



LIFE
NatConnect
2030



I principali risultati del progetto PAGA-LO



PSR
2014 2020
LOMBARDIA
L'INNOVAZIONE
METTERE A RAGIONE

Regione
Lombardia

Fondo Europeo Agricolo per lo Sviluppo Rurale: l'Europa investe nelle zone rurali

Iniziativa realizzata nell'ambito del progetto PAGA-LO, cofinanziato dall'operazione 1.2.01 "Progetti dimostrativi e azioni di informazione" del Programma di Sviluppo Rurale 2014 – 2020 della Regione Lombardia.

Responsabile del progetto è il prof. Bruno E.L. Cerabolini

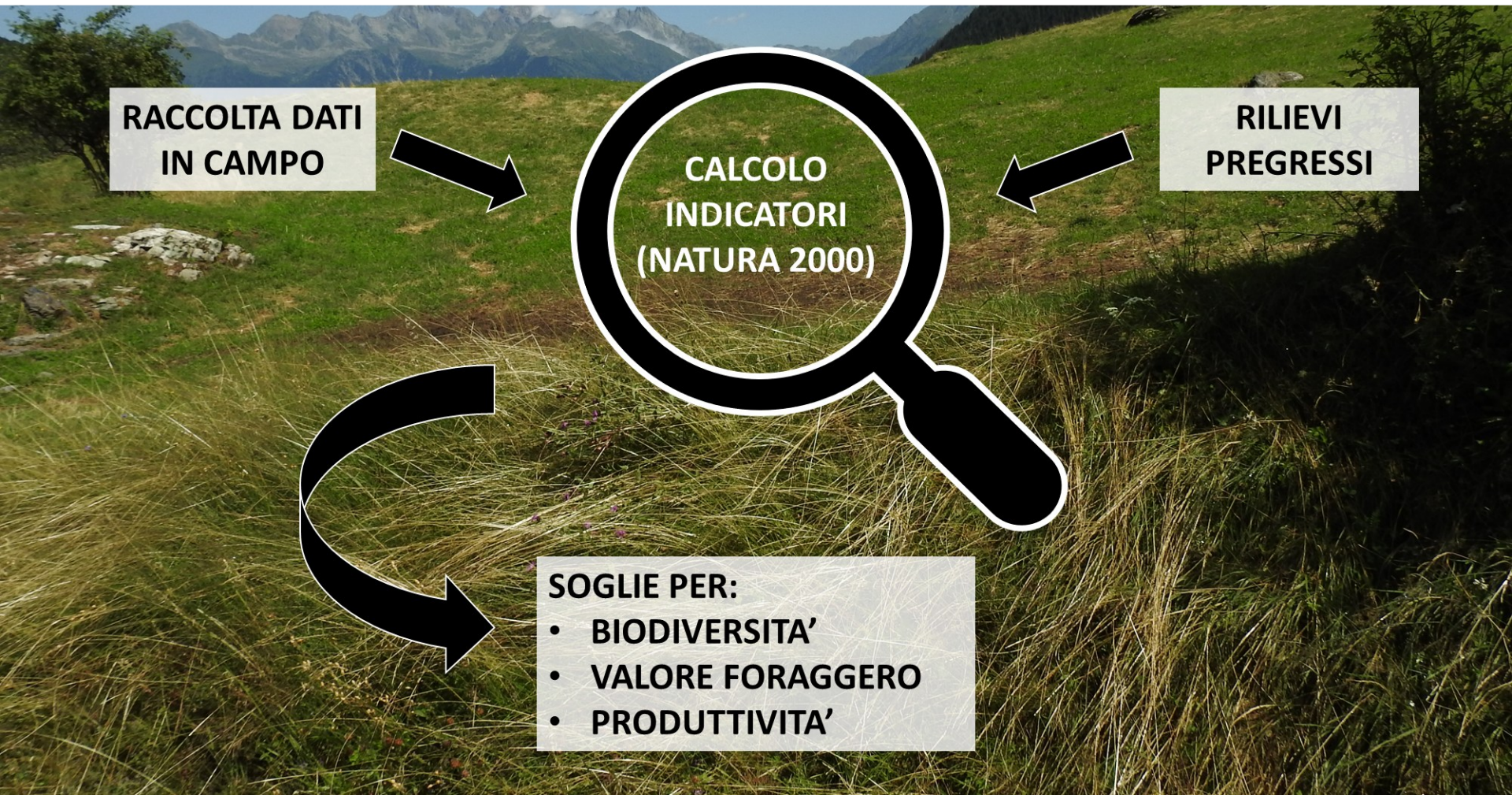
Michele Dalle Fratte

Dipartimento di Biotecnologie e Scienze della Vita, Università degli Studi dell'Insubria

michele.dallefratte@uninsubria.it

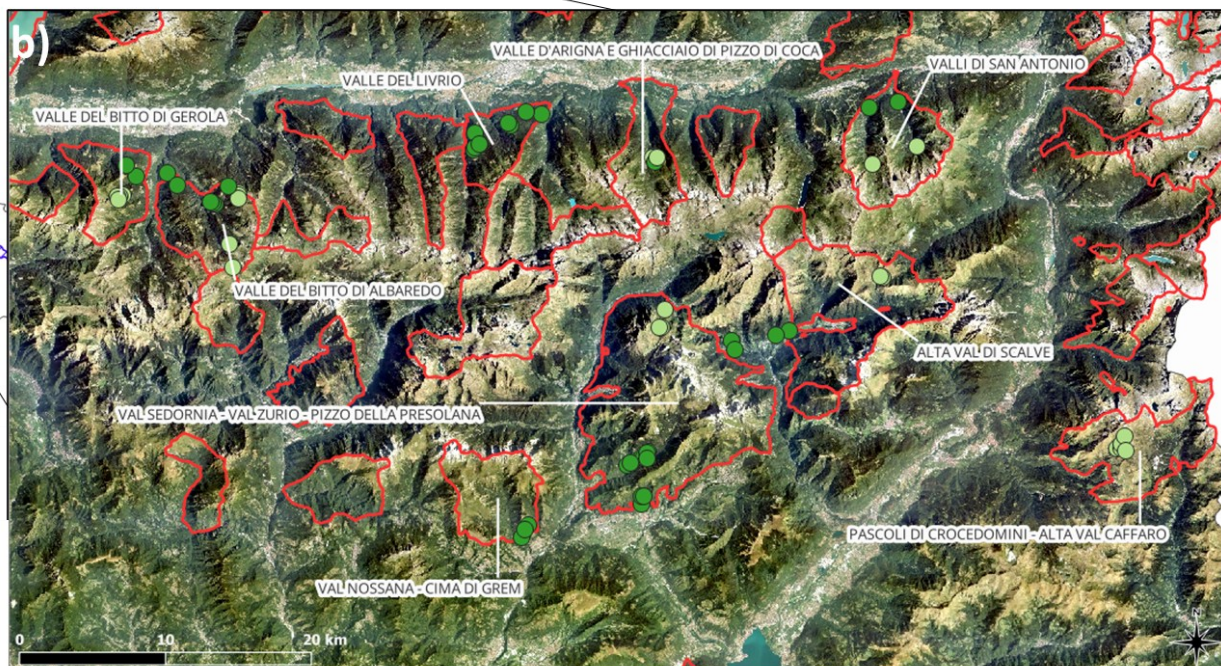
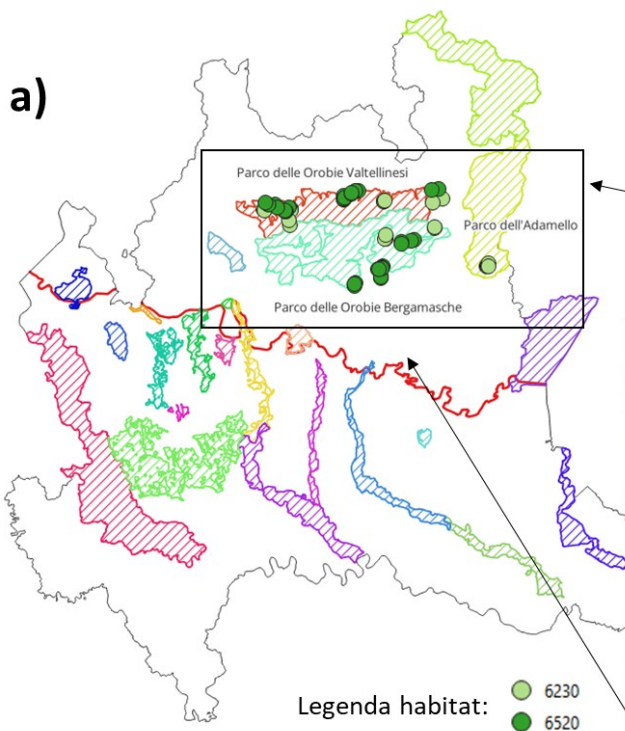
Milano, 24 ottobre 2025

