity of the algorithms that are used for the training of the trees or to define the optimal logical conditions and threshold values to be verified is a completely transparent for the final user and also within certain limits for he that develops it.

In particular among the advantages of a *classification tree* the following are important:

- they are easy to put together thanks to generally efficient and tested algorithms (e.g. C4.5, ID3, CHAID, etc.) and in some measure are capable to autonomously estimate the optimal structural parameters for a tree;
- they are easy to understand and represent graphically and to interpret unlike other machine learning techniques such as artificial neural nets or statistics such as non-linear regressive models;
- their practical application does not require calculations of any type but only a the verification of a group of simple logical conditions;

- they can manage equally efficiently both quantitative variables and semi-quantitative or nominal ones while other methods do not always treat efficiently the latter;
- they are particularly efficient for the managing of cases of interactions between variables that are resolved by opportune partitioning of the defined space of the attributes under consideration;
- they can suggest which parameters are more important in determining the classification and this does not require particularly acted analysis but only a visual inspection of the tree structure.

4.3 Development of the IFP survey form

The definition of the parameters for the IFPs survey form was done between 2004-2009 by a series of attempts that began with the identification of a wide range of parameters that could be associated to the lakeshore zone functioning. The first group of parameters were narrowed after using the form on some Rivers and eliminated the redundant or not very significant information. An attempt was made to select the parameters on the basis of finding them easily for all types of rivers; due to this some meteo-climatic information was excluded that in some cases was not available.

The initial use of an experimental form made it possible to evaluate the objective difficulties of compiling it and to better define the required parameters as well as the method of assigning a score. By the experimentation in the field he was also possible to make a preliminary protocol for the correct interpretation of the form. Throughout these last years this first work phase created the definition of the IFP parameters in survey form that are discussed later.

5. Index of Lakeshore Zone Functioning (IFP): application of protocol

5.1 Preliminary Investigations

First of all the use of the IFF card requires indepth knowledge of the environment that is being studied. Due to this it is necessary to have an adequate cartography that permits to put into perspective the stream in its entirety, to define the soil use, to note the roads and the access points to the river and to mark homogeneous tracts.

Also thematic maps with geo-referenced information may be very useful (for example vegetation maps, maps on soil use, altitude, bathymetry, aerial photos, etc.). Independently from the scale chosen to show the results, for the fieldwork a map is necessary that has a scale one to 10,000 to be able to identify with a certain amount of detail the necessary elements for the environmental analysis.

It is also advisable to study aerial photography in advance so that the general characteristics of the lakeshore area are known as they're not always well interpreted by a land survey.

5.2 *Card for the survey of IFP parameters*

These parameters considered useful for the determination of the IFP are collected in a field card divided into two parts. The first with the general data is filled out for the entire lake; the second with the ecological morphological data is filled out for each homogeneous tract, or for each tract that has similar and constant in space eco-functional characteristics. The homogeneous tract is identified in the field and with the amount of information collected from the examination of the vegetation photographs. The change in tract and form happens each time that the zone theories obviously a specially regarding the characteristics regarding the week of the impact (e.g. artificial) or of the lake shore area (composition, width, conformation, etc.).there is no pre-established length for the homogeneous tract that can also be kilometers long but must be equal or superior to the minimal stretch to be sampled (TMR). The size of the TMR cannot be easily characterized as it depends on the size of the lake, the weight of anthropic impacts, on the structure and conformation of the lakeshore zone and others.

In the case of large lakes (perimeter above 50 km) generally the minimum stretch to be sampled is not less than 200 meters unless there is the presence of stretches with particular characteristics or anthropic impacts that would require the filling out of another card.

The information requested in the first part of the card (Table 1) can be gained from cartographic or bibliographical sources or by monitoring campaigns. In any case, these are additional information that enrich the environmental knowledge of the lake under examination but are not directly used for the assigning of the functioning judgment of the lakeshore zone.

	INDICATOR	Parameter expression	typology
TOPOGRAPHICAL	origin1	-	category
	type2	-	category
	location3	-	category
	latitude	degree, minutes, seconds	number
	longitude	degree, minutes, seconds	number
	altitude of lake	meters slm	number
	average altitude of catch basin	meters slm	number
MORPHOLOGICAL	area of catch basin (SB)	km2	number
	shore slope	degree or peercent	number
	development of coast line	-	number
	area of lake (SL)	km2	number
	volume	km2	number
	maximum depth	meters	number
	average depth	meters	number
	average residence time	years	number
	tributary/effluent capacity	m3/scond	number
	SB/SL relationship	-	number
	level changes	-	presence/absence
CLIMATIC	raininess	mm/year	number
	average maximum Jan. temp.	degree centigrade	number
	Average max. July temp	degree centigrade	number
	main geological type of substrate	-	category
OTHER	thermic cycle	-	category
	summer transparency (disco Secchi)	meters	number
	trophic classification using indicator principles	-	category

[1]= *tectonic, volcanic, glacial, oxbow lake, landslide, endorheic, coastal, seasonal, other*
[2]= *artificial, open natural, natural large, natural closed, natural regulated, other*
[3]= *alpine (mountain), pre-alpine (half mountain), lowland*
4= *calcareous, magma, metamorphic, sedimentary, other*
5 = *holomitic, monomitic, dimitic, polymitic, meromitic, amitic, other*
6 = *ultraoligotrophic, oligotrophic, mesotrophic, eutrophic, hypertrophic*

Table 1 - First part of IFP card: general data

The second part of the card refers to the conditions of each single homogeneous stretch of the lakeshore zone, selected according to the method described later (Table 2).

The necessary information for the filling out of this part are to be entirely field based as per the card in Table 3. The method of expression of each parameter is specified each time. It was decided to use a scale of number scores for ease of future statistical elaboration; the scores are defined by a discrete scale or range of values that takes into consideration the graduated expression of each parameter.

	Parameter	Typology	Value	Notes
1	width of lakeshore zone	category	0,1,2,3,4,5	
2	characterization of lakeshore vegetation			
2.1	cover/composition%	numerical	% - from 0 to 1	Σ = 1 except in particular cases
2.2	hygrophilous and non-hygrophilous vegetation	numerical	% - from 0 to 1	Σ = 1
2.3	exotic species presence	numerical	% - from 0 to 1	
2.4	heterogeneous arboreal-bush vegetation	numerical	from 0 to 1	
3	continuity of lakeshore vegetation	category	0, 0.5, 1	
4	interruption within lakeshore zone	numerical	from 0 to 1	
5	anthropic typology of uses in lakeshore zone	category	0, 0.5, 1	
6	main use of surrounding territory	category	0, 1,2,3	
7	infrastructure	numerical	from 0 to 1	
8	emerged lakeshore zone	numerical		
8.1	average slope	category	0,1,2,3,4,5	
8.2	comparison of slope between emerged/submerged areas	category	0,1	
9	shoreline profile	numerical		
9.1	concavity and convexity	numerical	from 0 to 1	
9.2	complexity	numerical	from 0 to 1	
10	shoreline artificiality	numerical	from 0 to 1	
11	apparent channeling of run-off	category	0, 0.5, 1	
12	personal judgment	category	0,1,2,3,4,5	

Tab. 2 – Useful parameters for the IFP with indications of the typology and evaluation of the same.

As described later in the method section not all parameters will be part of the resolution set and identification of level of functionality; however, it is opportune to fill out the card in its entirety to have a complete inventory of the characteristics of the lakeshore zone in order to allow other possible elaboration and project discussions for planning.

In addition, as it occurs for all the qualitative or semi-qualitative indexes based on heuristic processes and fuzzy logic after some years of application it is probable that it is necessary to recalibrate the method.

Date
Lake
Card Number
Delimitation of stretch
Number of photograph
Surveyors
GPS coordinator

Lakeshore Zone
boundaries of the zone determine by ……………..

1. width of lakeshore zone	
0	0
1-5m	1
5-10m	2
10-30m	3
30-50m	4
>50m	5
2. characterization of lakeshore zone vegetation	
2.1 cover/composition % (expressed from 0-1)	
trees %	
shrubs%	
reeds%	
grasses%	
bare soil%	
2.2 Hygrophilous and non-hygrophilous vegetation (expressed from 0-1)	
hygrophilous	
non-hygrophilous	
2.3 Presence of exotic species	
exotics	
2.4 heterogeneousness of arboreal-shrub vegetation	
diversified	1
intermediate	0.9-0.7
monospecific	0.6
autochthonous hygrophilous arboreal-shrub species >2/3	
diversified	0.5
intermediate	0.4-0.3
monospecific	0.2
autochthonous hygrophilous arboreal-shrub species < 2/3 and autochthonous arboreal-shrub < 2/3	
autochthonous relevance	0.1
exotic prevalence	0
arboreal-shrub vegetation absent	0

3. Continuity of the lakeshore vegetation	
arboreal and shrub zone	
absent	0
discontinuous	0.5
continuous	1
wet reed zone	
absent	0
discontinuous	0.5
continuous	1
dry reed area	
absent	0
discontinuous	0.5
continuous	1
4. Presence of interruption on the lakeshore zone	
absent	0
intermediate	
present along the whole stretch	1
5. typology of anthropic use of lakeshore zone	
uncultivated meadows or unpaved streets, etc.	0
sparse urbanized, cultivated meadows, etc	0.5

SHORE AND SURROUNDING TERRITORY

6. Main Use of nearby territory	
woods and forest	0
meadows, forests, arable land, uncoltivated	1
seasonal cultures and/or permanent ones and sparse urbanization	2
urbanized area	3
7. Infrastructure	
provincial/state roads	
absent	0
intermediate	
present along the whole stretch	1
railroads	
absent	0
intermediate	
present along the whole stretch	1
parking	
absent	0
intermediate	
present along the whole stretch	1

Tourism related infrastructure	
absent	0
intermediate	
present along the whole stretch	1
8. emerged portion of lakeshore zone	
8.1 average slope	
level	0
slightly noticeable slope	1
obvious but can be overcome without problems	2
significant but can be overcome with trails or ramps	3
strong slope, roads or trials with bends	4
extreme, vehicles cannot drive	5
8.2 comparison between slope of emerged and submerged area	
non in agreement	0
in agreement	1
9. Shore profile	
9.1 concavity and convexity	
concavity	
absent	0
intermediate	
present along the whole stretch	1
convexity	
absent	0
intermediate	
present along the whole stretch	1
9.2 complexity	
absent	0
intermediate	
present along the whole stretch	1
10. shoreline artificiality	
absent	0
intermediate	
present along the whol stretch	1
11. apparent channeling of run-off	
no prevalent direction of flow	0
intermediate	
all the run-off converges in a single point	1

12. Personal judgment	
excellent	1
good	2
average	3
below average	4
terrible	5

Table 3 - Parts 1and 2 of the IFP card to be used in the field

5.3 Sampling method

The data sampling for the entire lake (Part 1) can precede the field inspection.

The filling out of Part 2 of the card is done exclusively in the field and refers to each homogeneous tract. As soon as a significant change occurs even in only one of the parameters to sample a successive homogeneous stretch should be identified for a new card.

When one states significant variation one intends an impressive change in one or more parameters as a great difference in the width or typology of the lakeshore zone, the presence of infrastructure or interruptions that are absent in the previous stretch, noticeable changes in complexity or artificiality of the shore, etc. The change in only the parameter of concavity and/or convexity often is not enough to determine a change in card if all the other parameters remain constant. In the case of shorelines with frequent valleys and inlets it is best to take into consideration the scale of that which is being surveyed (on the length of the minimum stretch to be sampled) so to make an adequate stretch subdivision.

For practicality and safety it is advisable that the sampling is done by at least two people. This also guarantees a reciprocal scientific validation.

The card must be compiled following the stretch to be monitored by foot along the bank. The fieldwork should be concentrated during the vegetative season as information regarding the lakeshore zone vegetation is requested. In the case of stretches with dense bank vegetation or steep, for which access is difficult it is recommended to go along the lake with a boat to survey possible interruptions in the vegetation and natural or artificial situations of the bank.

It is often useful to do an adequate photographical documentation. For a more precise delimitation of the stretches it is recommended to use GPS that allows the registration of coordinates of beginning and end of a stretch which would enhance further cartographic representation by GIS programs.

The necessary material for the application of the method consists of:

- trekking clothing and adequate personal safety equipment

- maps scale one to 10,000 of the stream for the detail
- vegetation maps
- An adequate number of cards for the study
- digital Camera
- Pencils and erasers
- Paper to take notes on things of particular interest
- metric cord
- Fishing boots
- Optic telemeter laser (advisable)
- GPS

Very useful are the PC tablets with GPS incorporated so to geo-reference the stretches and to directly mark them in the field on a digitalized may as well as the possibility of compiling the card directly in the tablet.
The data can then be downloaded, re-organized, and elaborated.

5.4 Calculation of the lakeshore level of functioning

The application of a classification tree to the data relative to the attributes of the lakeshore zone has allowed the identification of a first hypothesis regarding the creation of the evaluation criteria for the lakeshore functionality that stems from the elaboration of a database composed of 450 cards.
The use of the classification tree was made simpler by a Windows program that requires data relative to only the essential descriptors. In the list of the attributes considered by the classification tree developed for the evaluation of the lakeshore functioning, the 9 parameters from this elaboration of the database of cards that were determined to be essential for stretch classification are the following:

- Bank artificiality
- Vegetation cover
- Interruption of the lakeshore zone
- Concavity of the shore profile
- Covering by reeds
- Cover by arboreal species
- Road Infrastructure
- Heterogeneousness of arboreal vegetation
- Cover by non-hygrophilous species

It should be specified that the information regarding the descriptors that currently are not required for the definition of the index value (non included in the extant classification tree) are useful as they compose a database of the morphological and ecological characteristics of the lakeshore zone some of which correspond to the qualitative elements required for the classification of the ecological state of lakes (EC Directive 2000/60/CE).
In Figure 3 the classification tree obtained is represented. In the leaves as well as the nodes, the probability of belonging to each of the functionality classes is given is estimated, that are indicated with a 1 (excellent) to 5 (horrible). The most probably class selected is given over and over that on the gray background in the table contained in each leaf or node.
To proceed with the classification of a lake stretch one must start from the tree root and verify first the condition (artificiality <0.22 o >0.22), thus the interruption or herbaceous vegetation, and so on until the end of the tree that will indicate the probability of the level of functioning.

It is interesting to note how the tree branches below this first node lead to different classifications that can be obtained as a function of other conditions. However, the functioning of the tree is very simple and any other condition falls within the cases that will be found proceeding along the structure.

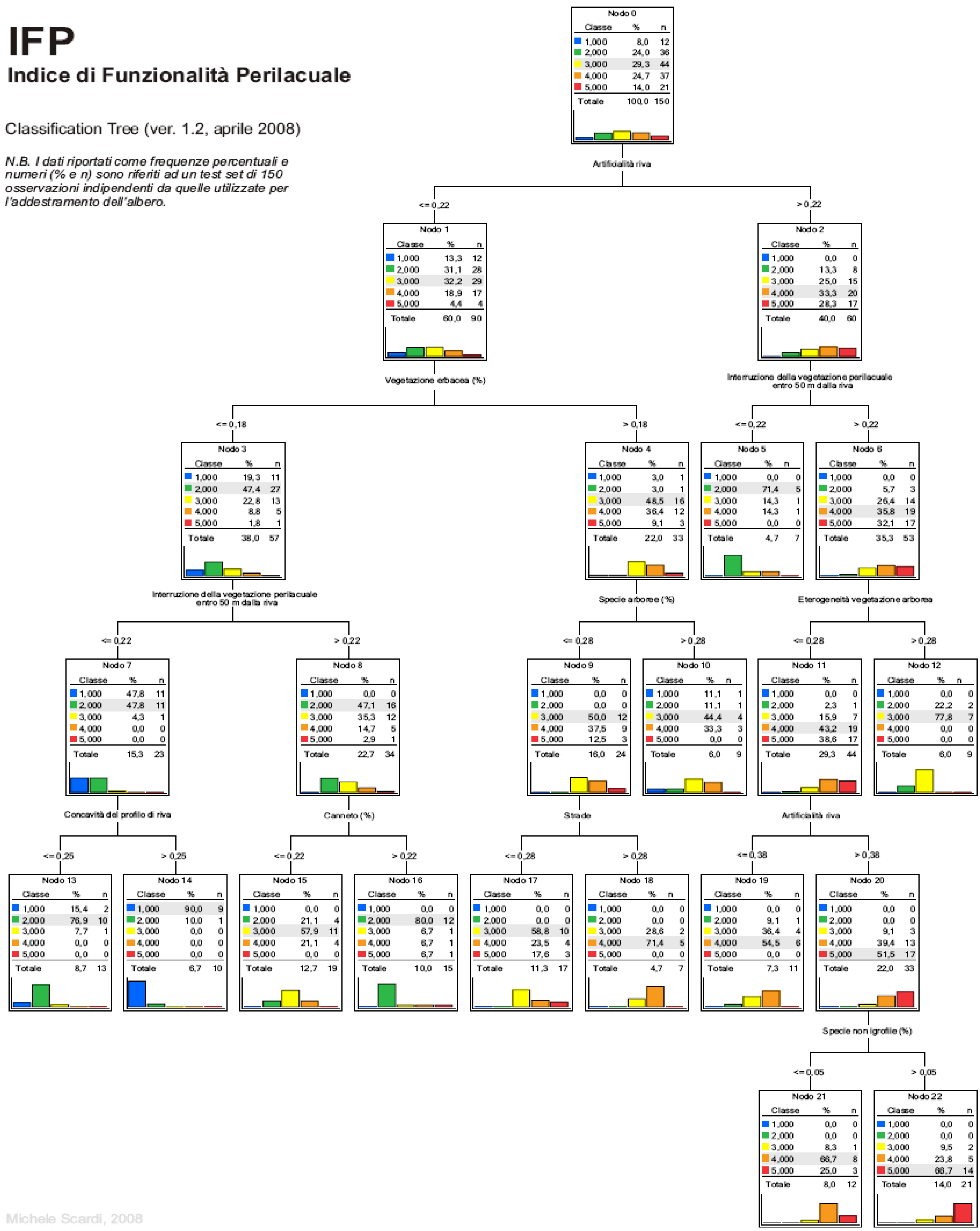


Figure 3 - Classification tree for the determination of the lakeshore level of functioning with the relative percentages.

Using the correct software for the definition of the IFP vale one can obtain as output the level of functioning and the probability of each of the levels being assigned.

For this reason it is important to emphasize how some attributes come into play various times in different parts of the tree (e.g. see % grasses). The reflects the optimal use of all the information available.

In table 4 the verification of the correspondence between the results obtained by direct observation of the areas (based on expert judgment) and the expected outcome obtained by the application of the model are given.

True Class	Predicted Class 1	2	3	4	5	sum
1	10	5				15
2	6	39	19			64
3		26	42	13	4	85
4			6	16	14	36
5			5	8	4	17
sum	16	70	72	37	22	217

Table 4 - Correspondence of the theoretic results, derived from the application of the model, and real ones.

The application of the accordance test pondered by Cohen (1960) has shown a value K = 0.673 ($p<0.01$). In addition, 51.2% of the cases was estimated perfectly and 95.9% of the cases was estimated with an error of only one level of functioning. Therefore, the errors above this margin regard on a residual 4.1% of the cases and are anyway relative to errors only within the classes between 3 and 5.

5.5 Levels and Functioning Maps

The final score is divided into 5 functioning levels (F.L.) expressed in Roman Numerals (from I which indicates the best situation to V that indicates the worst) to which the relative functioning scores correspond; intermediate levels are also foreseen to better gauge the passage from one class to another (Table 5).

This method does not foresee any intermediate situation as do other indices as the result of the classification tree gives probable values to assign levels and by definition one assumes the most probable as the final judgment. However, it is possible that the result from the classification tree does not give a clear cut judgment between two levels; if this is the case it will be the operators job to define a real interpretation of the data.