Metodi



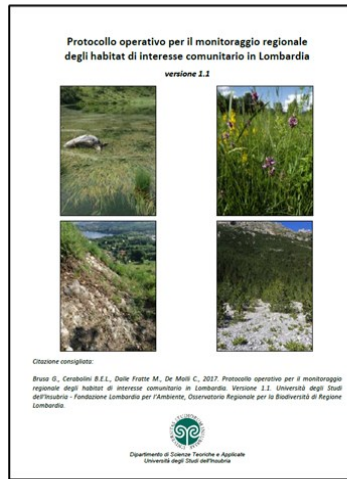
Raccolta dati

Selezione dei punti di campionamento (59 punti)

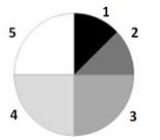


Raccolta dati

- Rilievo floristico-vegetazionale (16 m²)
- Campionamento della biomassa (0.25 m²)
 - peso secco
 - contenuto di fibre (Van Soest)
 - contenuto di nutrienti (CHNS)



Scala di copertura-abbondanza	Valutazione (%)	Valutazione (frazioni)
5	75-100%	3/4 - 4/4
4	50-74%	1/2 - 3/4
3	25-49%	1/4 - 1/2
2	12.5-24%	1/8 - 1/4
1	1-12.4%	1/100 - 1/8
+	<1%	< 1/100
r	<1%, max. 3 individui	< 1/100, max. 3 individui

[illegible]

Raccolta dati

Contenuto di fibre e nutrienti

- biomassa → stima diretta
- singola specie → stima indiretta → media ponderata (CWM)



Database contenuto di fibre a livello di **specie**



Dati in letteratura
45 lavori

Gap filling



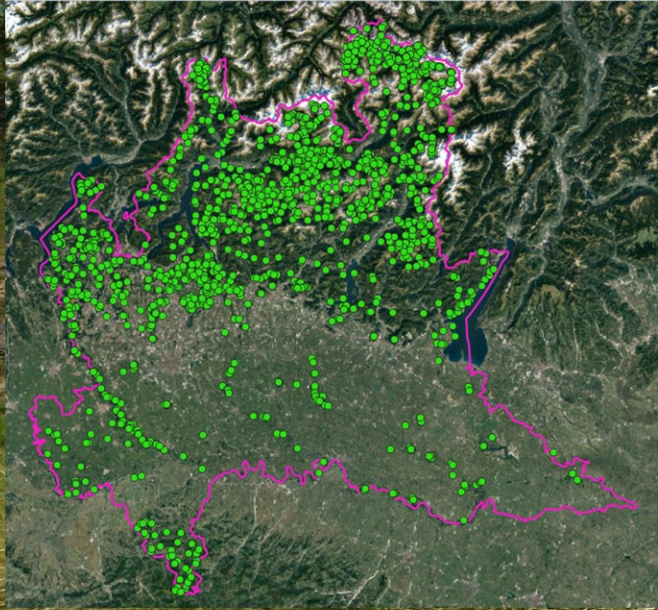
Dati di laboratorio

basati su tratti funzionali e fibre di 1757 specie

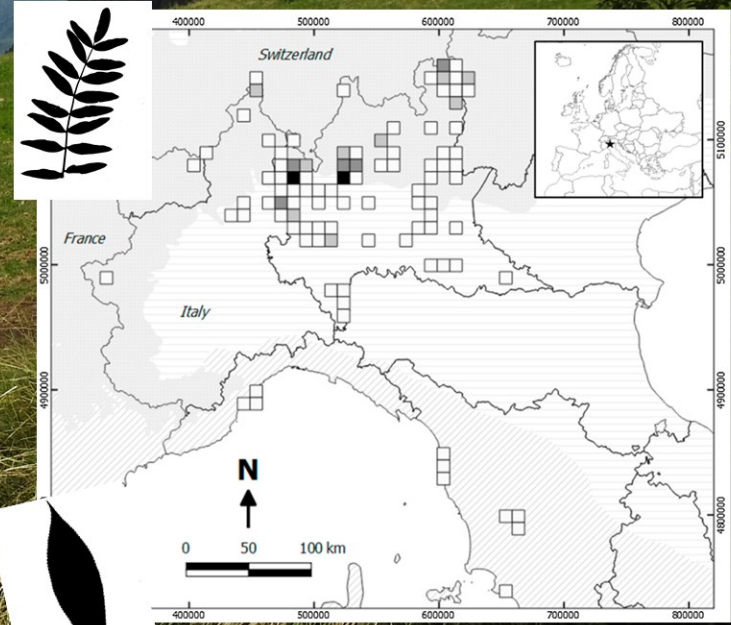
Parole chiave: NDF, ADF, ADL, fiber content, lignin, cellulose, hemicellulose