LEVEL	JUDGMENT	COLOR
I	excellent	**BLUE**
II	very good	**GREEN**
III	good	**YELLOW**
IV	fair	**ORANGE**
V	poor	**RED**

Tab. 5.1 Functioning Level and relative judgment and color for reference.

A conventional color is associated to each functionality level for a cartographic representation. The graphic representation is done with a buffer zone along the shore of the lake and divided into various identified tracts with their associated Functionality Levels color (Fig. 4). For a detailed representation it can be done on maps in the scale of 1:10,000 or 1:25,000 and for a detailed a complete representation can be done in a scale of 1:50,000. It is opportune to be able to use the obtained data in an operative and punctual manner, to not limit oneself to the reading of the map, but to examine in detail the IFP and also the score given to the different groups of questions. This can better emphasize the environmental components that are more compromised and thus consequentially shape the politics of environmental rehabilitation.

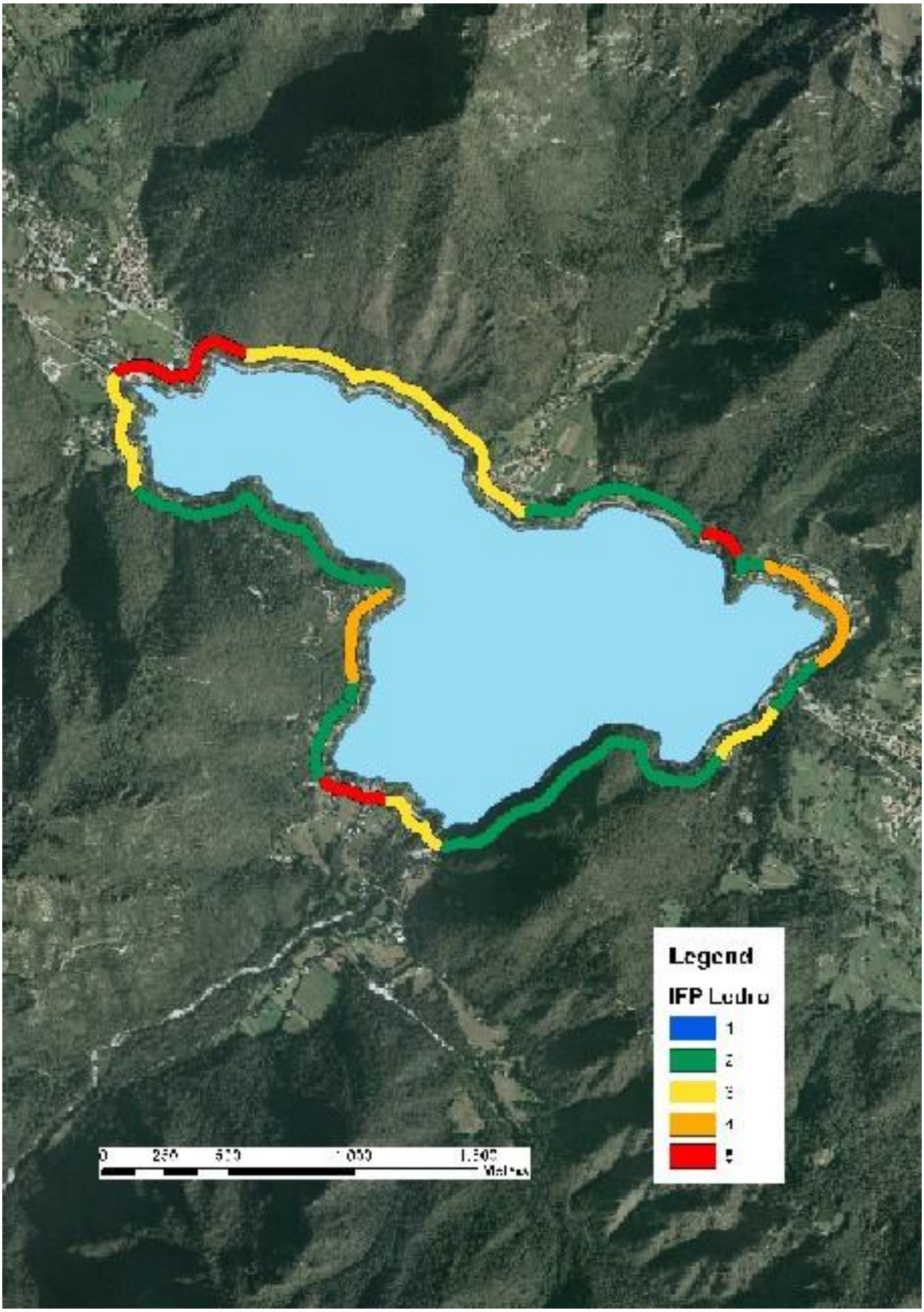


Fig. 4 - Example of a lakeshore zone functioning map (Ledro Lake, Trentino)

6. Guide to filling out the card

6.1 Width of the lakeshore zone

To correctly fill it out be IFP form is necessary to identify unequivocally the lakeshore zone.
As already defined in Chapter 3 it corresponds to the zone that extends from the river banks (contact line between aquatic and earth environment – Shoreline) two awards be external portion of the lake for a maximum of 50 m. it includes the riparian zone (shorezone) and the littoral zone (Fig. 1). Such zone can be in continuity with forests and woods and the surrounding territory or extend until an interruption.

In the case of artificial or natural basins that are characterized by noteworthy changes in water level that periodically cause the emergence of wide littoral areas, the shoreline SL has the maximum level of encroachment a recognizable by the obvious separation from the temporary release submerged part and the portion that has emerged that is more or less colonized by stable vegetation.

The presence of wet reads is to be considered within the lakeshore zone. The internal limit towards the lake corresponds to the portion of the lake up to a depth of 1 m (Fig. 5). Within such littoral zone there can be both helophytes and hydrophytes.

Helophyte my aquatic plants with the base and perennial buds submerged but with the stem and leaves in the air; they are usually present on the lake and river banks, swamps and marshy areas where leads are. Common examples are Typha (Typha l Amadaatifolia, T. longifolia), the Carex (Carex riparia, C. flacce) and the marsh reed (Phragmites australis) the marsh reed (Schoenoplectus lacustris) the marsh Rumex (Rumex hudrolapathum), the water lily (Iris pseudacorus) and rice (Oryza sativa).

Hydrophytes are perennial aquatic plants whose buds are either submerged or floating; they are divided into roots, with a root system that attaches them to the bottom (e.g. Potamogeton spp, Nymphaea alba, Callitriche spp., Ranunculus spp., etc) and floating that do not have anchoring roots and float on the water surface e (e.g. Lemna spp., Utricularia spp., etc.).

The importance of the riparian zone as a buffer strip and patch for the increase of biodiversity was shown in the preceding pages (Chapter 3); the efficiency of the ecological functions in the riparian zone depends on its width.

Fig. 5 - Internal border of the lakeshores zone in the absence (yellow line) or in the presence (red line) of wet reeds.

The width of the lakeshore zone (trees, shrubs, wet or dry reed, etc.) in its entirety is estimated in meters as a projections on a horizontal plane by the leaf cover of the vegetation and is placed in one of the categories indicated (with points from 0-5). In the case of step rocks on the surface of the lake, as the lakeshore zone if it is present only the portion in proximity to the lake should be used while the rocky walls are considered as external to the zone.

If the lakeshore zone is herbaceous, its width is evaluated only if it is represented by spontaneous formations, while mowed meadows or urban parks are excluded. It could happen that the lakeshore zone have large trees, even scarce, under which there is a non-hygrophilous herbaceous growth; in such an event only the arboreal vegetation is considered while the herbaceous cover must be considered as an accessory and not within the evaluation of the width.

The width of the zone, especially in anthropic context, is determined and limited by the presence of man-made interruptions and structures that interrupt the continuum with the surrounding territory.

Based on the width of the zone the following values are assigned:

- 0 (zero): width below a meter or inexistent or there is only bare soil (little pebbles or sand). One answers 0 (zero) also she there is the presence of infrastructure or impermeable soil that reach the bank with the absence of reeds;

- 1 : width from 1-5m;
- 2 : width from 5-10m;
- 3 : width from 10-30m;
- 4 : width from 30-50m;
- 5 : width greater than 50m;

It is best to emphasize that for survey purposes, the presence of impermeable wall, which is thus able to obviously condition the transverse continuum, is a limiting factor of the lakeshore zone vegetation (Fig. 6).

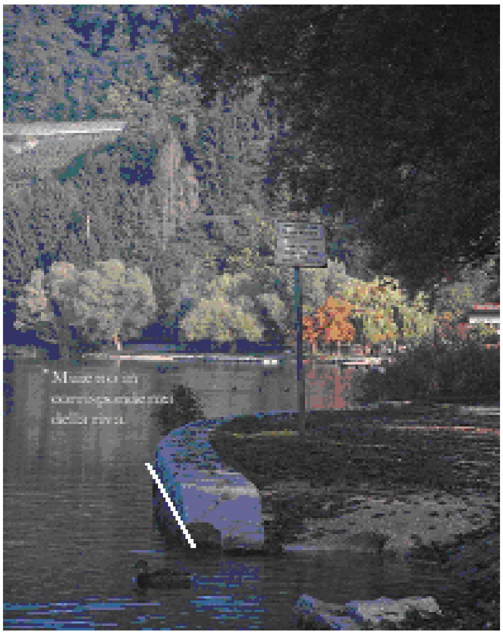


Fig. - *Muretto (non lambito dalle acque del lago) che costituisce interruzione della fascia perilacuale. Muretto (lambito dalle acque del lago) che coincide con la linea di riva.*

If
o
o
6

Consequently, if the wall is permeable or if other artificial structures are present that anyhow guarantee the permeability and the transversal continuity with the surrounding territory, even the vegetation present outside the wall in comparison to the lake is considered as lakeshore zone vegetation.

6.2 Characterization of the vegetation of the lakeshore zone

6.2.1 Composition/cover

The composition of the vegetation of the lakeshore zone is expressed in terms of cover with respect to the surface occupied by the zone itself (percentage value, then transformed into number from zero to one) within the following vegetation categories: arboreal species, shrub species, reed, grass and bare soil. For example, if there is a zone composed of 75% reeds and 25% arboreal species, the values assigned will be 0.75 reeds and 0.25 arboreal species. The attribution of percentages when added together total 1, but stem from the percentage estimate of the portion of trees and shrubs and then other categories beyond the reaches of the tree leaves. In the case of that in section 6.1 in which the vegetation in the zone is composed of large trees under which there is grass, it is not correct to assign the value of 1 to the grass component; one proceeds by evaluating first the percentage of cover by trees and shrubs (amount of tree-cover) and then evaluating the remainder outside the tree-cover and giving that area the percentage of grass cover and/or bare soil.

If the lakeshore zone is natural and in continuity with woodlands and forests from the surrounding areas, the composition/cover of the different types of vegetation must be analyzed of an area of the territory next to the lake equal to the width of 50m. If the identified lakeshore zone has an extension less than 50m and is limited by anthropic uses, the attribution of the composition/cover must be done on the area truly identified.

When the lakeshore zone is simply composed of a meadow or beach it is necessary to evaluated the stretches giving the percentage only to the categories of grass (grass=1) in the first case and bare soil (bare soil=1) in the second.

In the homogenous stretch there could be either meadow or beach present with areas of reeds or areas with trees: in this case the percentages of all typologies present in the lakeshore zone being analyzed will be given.

In the case in which the lakeshore zone vegetation is absent one responds with the value 1 to the component of bare soil and 0 (zero) to the other components; in the cases in which infrastructure (e.g. little wall, impermeable embankment) or impermeable soil (e.g. port, parking area) on all the stretch of the bank a value of zero is given to all the components.

If the portions of the soil that are impermeable are located within the lakeshore zone and only occupy a portion of it (e.g. cement tennis courts, pools, housing or other) one attributes to such areas a percentage value of cover as if it were bare ground.

The total of the values given to the single typologies of cover must equal 1 except in the case in which artificialization are present along the whole stretch so that the sum will be equal to zero (see above).

In the category “reeds” there are the species belonging to the biological forms belonging to the helophytes, such as *Carex* species, *Sparganium* species and *Phragmites* species. The hydrophytes with roots, submerged or with floating leaves and flowers possible present in the portion of the lake adjacent to the shore, as for example lilies (*Nymphaea alba*), yellow pond lilly (*Nuphar lutea*) and water chestnut (*Trapa natans*), do not belong to the lakeshore zone used in the IFP. Despite their presence guarantees the occurrence of some ecological functions such as sediment retention, the availability of microhabitat and shade, such components are not considered in the IFP.

If the option in which all the components amount to zero has not occurred, the attribution of percentages is done by units not less that 5% or values equal to 0.05. In the case of the voice “grass” one must pay attention as this variable is inserted in the classification tree and defines the route after node number two (see figure 4). In fact for value equal to or less that 0.15 (15%) the route will be headed towards the left while values above 0.2 (20%) will head towards the right with obvious differences in the resulting final evaluation. (see Classification Tree, Figure 3).

For these reasons, if the operator finds itself in a borderline 15-20% he must take great care in the attribution of the percentage of “grass” so not to create changes in the routes and thus in the final evaluation of functionality. The indication is that to identify the 20% limit (or 1/5 of the stretches surface free from the protection of tree-cover) and decide if the “grass” portion is superior or less than this limit and thus indicate with a value of $\leq$0.15 (15%) in below and with values $\geq$0.20 (20%) is superior.

6.2.2 Hygrophilous and not non-hygrophilous vegetation

The category of “hygrophilous vegetation” includes the helophytes and the shrub and arboreal species that are strictly riparian. An incomplete list of these is given in Table 6.

The percentage values given are transformed into numbers from 0 to 1 and the sum of the two must equal 1. The attribution is done on the same stretch taken into consideration in the section Composition/cover.

Should the entire zone be only bare soil it is given a score of 1 in the category “not hygrophilous” as if the vegetation were completely non-hygrophilous. The same score is given even if the soil is impermeable throughout the entire stretch and in the case of impermeable wall without hygrophilous species behind it, while if the wall were permeable or hygrophilous vegetation were present an intermediate value is given as in this case the wall is considered only an interruption (see page with 6.1).

HYGROPHILOUS SPECIES	***family***	***Common name***
***Alnus glutinosa* Gaertn.**	Betulaceae	Common alder
***Carpinus betulus* L.**	Corylaceae	European or common hornbeam
***Cornus sanguinea* L.**	Cornaceae	bloodtwig dogwood
***Euonymus europaeus* L.**	Celastraceae	European spindletree
***Frangula alnus* Mill.** (=*Rhamnus frangula* L.)	Rhamnaceae	glossy buckthorn
	Oleaceae	Ash; also European Ash or

***Fraxinus excelsior* L.**	Oleaceae	Common Ash
***Fraxinus oxycarpa* Bieb.**		Raywood ash
***Populus alba* L.**	Salicaceae	White poplar
***Populus canescens* (Aiton) Sm. (=*P. albo-tremula* Auct.)**	Salicaceae	Gray poplar
***Populus nigra* L.**	Salicaceae	Black poplar
***Prunus padus* L.** (=*Cerasus padus* DC.=*Prunus racemosa* L.)	Rosaceae	European bird cherry
***Quercus robur* L.** (=*Quercus peduncolata* Ehrh.)	Fagaceae	English Oak, Truffle Oak, Pedunculate Oak
***Salix apennina* A. Skortsov** (=*Salix nigricans* Sm. var. *apennina* Borzi)	Salicaceae	Arctic willow
***Salix cinerea* L.**	Salicaceae	Grey Willow; also occasionally Grey Sallow
***Sambucus nigra* L.**	Caprifoliaceae	Elder or Elderberry
***Ulmus laevis* Pallas** (= *U. effusa* Willd.)	Ulmaceae	European White Elm, Fluttering Elm, Spreading Elm and, in the USA, Russian Elm
***Ulmus minor* Miller** (= *U. campestris* Auct. non L.; *U. carpinifolia* Suckow)	Ulmaceae	Field Elm
***Viburnum opulus* L.**	Caprifoliaceae	Guelder Rose, Water Elder, European Cranberrybush, Cramp Bark, Snowball Tree

Tab. 6 - List of some hygrophilous species that characterize riparian environments of lakes.

6.2.3 Presence of exotic species

In riparian environments also exotic arboreal, shrub and herbaceous species can be found. For the IFP the attribution of the percentage value of exotics (later expressed in a value from zero to one) is done taking into consideration the list of species given in the following table (Table 7).

The attribution is done on the same stretch as that taken into consideration under the section Composition/cover.

EXOTIC SPECIES	***family***	***Common name***
ARBOREAL		
***Robinia pseudoacacia* L.**	Fabaceae	Black locust
***Ailanthus altissima* (Miller) Swingle**	Simaroubaceae	Tree of Heaven
***Prunus serotina* Ehrh.**	Rosaceae	Black cherry
SHRUBS		
***Buddleja davidii* Franchet**	Scrophulariaceae	Orange eye butterflybush
***Amorpha fruticosa* L.**	Fabaceae	Desert false indigo
***Acer negundo* L.**	Aceraceae	Boxelder, Maple, Maple Ash
HERBACEOUS		
***Reynoutria japonica* Houtt.**	Polygonaceae	
***Phytolacca americana* L.**	Phytolaccaceae	American Pokeweed
***Sycios angulata* L.**	Cucurbitaceae	Single seeded cucumber
***Humulus scadens* (Lour.) Merril**	Moraceae	Japanese hop
***Solidago gigantea* Aiton**	Compositae	Late goldenrod, great goldenrod
***Amaranthus retroflexus* L.**	Amaranthaceae	Redroot amaranth, redroot pigweed, red rooted pigweed, common amaranth, common tumble weed
***Ambrosia artemisiifolia* L.**	Compositae	Annual ragweed
***Artemisia verlotorum* Lamotte**	Compositae	Chinese mugwort
	Compositae	

***Bidens frondosa* L.**		Devils beggartick
***Helianthus tuberosus* L.**	Compositae	Jerusalem artichoke, sunroot, sunchoke, earth apple, topinambur
***Arundo donax* L.**	Graminaceae	Giant cane
***Impatiens glandulifera* Royle**	Balsaminaceae	Policemans helmet

Table. 7 – List of exotic species used in IFP.

6.2.4 Heterogenous arboreal and shrub vegetation

Arboreal and shrub vegetation is considered part of the lakeshore zone. Number values from 0 to 1 are given as per the scheme given in Fig. 7.

Observing the arboreal and shrub vegetation (including reeds) it must be initially evaluated the presence or absence of the hygrophilous autochthonous vegetation and if this is greater than 2/3 one can go to the evaluation of the diversification (left branch at first node of tree in Fig. 7). If instead the presence of hygrophilous autochthonous vegetation does not reach 2/3 of the total then of goes to the evaluation of the percentage of autochthonous arboreal shrub vegetation cover be it either hygrophilous or not (right branch after first node of tree in Fig. 7). If this last one is greater than 2/3 of the total arboreal and shrub cover, then one proceeds with the definition of the diversity (on the left after second node). If it is not, one evaluates the prevalence of autochthonous versus exotics.