Dati pregressi



**Rilievi floristico-vegetazionali
georeferenziati nella banca dati degli
habitat ORBL (n = 6018)**

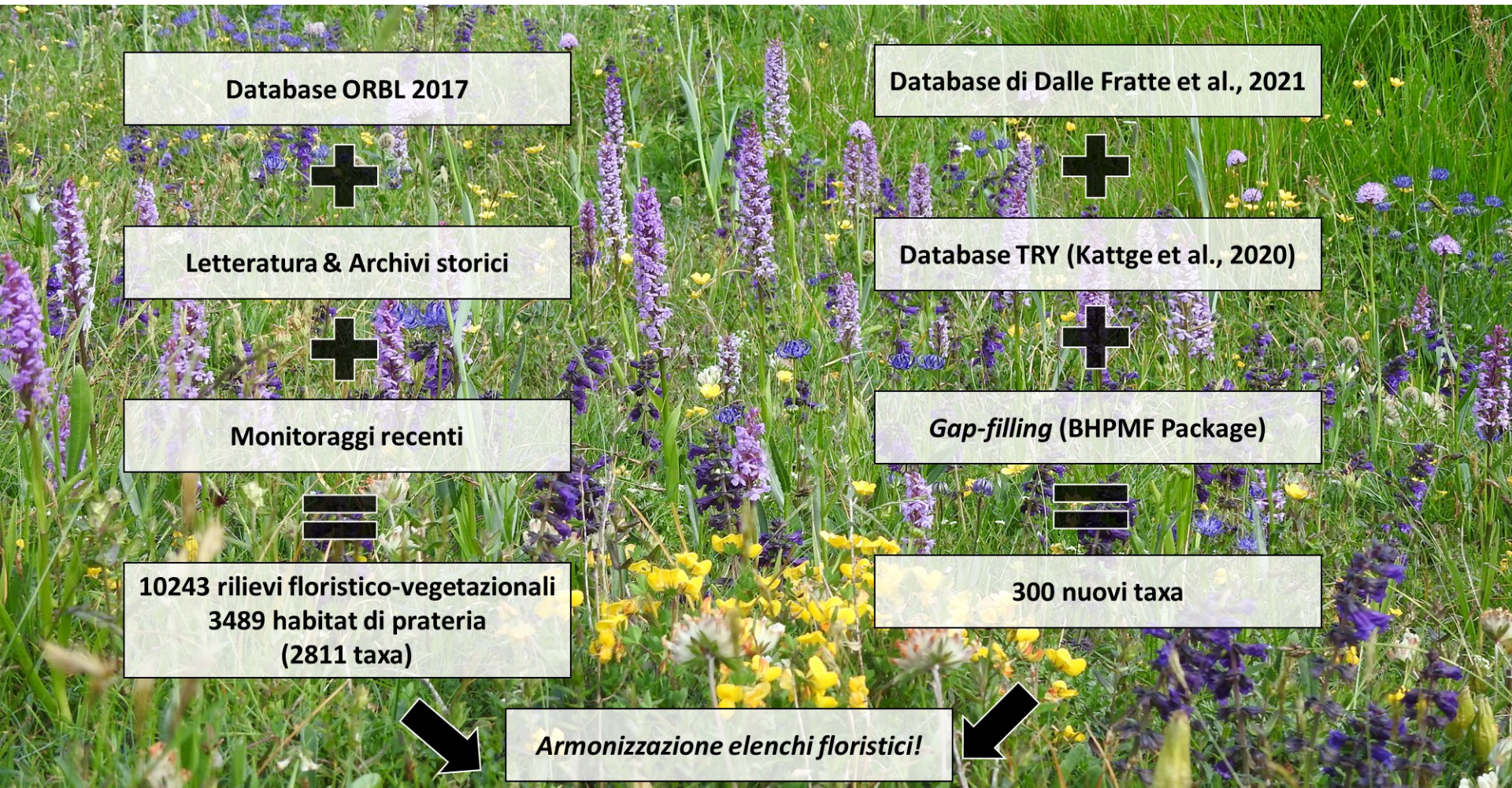


**Database dei tratti funzionali del
laboratorio Uninsubria
(n = 1841)**



- **Biodiversità tassonomica**
- **Biodiversità funzionale**

Dati pregressi



Biodiversità

In Lombardia:

Habitat 6230*-C

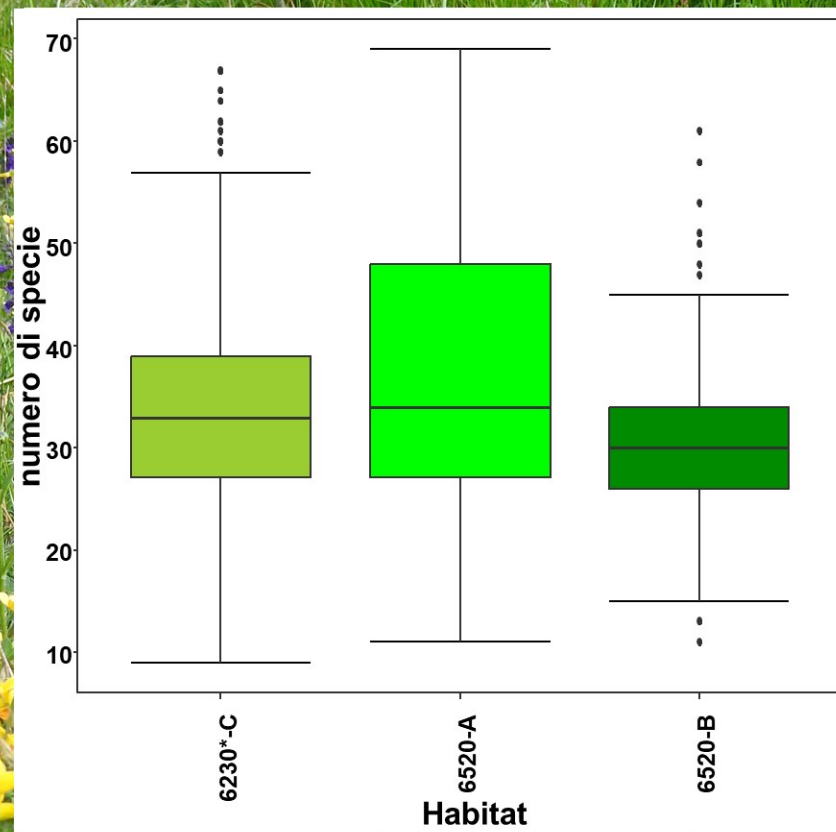
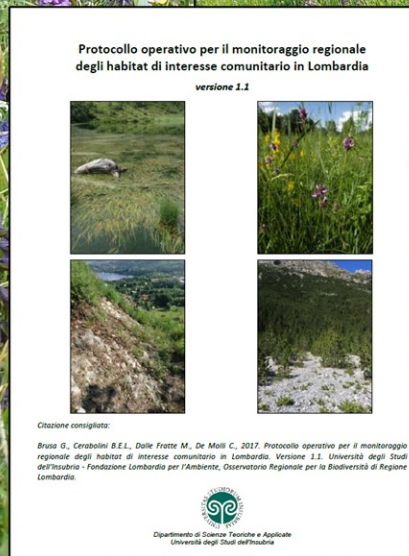
289 rilievi (23 PAGA-LO)
529 taxa

Habitat 6520-A (magro)