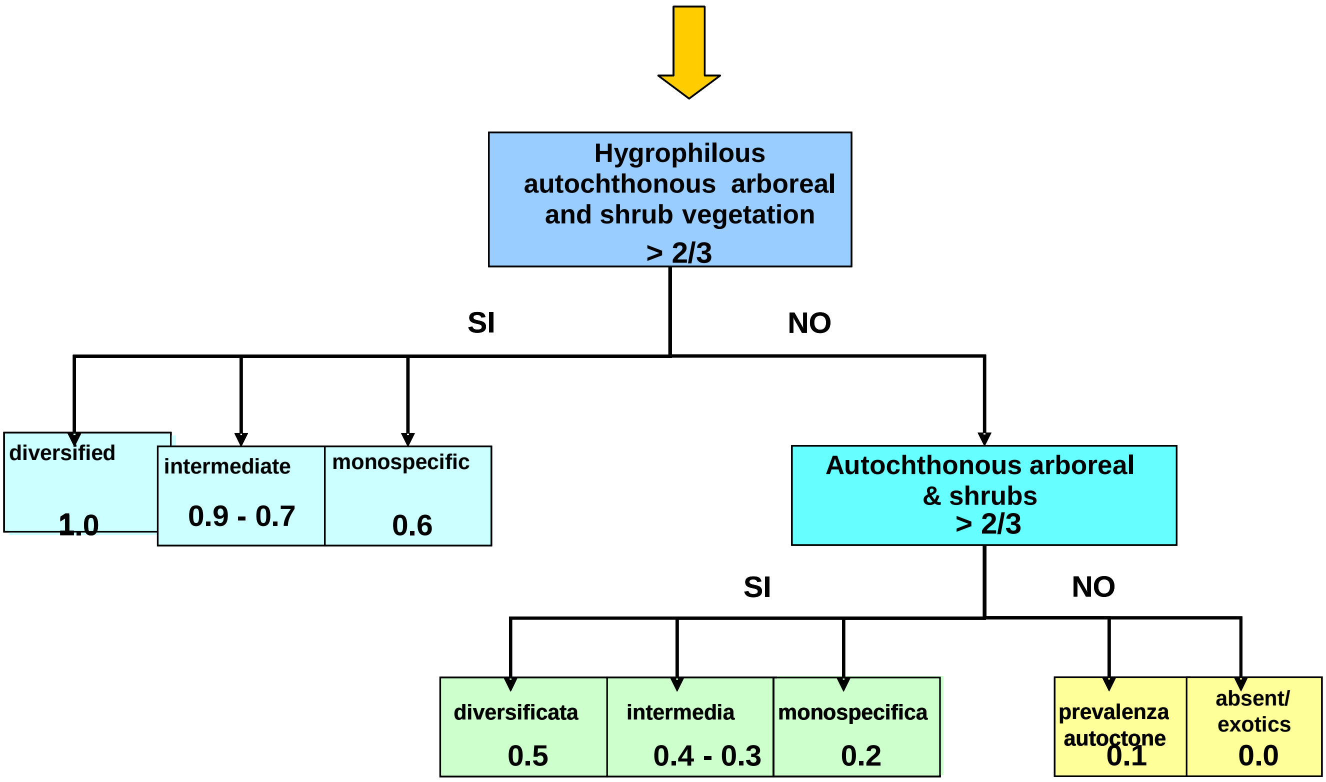


Fig.7 - Scheme for attribution of values relative to heterogeneous arboreal and shrub vegetation present.

In synthesis one could summarize as following:

a) Cover by autochthonous hygrophilous arboreal-shrub vegetation >2/3

-diversified = 1.0

- intermediate = 0.7-0.9

-monospecific = 0.6

b) cover by autochthonous hygrophilous arboreal-shrub vegetation < 2/3 with autochthonous > 2/3

-diversified = 0.5

-intermediate = 0.3-0.4

-monospecific = 0.2

c) cover by hygrophilous autochthonous arboreal-shrub vegetation < 2/3 with autochthonous < 2/3

- prevalence of arboreal-shrub autochthonous species = 0.1

- absent or with exotic prevalence = 0

At the moment of estimation of the arboreal-shrub vegetation community diversification it is useful to take the following under consideration:

- A diversified cover is registered when one finds at least three different types of trees and/or shrubs whose distribution is homogenous throughout the stretch or the percentage presence of the species are distributed in an significantly equal way;

- Mono-specific cover is assigned not only when a single vegetation type is present but also when a species is more strongly represented over the others (but can be present also in a high number, more than three), with a presence of at least more than 90%.

6.3 Continuity of lakeshore vegetation

The lakeshore vegetation (arboreal and shrub, wet and dry reeds) is evaluated along the stretch as homogenous if it represents a continuous structure or if it is interrupted by man-made structures for various reasons (e.g. tying a boat), beaches, access zones to the lake, zone in which the reeds are cu, etc. The continuity of the arboreal and shrub formations must be intended as the projection of the tree-cover and interpreted longitudinally. For the three categories identified (arboreal and shrub vegetation, dry and wet reeds) one attributes discrete numerical scores: 0: absent; 0.5: discontinuous; 1: continuous.

Also in this case what is important is the capacity to understand the area being studied as well as the good sense in attributing the said values; thus, for example, small interruptions along an pretty long stretch would not be taken into consideration as their “permeability” to superficial or hyporrheic contributions appears reduced and almost insignificant. An overall indication is to consider the interruptions as significant is they surpass 10% of the considered surface; in this case the score to be attributed is 0.5. If the interruptions are much higher in proportion and the areas covered by vegetation do not surpass 10% of the length of the stretch, a point of 0, or continuity is absent.

6.4 Presence of interruption within the lakeshore zone

An interruption is any intervention or work that in some way can reduce, condition, limit the functionality of the vegetation in the lakeshore zone.

The interruption can be developed in a linear form parallel to the coast (e.g. trails, roads, railroad tracks, etc.) or exist in more or less regular areas (e.g. house gardens, vegetable plots, cultivated fields, managed meadows, parking areas or other infrastructure).

A zone composed of only grass or bare soil is to be considered a single interruption of the vegetation zone.

In the case in which the lakeshore zone is thinner that 50m, one considers as interruptions only those that occur in the lakeshore zone while others are to be considered as belonging to the surrounding territory. To better understand the difference, imagine a lakeshore zone of 30m with a asphalt road and thus with interruption characteristics about 40 m from the shore: as this is outside the lakeshore zone, even though present within the 50m it is to be considered as infrastructure in the surrounding territory,

If the interruption only affects a more or less extensive portion of the homogenous stretch, intermediate points/score is assigned.

If arboreal-shrub vegetation is not present, when answering the question relative to the interruption one gives the value of 1 as it is considered a single and constant interruption.

The score of 1 is also given if an impermeable wall is present with a well-consolidate hygrophilous area of vegetation nearby (see section 6.1).

If there is only reeds, it is necessary to evaluate its interruption due to widening of the beach or presence of artificial structures (wharfs, platforms for swimmers, etc.)

The non-paved roads and trails are not considered interruptions of the lakeshore zone if they do not compromise the continuity of the tree-cover. The unpaved streets or trails that act as simple passageway with limited amount of traffic and insignificant impact on the landscape and structure of the lakeshore zone are not considered either interruptions or tourist infrastructure (see section 6.7). If there are modest intervention of consolidation (for example following naturalistic engineering) but the natural development of the vegetation of the lakeshore zone is not compromised, the unpaved trail is not considered as an interruption.

The unpaved roads that are considered as interruption are those that are characterized by both modest and elevated anthropic intervention (severe cutting back of vegetation, terracing of the crest, substantial modification of the natural morphology of the banks, presence of support walls, etc.)

6.5 Typology of anthropic uses within the lakeshore zone

Discrete values of 0, 0.5 or 1 are given depending on the type of interruption present in the lakeshore zone width identified.

If there are more than one type of interruption, both linear by running parallel to the coast as well as in more or less regular spaces within the lakeshore zone areas, one assigns the number that corresponds to the **most prevalent typology**. This is done after evaluating both its impact on the functionality of the lakeshore zone, the extension, and distance from the coastline. For example, a very large managed meadow is less of an impact when compared to a production industry that occupies a smaller area. In this case one would assign a value of 1.

In particular one assigns:

- The value of 0 in the presence of uncultivated land, trails or unpaved roads, vegetable plots or family garden, managed meadows, hedges, playground, filtrating parking;

- The value of 0.5 is given in the presence of sparse urbanization, cultivated meadow, non-intensive cultivations, asphalt road, impermeable parking, impermeable wall that anyway allow the hygrophilous vegetation to develop, (see sections 6.1 and 6.4);

- The value of 1 in the presence of an urban area, productive centers, seasonal and perennial intensive cultivations, extraction of inert substances, primary infrastructure, impermeable wall without the presence of hygrophilous vegetation behind it.

  For primary infrastructure one means the provincial and state roads, railroad tracks and parking area that is of considerable size.

  The municipal roads that have a significant amount of minor traffic are considered as asphalt road and it receives a value of 0.5.

6.6 Most prevalent use of surrounding area

Evaluate the surrounding area giving discrete number values from 0 to 3 depending on the amount of anthropization taking under consideration the conventional area of land that extends up to 200m from the bank.

The following values are assigned:

-0 if there is a prevalence of forests and woods;

-1 if there are uncultivated meadows for pasture, woods, and ploughable areas;

-2 if there are seasonal or permanent cultivations and sparse urbanization;

-3 in the case of an urbanized area.

In the first case the area is characterized mainly by broad leaf woods and/or conifers, Mediterranean scrub, or trees placed outside the altitudinal limit for woody species.

In the second case, these are situations in which man-made works, despite being modifiers of the morphological stretches, permits a balanced co-presence of human activities and natural environments. Sheep farming is limited and the cultivations that require ploughing have a marginal and secondary role when compared to the remainder of the natural habitat. In this case also recently cut copse, gravelly area, prairies/pastures formed due to human intervention (or below the altitudinal limit of trees), uncultivated areas in which advanced natural re-colonization is occurring (or not only composed of synanthropic or roadside species).

In the third case one means situations in which intensive cultivations are present that have profoundly altered the area by reducing the diversity and making it monotonous. Agriculture is industrialized and the use of fertilizer and pesticides is high: the typical cultivations are rice, corn, wheat, beets, vegetables, flowers, small fruits, etc. that are planted yearly. Analogously, in this section also permanent cultivations, those that require agricultural practices during the entire vegetational phase and beyond, such as orchards, vineyards, poplars are included.

In this section tourist campsites, boathouses and coverings for paddle boats.

In the fourth case there are the urbanized area or those that are completely artificial. An urbanized area is a group of housing, productive structures, infrastructure or services. As a first indication, one is advised not to consider an area urbanized if the agglomerates are fewer than ten normal sized buildings.