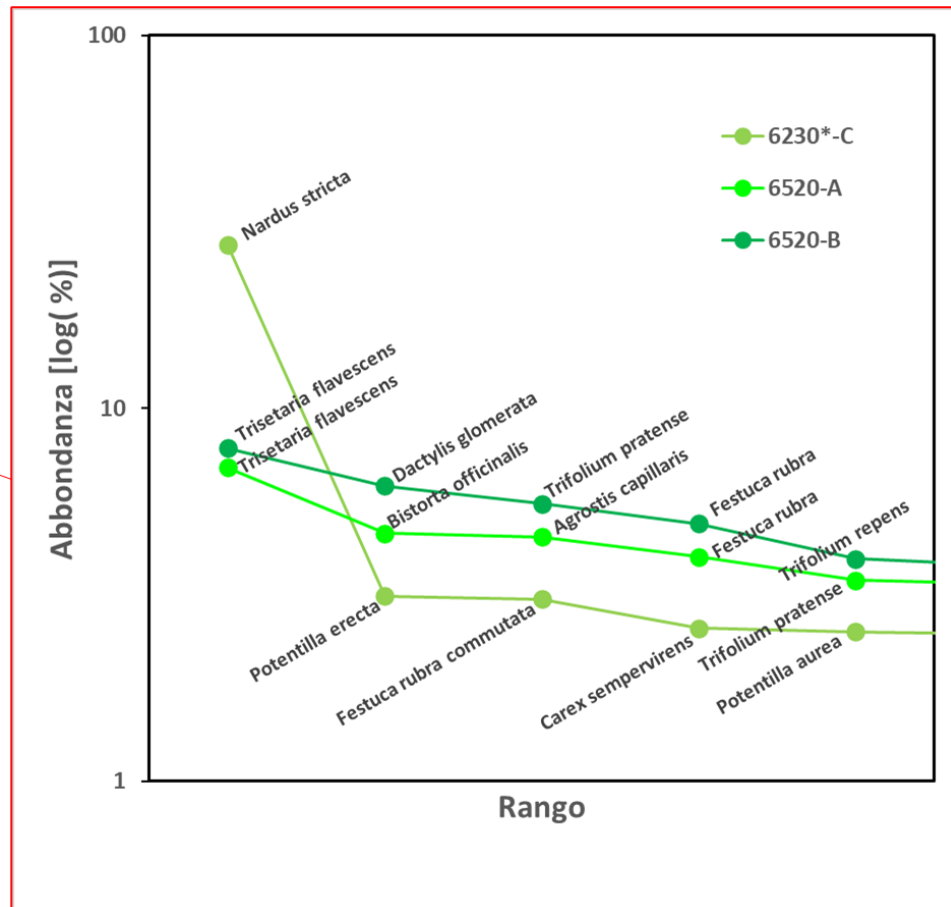
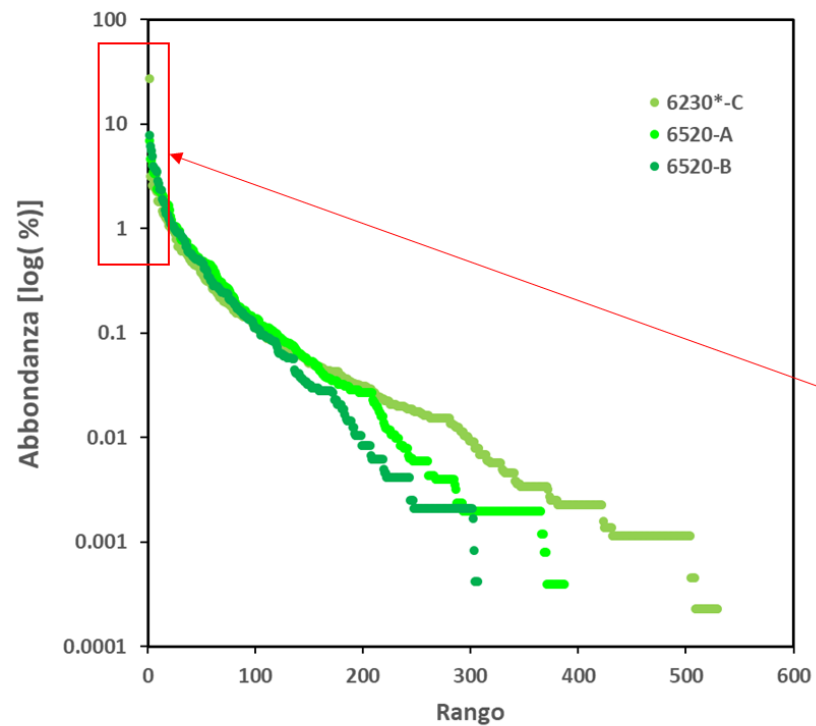
136 rilievi (15 PAGA-LO)
387 taxa

Habitat 6520-B (tipico)

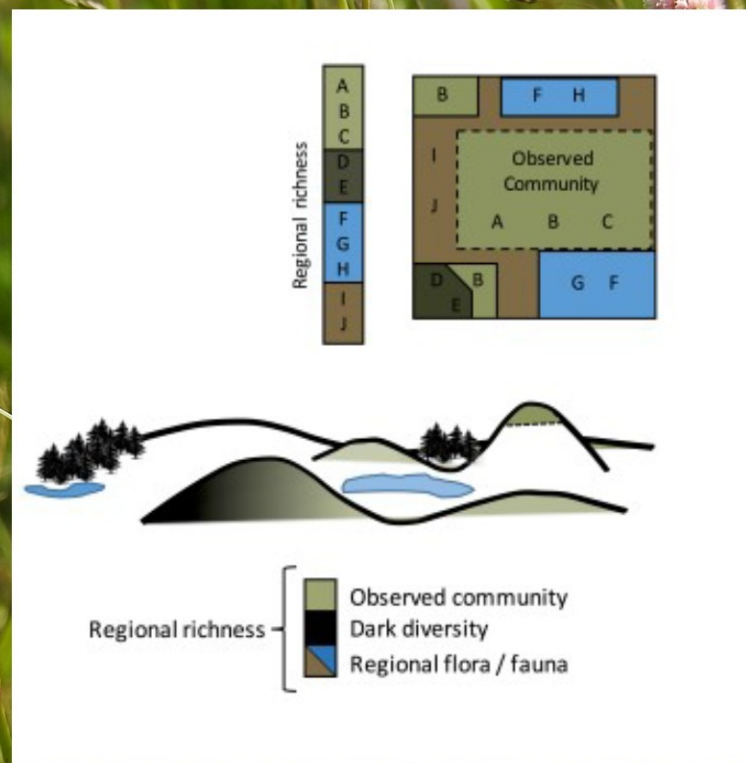
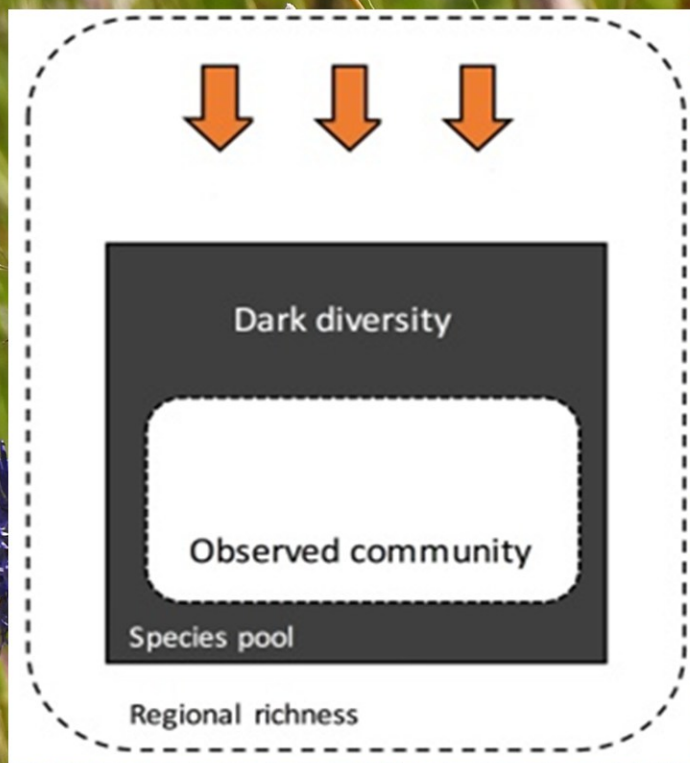
132 rilievi (21 PAGA-LO)
306 taxa