6.7 Infrastructure

Within the 200m of the bank if there are infrastructures such as provincial/state roads, railroad tracks, and parking lots they need to be noted. A number value between 0 (absence) and 1 (constant along the entire homogenous stretch) is given. In the case that the infrastructure does no affect the entire stretch intermediate values can be given.

In this section municipal roads with a low amount of traffic present in the lakeshore zone are not considered as infrastructure but as an interruption of the vegetation zone (see section 6.5).

Emphasized are also all the infrastructure for tourism present within the 200m of the bank. A tourism related infrastructure would be any fixing intervention with the aim of access to the lake and passage and or stopping area in vicinity to the river banks. Some examples of tourism related infrastructure are gangways along the lake, facilities, bicycling lanes, campsites, beaches for swimming, little wharfs, etc. Possible unpaved trails are not considered as tourism related infrastructure if they are simply transit ways and that not characterized by relevant impacts on the natural state of the banks.

In addition, in this case points are assigned between 0 (absence) and 1 (present on the entire stretch); intermediate points can be given is the tourism related infrastructure interfere with only part of the homogeneous stretch (for example, there are some little wharfs within the homogeneous stretch).

The unpaved streets and trails can be considered as tourism related infrastructure if that is their use. The suspended gangways along the lake are considered tourism infrastructure but not as interruptions as they are permeable and have a small effect on ecological function of the zone (see section 6.4). The passage of the elevated trail does not interrupt the natural evolution of the vegetation formation if it is not accompanied by consolidation intervention or support on the banks (little walls, terracing…).

To make it easier for the operator to give values, in Table 8 there are schematically represented some different types of anthropic interventions and what they are considered: interruption of the lakeshore zone or infrastructure within 200m of the banks.

ELEMENTS PRESENT WITHIN THE REFERENCE ZONE	*INTERRUPTION (section 6.4)*	*ANTHROPIC TYPOLOGY USE IN THE LAKESHORE ZONE (pgf. 6.6)*	*INFRASTRUCTURE TOURISM (pgf. 6.9)*	*ROAD INFRASTRUCTURE (pgf. 6.8)*
a) *unpaved trail that does not compromise the transversal continuity, that does not determine considerable impacts and does not constitute tourism infrastructure*	*0*	*0*	*0*	*0*
b) *unpaved trail or other man-made object in the lakeshore zone that compromises the transversal continuity due to the presence of non relevant support walls as tourism infrastructure.*	*X*	*0*	*0*	*0*
c) *unpaved trail in the lakeshore zone that compromises the transversal continuity with the presence of support walls, relevant as tourism infrastructure.*	*X*	*0*	*X*	*0*
d) *unpaved trail that does not compromise the transversal continuity but is relevant as tourism infrastructure.*	*0*	*0*	*X*	*0*
e) *Asphalt municipal road in the lakeshore zone.*	*X*	*0.5*	*0*	*0*
f) *municipal road that is more than 50m but less than 200m from the bank.*	*0*	*0*	*0*	*0*
g) *provincial or state road beyond the lakeshore zone but within the 200m.*	*0*	*0*	*0*	*X*

h) *provincial-state road in the lakeshore zone.*	*X*	*1*	*0*	*X*
i) *Urban park within the lakeshore zone.*	*X*	*0*	*X*	*0*
i) *Urban park beyond the lakeshore zone but within the 200m of the lake bank.*	*0*	*0*	*X*	*0*
l) *tourism campground within the lakeshore zone.*	*X*	*0.5*	*X*	*0*
m) *tourism campground beyond the lakeshore zone but within 200m of the bank.*	*0*	*0*	*X*	*0*
n) *along the lake gangway, also hanging, permeable*	*0*	*0*	*X*	*0*
o) *floating structure for tying boats and detached from shore and does not interfere with the lakeshore zone.*	*0*	*0.5*	*1*	*0*

Tab. 8 - Scheme that allow the evaluation of the impact of viability elements on the continuity of the lakeshore zone (X is the vale that goes from 0.1 to 1 and can be assigned in response to the percentage of the stretch affected by such infrastructure).

6.8 Emerged lakeshore zone

6.8.1 Average slope

The average slope is the slope of the emerged portion (first 50m) of the homogeneous stretch.

Even in the case in which there is a greater slope closer to the bank, possibly due to consolidation interventions on the banks, on always uses the average slope.

A discrete value number is assigned from 0-5 based on the grade of the zone's slope:

- 0 if the zone is flat;
- 1 if the zone has a barely noticeable slope

- 2 if there is an obvious slope but can be passed over without any problems (the trails or roads that run perpendicularly to the shore)
- 3 if there is significant slope that can be passed over with trails or ramps
- 4 if there is a strong slope (the roads or trails proceed with hairpin bends)
- 5 if there is extreme slope that cannot be passed by vehicles and with great difficulty by foot at the maximum; in this section fall also rocky formations that fall shear to the lake surface.

For a correct response to this question it is useful to consult a map of the area with contour lines.

6.8.2 Slope comparison between emergent/submerged lakeshore zone

In this case the correspondence between slope of the area that is above water (first 50m) and the slope of the most external area of the littoral zone (the first submerged meters) (Figure 8). The number 0 is assigned if the slopes are not the same and a 1 if they are. For a correct response it is useful to consult a map with the altimetry of the area surrounding the lake and lake bathymetry.

Due to the enormous amount of possible cases, only in the case of great difference in slope does one consider the stretch as discordant.

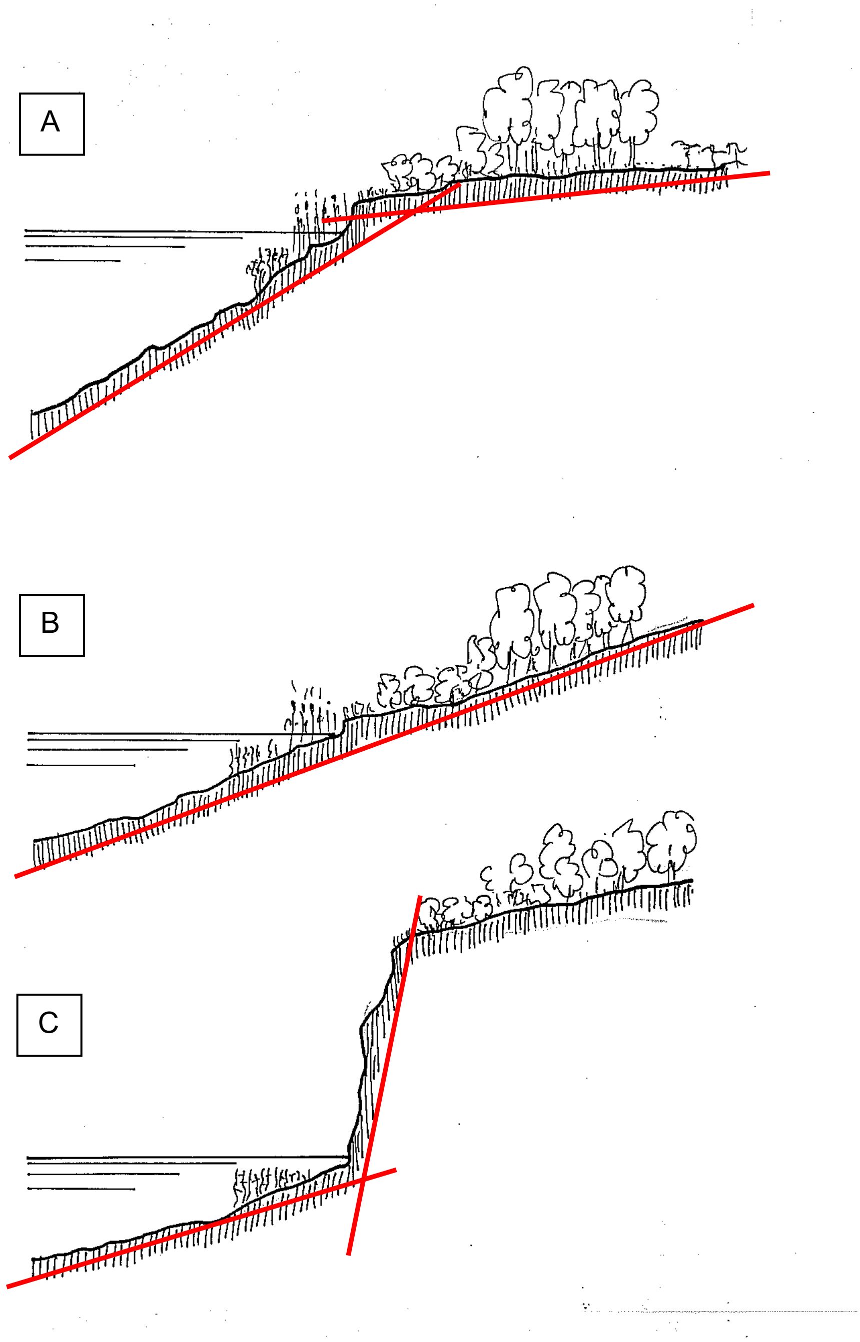


Figure 8 - Example with slope concordance (B) or not in accord (A,C) between the lakeshore zone and the littoral zone.

6.9 Shore profile

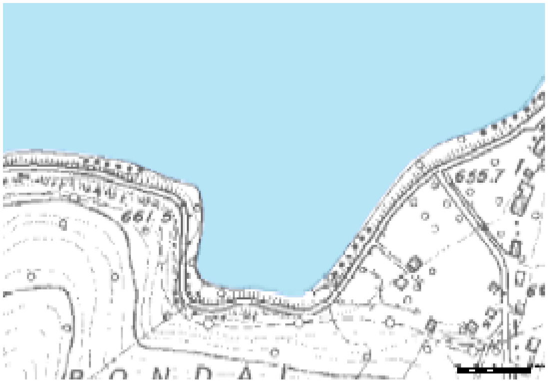
6.9.1 Concavities and convexities

The parameters "concavity/convexity" and "apparent channeling of run-off" are surveyed to identify possible situation regarding trophic loads. Only elevated concavity does not always favor an accumulation of nutrients and/or pollution in the lake (just think to a concave and level coastline).