Biodiversità

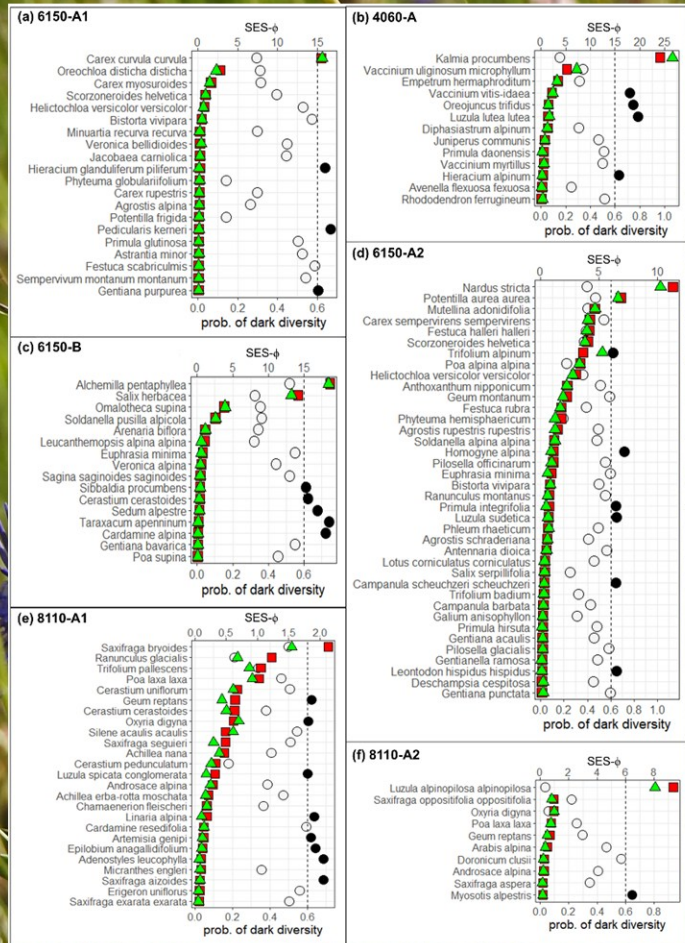


Dark diversity



Lewis & Pärtel 2016 methodsblog.com

Specie tipiche



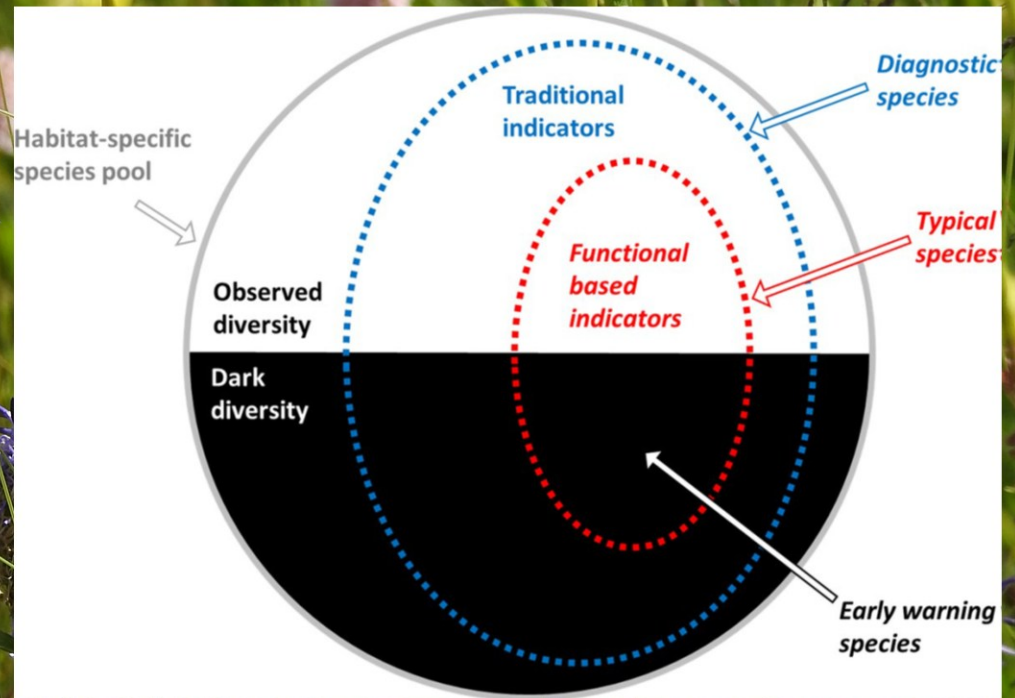
Biodiversity and Conservation (2022) 31:1735–1753
<https://doi.org/10.1007/s10531-022-02427-4>

ORIGINAL PAPER

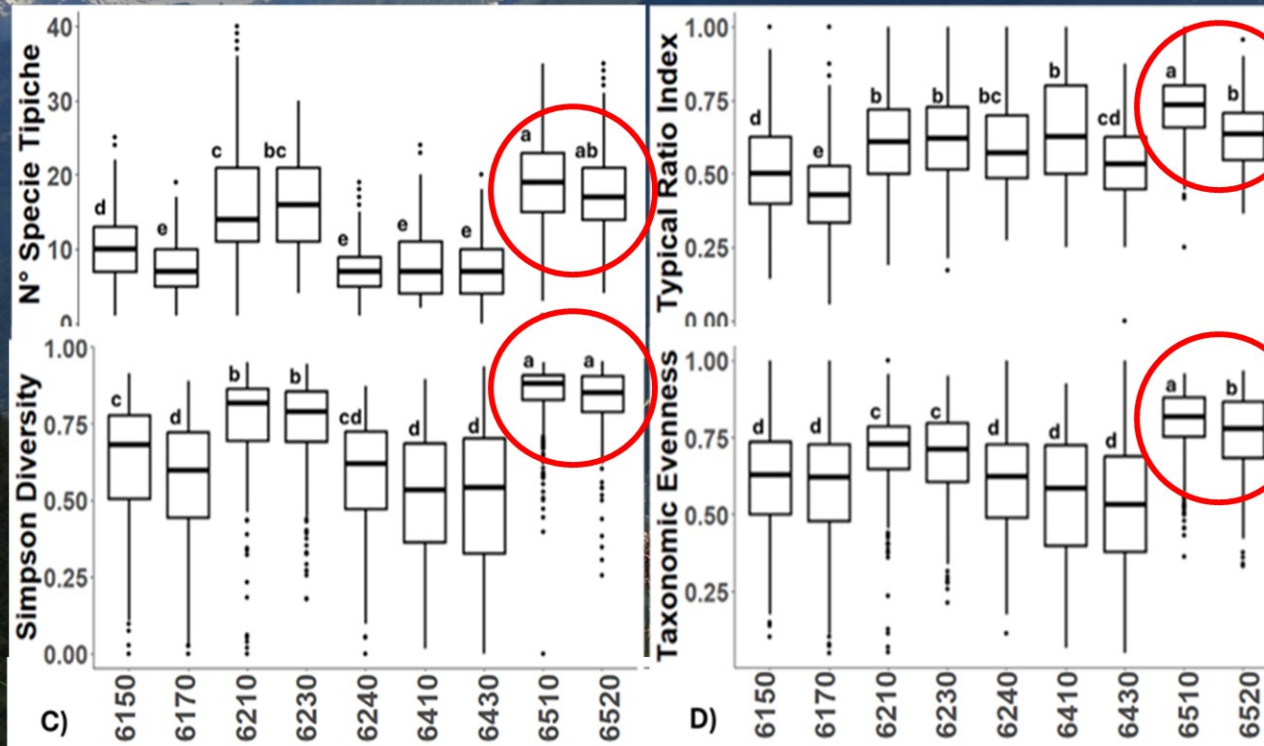


Identifying typical and early warning species
 by the combination of functional-based diagnostic species
 and dark diversity

Michele Dalle Fratte¹ · Marco Caccianiga² · Carlo Ricotta³ ·
 Bruno E. L. Cerabolini¹



Analisi della diversità tassonomica



Elenchi di specie tipiche

Habitat 6230*-C

38 sp. tipiche (16 *early warnings*)

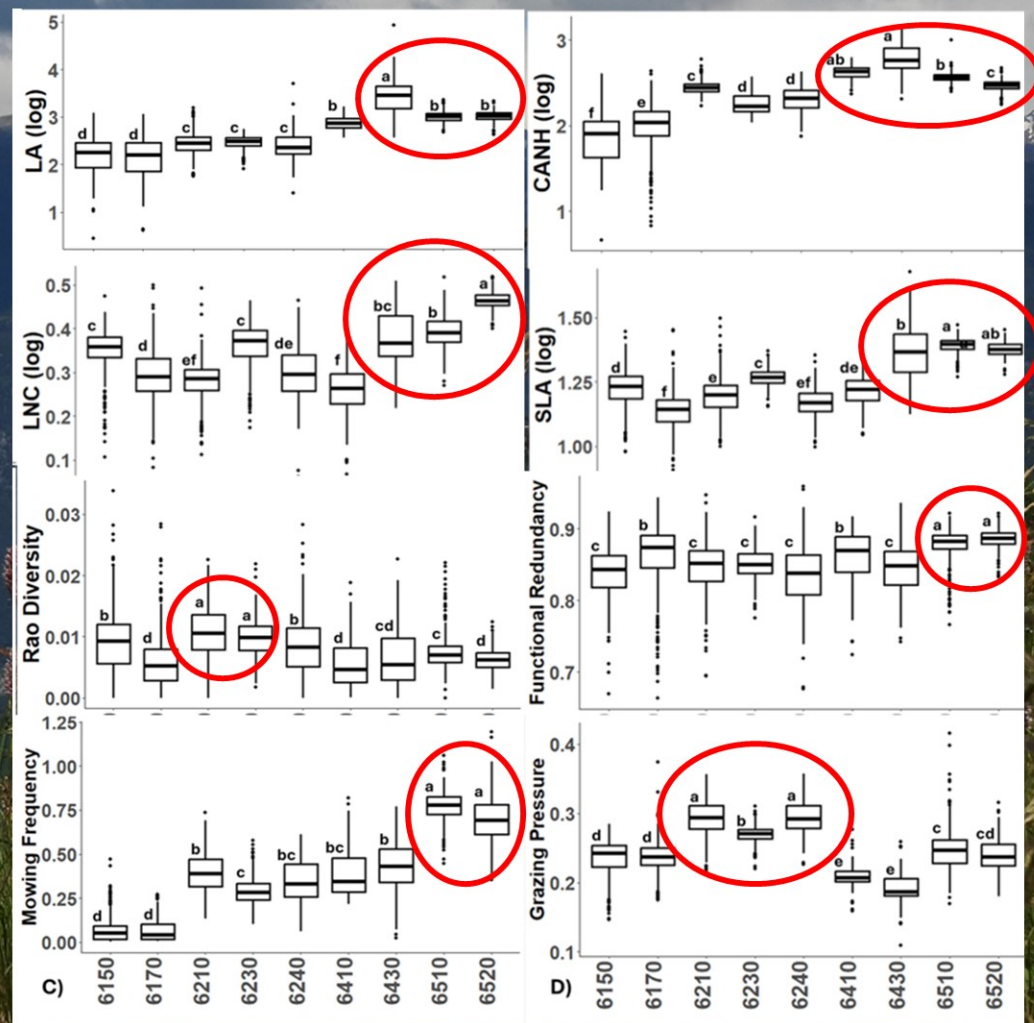
Habitat 6520-A

42 sp. tipiche (16 *early warnings*)