To respond to this question one evaluates the presence or lack of the concavity (or of basins and inlets) and convexities (or promontory) of the shore profile in the studied homogeneous stretch.

An almost linear shore profile gets very low (0 if profile is completely straight) (Fig. 9, case **a**)concavity and convexity . In the case that the stretch has a single inset there is a concavity value of 1 and convexity 0 (case **b1**). On the contrary, if the homogeneous stretch corresponds to a sing promontory the concavity is 0 and the convexity is 1 (case **b2**). If in the same homogeneous stretch there are both concavity and convexity the value of 0.5 is given to each (case **c**). In the case of round shaped lakes, especially if small, where there are no significant concavities or convexities a value of 1 is given (as if it were a single concavity where the flow ends converging) (case **d**).

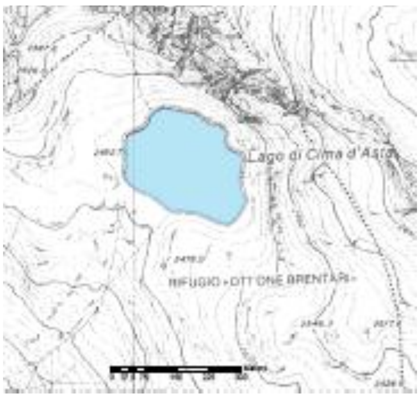
a)



b1)

b2)

c)



d)

Figure 9 - Scheme regarding the three different concavity situations and the complexity of the shore profile.

6.9.2 Complexity

The presence of digitization and undulations in the shore profile (for shore profile one means the limits between wet portion and shore) are evaluated.

In this case the scores go from 0 (no complexity) to 1 (the entire profile has complexities) with the attribution of possible intermediate values. The complexity evaluation is based on the estimation of the relationship between the development of the shore line and the distance from its extremes.

In the case in which the shore profile has artificial infrastructure and the shore coincides with, for example, a little stone and cement wall (Fig. 10) with the presence of a wet reed between the wall and the lake, the complexity or not of the little wall is evaluated as this may constitute the shore. In presence of the wet reed with a natural shore, instead, one takes into consideration the digitization and complexities of the border line of the wet reeds-water towards the internal part of the lake.

Fig. 10 - Artificial shore with no complexity due to the presence of the little wall that coincides with the shoreline.

The visual estimation of the complexity is not immediate and to help the operator some examples of complex shores are given. From a cartographic analysis on the shoreline of different lakes it has been noticed that the high complexity does not hardly have a Ic (Complexity Index) superior to 0.5 as described in the formula:

$$Ic = 1 - Rc$$

Where Rc in the relationship between the shortest line between two points of shore and the curved line of coastline development between the two points.

Only in the particular cases of artificial lakes in very narrow valley and with various little lateral small valley could a maximum case of Ic =0.5 occur.

Such result leave us to consider a coast line with more than or equal to 0.33 or that the straight line between two points of coast is equal to or inferior to 2/3 of the real coast line as very complex. This one assumes this value as the limit for the maximum score for the answer, or 1.

To assist the operator below are some practical examples regarding the discrete values of Ic. Figure 11 in its different expression:

Case a) Ic=0.33, complexity value=1

Case b) Ic=0.3, complexity value=0.8

Case c) Ic=0.2, complexity value=0.5

Case d) Ic=0.1, complexity value=0.2

On the basis of the value assigned to Ic one assigns the value to the complexity parameter in the following way:

- 1: with Ic>0.33
- 0: with Ic=0
- Intermediate values in the other cases.

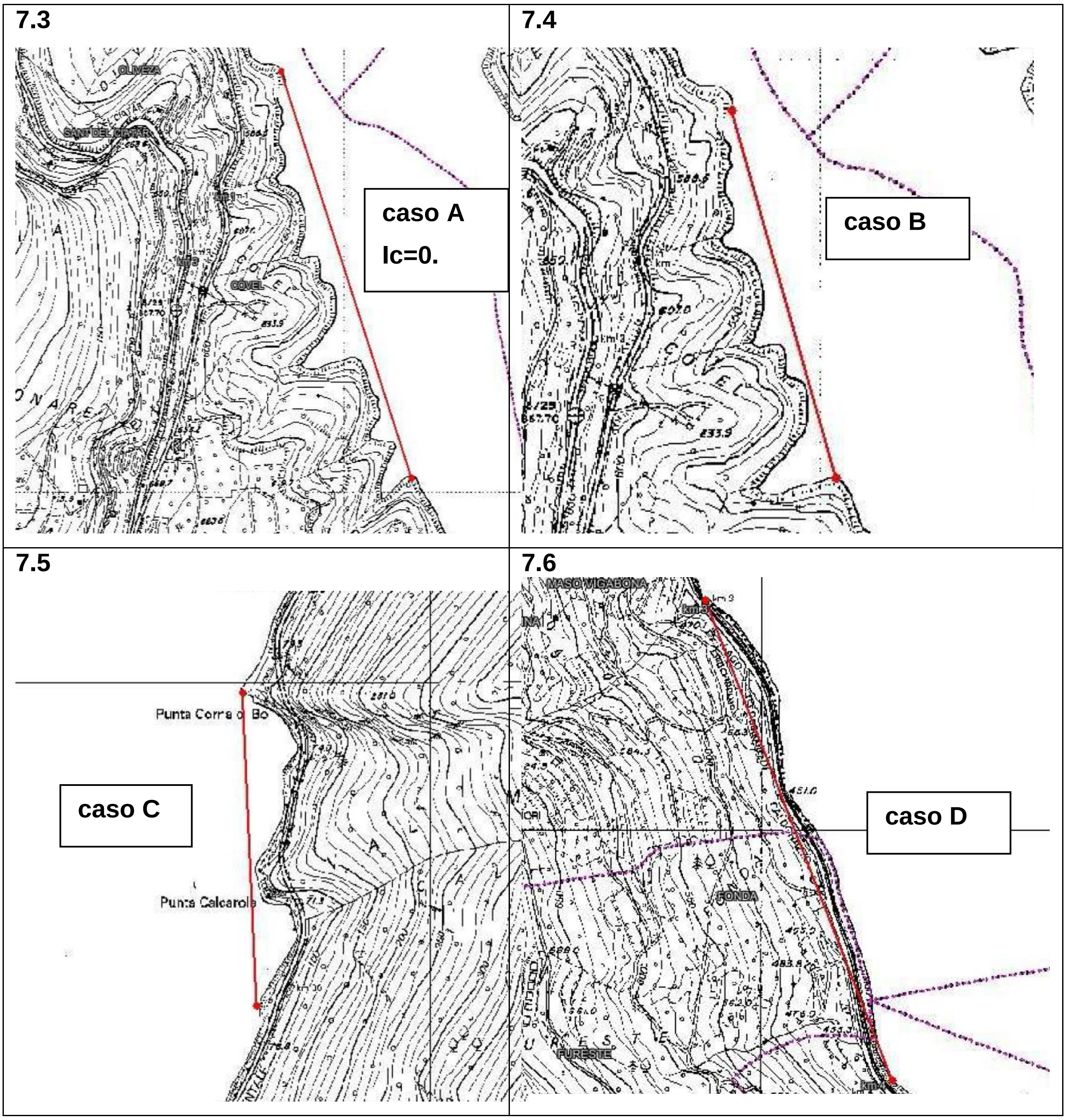


Figure 11 - Examples of coast development with complexity values relationships that are unit type: a = 0.67, b = 0.7 c=0.8 d=0.9

6.10 Bank artificiality

The presence of artificiality is evaluated that can include little stone walls, cement structures or other support structures in correspondence to the coastline (contact between water and land - shoreline SL).

As per the presence or absence, the typology of the extension, etc. variable points are assigned between 0 to 1.

- 0 = absence of artificiality

- 1 = artificiality that affects the entire homogeneous stretch and that drastically reduces or completely destroys the shore permeability.

- Intermediate score: presence of impermeable artificial coast that affects part of the homogeneous stretch or artificial permeable coast.

The level of artificiality of the shore depends on the amount of permeability of the same: an impermeable wall is more artificial than and little permeable wall made for example with wood planks (Figure 12).

In the defining of the intermediate percentage one must take great care in the case the artificiality is evaluated to be between 20-25%; in fact the classification tree foresees at the first node a change in course if the percentage is more or less than 0.22 (22%). If the artificiality is equal to or less than 0.20 (20%) one goes towards the left side of the tree while for values equal to or more than 25% the tendency is towards the right with consequences in the final judgment.

Figure 12 - Different level of permeability of the support wall corresponding to the shore and different levels of artificiality.