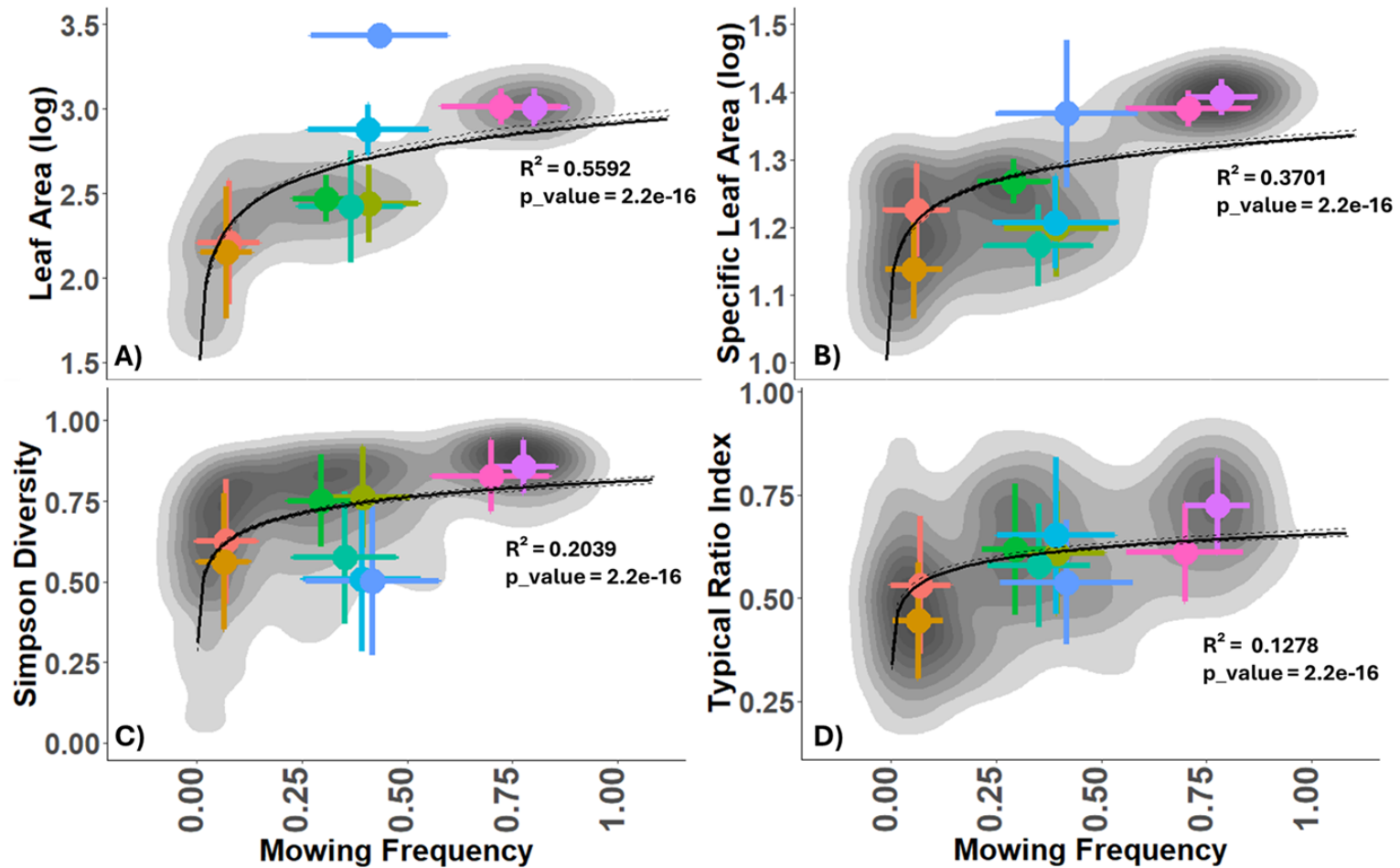
Habitat 6520-B

37 sp. tipiche (3 *early warnings*)

Analisi della diversità funzionale



Confronto con indicatori di disturbo

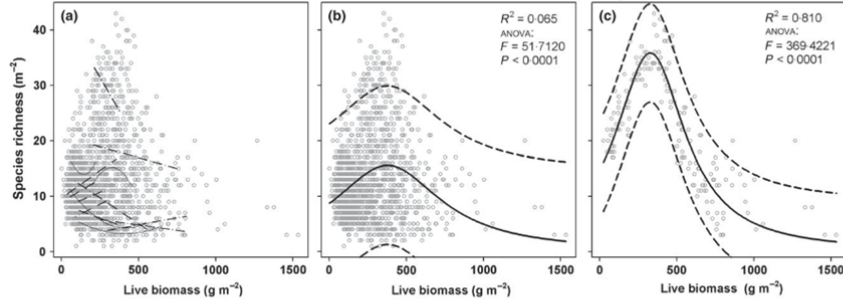


Confronto con indicatori di disturbo

Parametric regressions
applied within sites
(Original analysis of Adler *et al.* (2011))

Parametric regression
applied to entire dataset

Upper boundary regression
applied to top 20 points in each
100 g m⁻² interval class



Functional Ecology

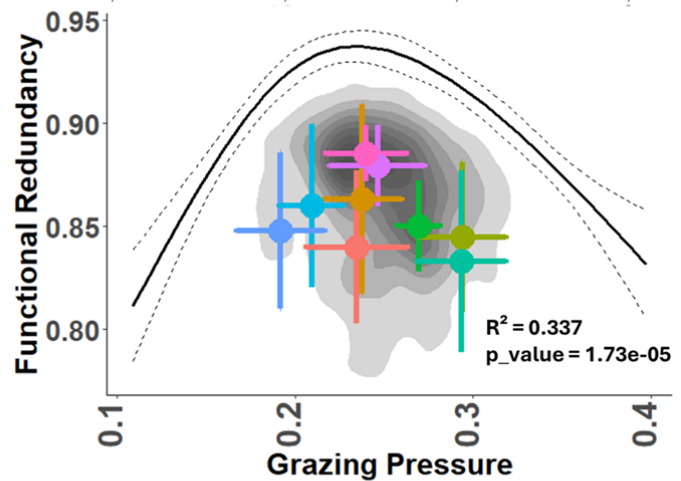
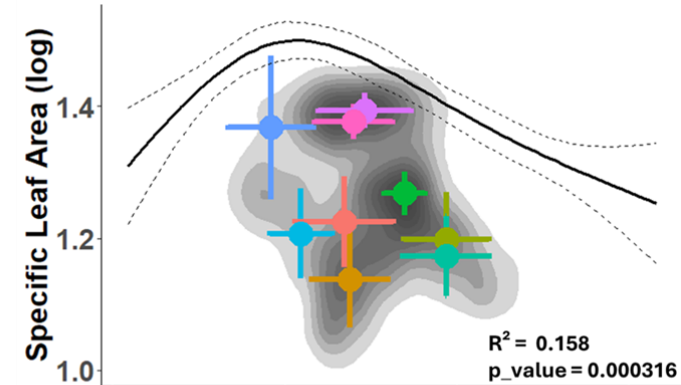
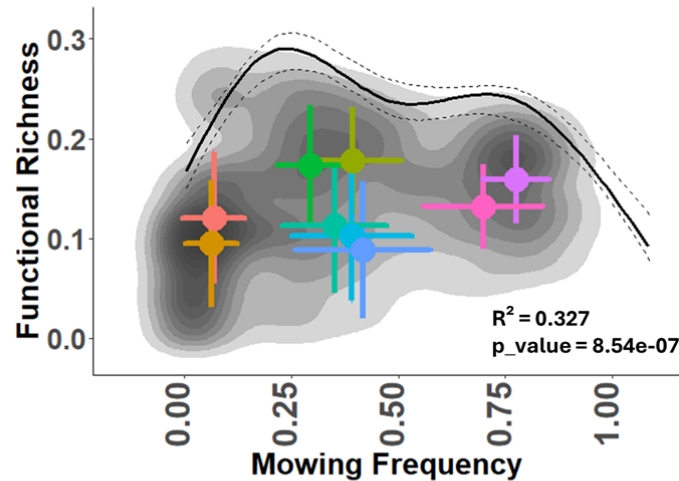
Functional Ecology 2014, 28, 253–257