6.11 Apparent channeling of the run-off

The issue is to evaluate if there is a prevalent direction in which the run-off goes, intended as superficial running of water towards the lake. The evaluation is not immediate, however, observation of the map of the position of the contour lines and morphology of the territory can be useful. Ideally, tracking the orthogonal directions to the contour lines could identify the lines with maximum slope that could be run by the superficial waters; this will be divergent in the case of a “scodella rovesciata” morphology of the territory next to the lake and convergent in the contrary case. The evaluation will be done as follows:

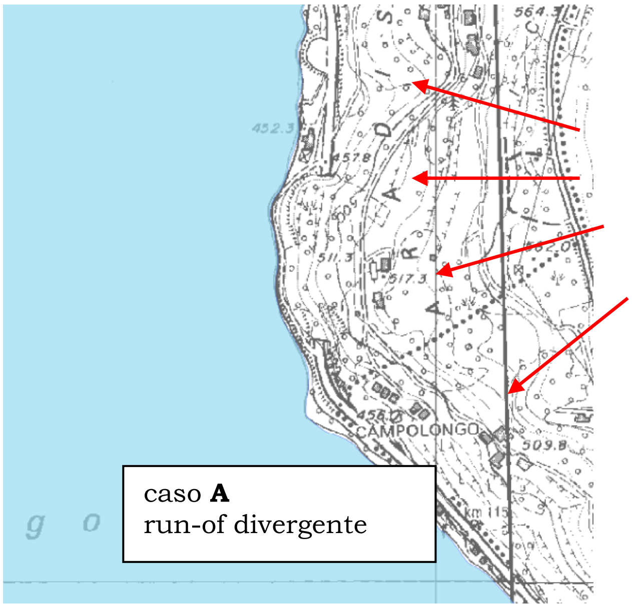
- 0 (zero) in the case in which the run-off is divergent (Fig. 13 case **A**) or the surrounding territory is completely level and thus without the confluence of the flow towards the lake”

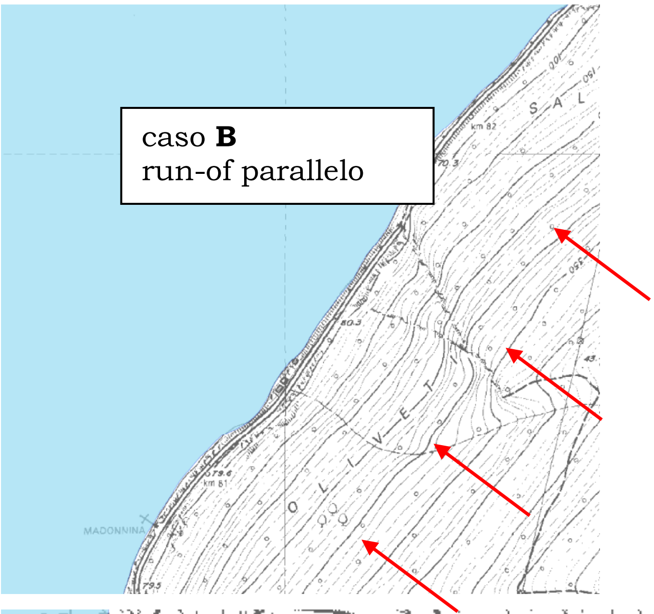
- 0.5 in the cas of parallel runoff (Fig. 13, case **B**);

- 1 in the case the run-off converges (Figure 13, case **C**)

- It could occur that the homogeneous stretch under consideration is small with respect to the territorial morphology of the lake and thus it is possible to have more stretches belonging to a single divergent or convergent system; the this case one attribute the same response to all the affects stretches. To attribute the channeling value of run-off of the single homogeneous stretch it is advisable to first proceed by doing an evaluation on technical map 1:10.000 with macroscale, dividing along the lakeshore the areas in which there is a single channeling intensity. The evaluations performed will be then taken on individual homogeneous stretches during the survey.

- Differently from the questions referred to for the concavity or convexity where it is required to reason bi-dimensionally on the profile of the shoreline, for the channeling of the run-off it is necessary to reason three-dimensionally taking into consideration the slope of the surrounding territory, evaluating the distance between the ISOIPSE in the technical map.


CAMPOLONGO
caso **A**
run-of divergente


MADONNINA
caso **B**
run-of parallelo

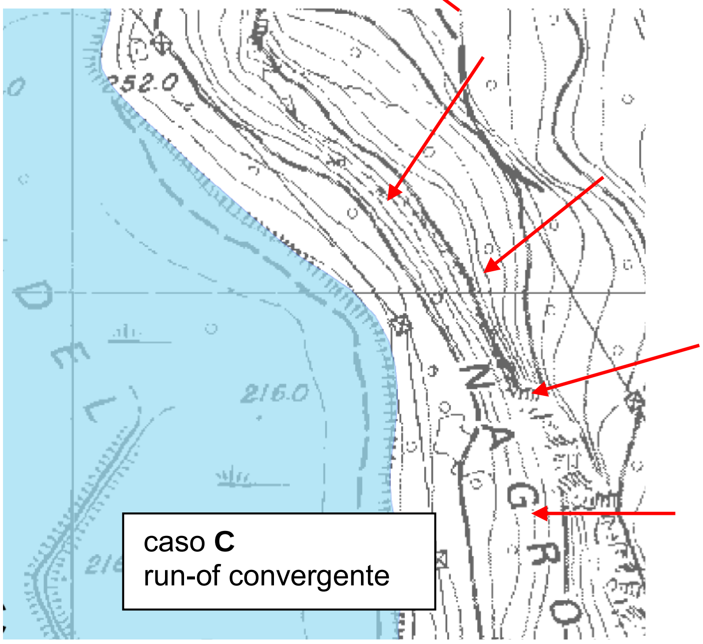

252.0
216.0
caso **C**
run-of convergente

Figure 13 - Representation of different run-off models

6.12 Personal evaluation

The expression of personal evaluation indicated with a number from 1 to 5 according to a decreasing scale of values (see table with parameters) must be formulated on the basis on the immediate impression by the operation following an ecological-functional logic.

It is known that our mind is able to express in fast times the feeling of "good looking" or "ugly" on the basis of an analysis of non-codified variables. For example, we can all express a positive or negative evaluation on a person, a painting, a dress, but when we are asked to identify the intrinsic motives for the evaluation, that is what we like or dislike, often we are unable to do so. This is because our mind takes in the entirety of parameters and summarizes them in an evaluation, but is not able to break down the analysis and recreate it as the sum of different details. Also the operator, in expressing the personal evaluation of the stretch, must not be influenced by the answers given previously, must actually express judgment prior to compiling the card.

If there is no congruence between the personal evaluation and the sum of the detailed parameters do not worry; the personal evaluation is in fact one of the parameters analyzed and not the conclusion or synthesis of the parameters in detail.

However, the personal evaluation, is a useful piece of information for the further development and validation of the method.

7. Functionality and lakeshore naturalness

In the preceding chapter we discuss the importance of the lakeshore zones as transition ecotones between two ecosystems not really for their natural characteristics but as ecological functioning entities. This is the most important aspect in the study of ecosystems, the relation of the energy flow between compartments, their courses and the homeostatic and resiliency activities.

It is increasingly important to think and act in order of the functionally in order to create and put into use conservation projects no only of the shorezones but all of the same lake as well as environmental reclamation inserted within a context of functional planning.

It is generally observed the conditions of maximal naturality correspond to that of maximal functionality but also some discordant situation occur. For example, lakes that are above the arboreal vegetation limit (absence of riparian arboreal vegetation leads to reduced IFP values even in conditions with maximum naturality); lakes is rocky FORRE and theus lacking riparian vegetation (reduced functionality); lakes with "anomalies" for example fed from sulphuric SORGENTI, thermo-mineral, saline, etc. sources.

The lakes with high naturality that have low IFP level are particularly vulnerable in that the limited functionality of the stretch must be considered as having reduced homeostatic capacity and system resiliency when confronting possible pressures. Thus they must be considered as ecological elements at high risk as even very minimal impact could cause great environmental problems.

The evaluation of the functionality given from the IFP, thus, does not correspond to the evaluation of naturality; if as already stated a high naturality can correspond to a low functionality, it is much harder to hypothesize the opposite. It is thus not absolutely possible to translate – by using a “conversion scale” the IFP value into a naturality judgment.

The method of IFP survey furnishes information organized in an inventory. The availability of information collect with standardized way makes the re-elaboration of the data at a different time possible as well as the use of different methods of evaluation.

Thus the dualism between naturality and functionality is thus defined, next is the need to get from the IFP method a differentiated evaluation based on the reference typology to which the water body being studied belongs. In other words, the real functionality of a given body of water, as the level of its functionality is compared to the potential one and see if that corresponds to its reported natural conditions. The relationship between real and potential IFP, definable as relative functionality, can give a measure of naturality coherent with the philosophy of the Directive Framework.

The introduction of the comparison with the reference condition and the consequent expression of a judgment on relative functionality via the IFP is an opportunity, that, by giving a synthetic additional information that has management value could end up increasing the application efficiency of this method.

However, the identification of the reference conditions for each single stretch, and thus of the potential functionality, on the basis of which it is possible to calculate the relative functionality, is an extremely delicate process that is established totally on the competency and scientific ethics of the surveyor. The use of incorrect references or worse, ethically wrong, can determine the expression of a non-trustworthy judgment of naturality with foreseeable consequences in the preservation, management and planning for the aquatic systems.

8. Ending notes

The group’s work in the creation of the Index of lakeshore functioning was done is a theoretical form with practical application of model support, developing a methodology that is conceptually coherent with that indicated by the Directive 2000/60/CE. The main objective was to put into place an instrument useful for territorial planning of area near lakes. Despite there are already several management and protection guides of the lakeshore (for example www.d.umn.edu/˜seawww/quick/ns.html and www.kelowna.ca/CM/Page360.aspx) these, re-working the lakeshore functionality, do not evaluate or quantify it.

The current version of the IFP was born after the application on a large array of typology of lakes be they natural or artificial, of the two Italian ecoregion (Alpine and Mediterranean) foreseen by the Work Groups of Directive 2000/60/CE.

The index of lakeshore functionality was born with the specific objective to evaluate the functional efficiency of the lakeshore zone especially in terms of capacity of nutrient removal from diffuse source.

Not withstanding the growing number of publications in the last ten years, the level of knowledge regarding the tampon capacity of the riparian zone is not yet satisfactory. There are definitely an insufficient amount of published works relative to lake environments and those with the aim of investigating the role of these transitional environments regarding the amounts of phosphorous are not complete.

It follows that the major limit of the Index of Lakeshore Zone Functioning resides in the difficulty of later being able to start a verification operation based on concrete experimentation in which one really measures the flows coming in and exiting from the riparian zone under consideration or from the use of pre-existing data.

The elevated capacity of the riparian ecotones in keeping and removing the nutrients and is anyway well documented and numerous studies done in Great Britain, France, Sweden, Denmark, Canada and the United States have shown that the riparian zone could consent to allow a sensible reduction, up to 90% of the nitrogen load coming from agricultural activities.

The management of water bodies needs adequate instruments for evaluation of the ecological processes guaranteed by the ecosystems. On results of such indices should be based on the decisions regarding territorial planning of environments next to lakes and the management of the water resource.

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