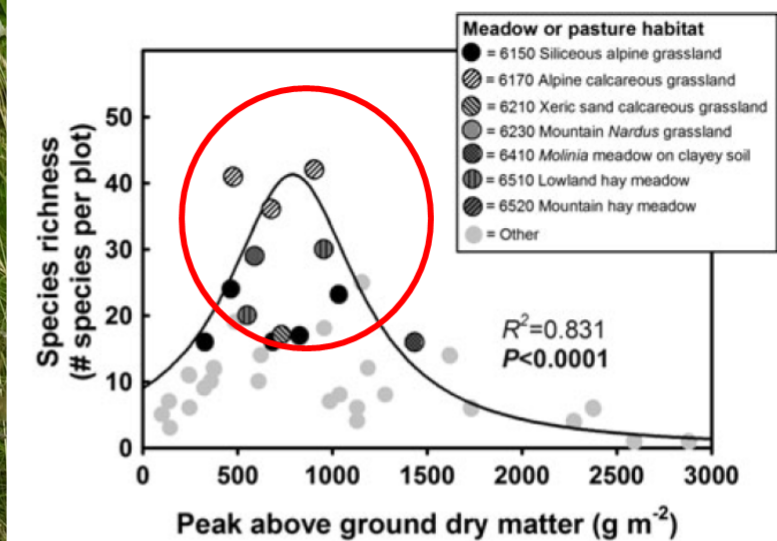
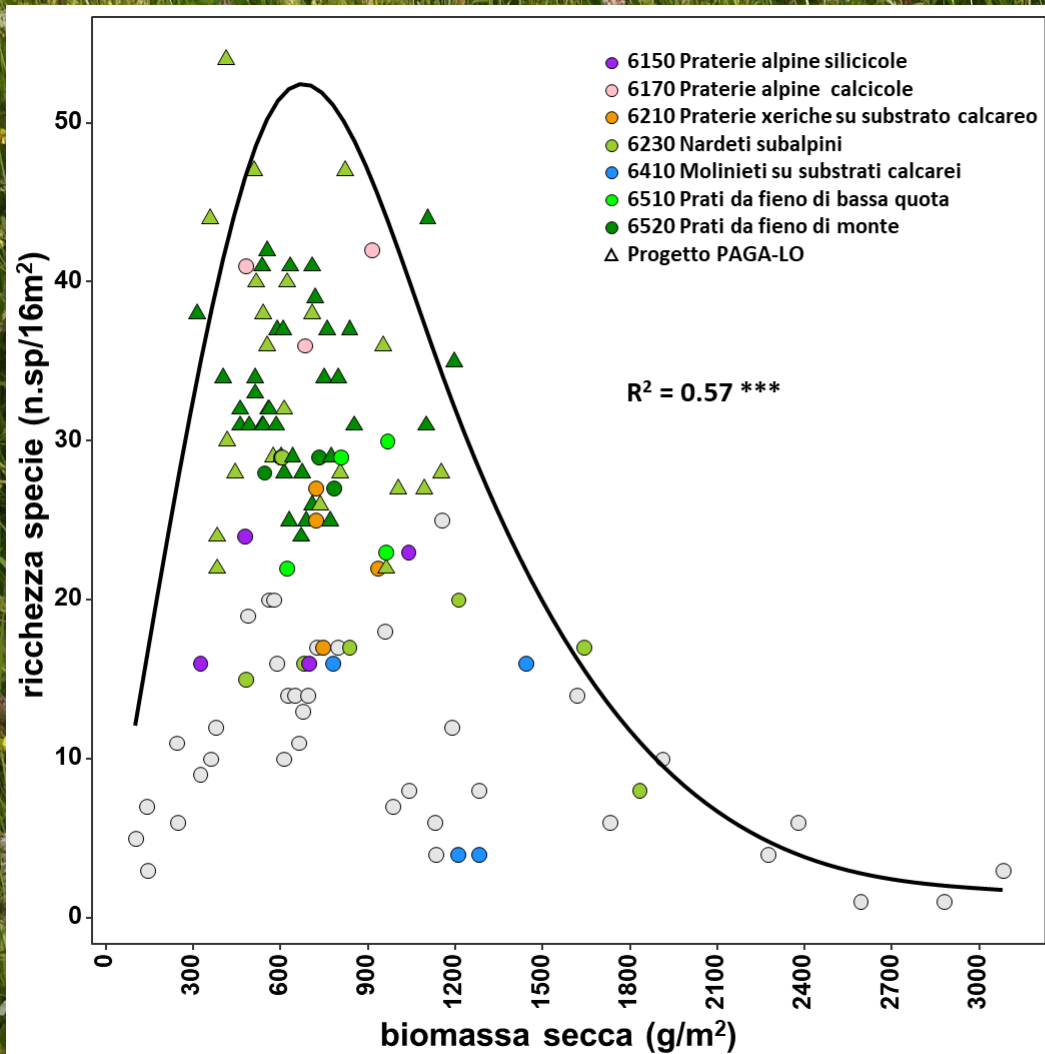
doi: 10.1111/1365-2435.12147

COMMENTARY

Implications for biodiversity conservation of the lack of
consensus regarding the humped-back model of
species richness and biomass production

Simon Pierce*





ORIGINAL ARTICLE

Plant Biosystems, 2016

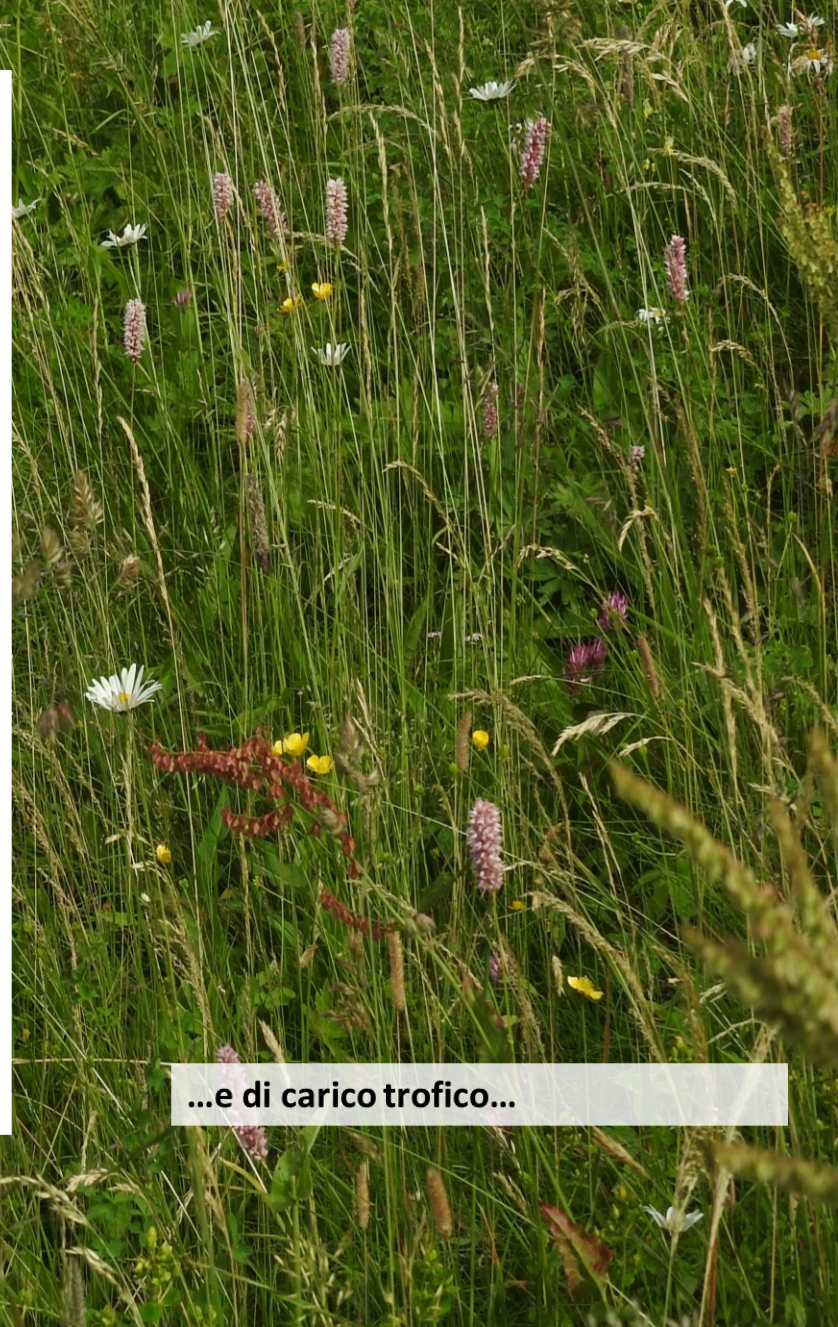
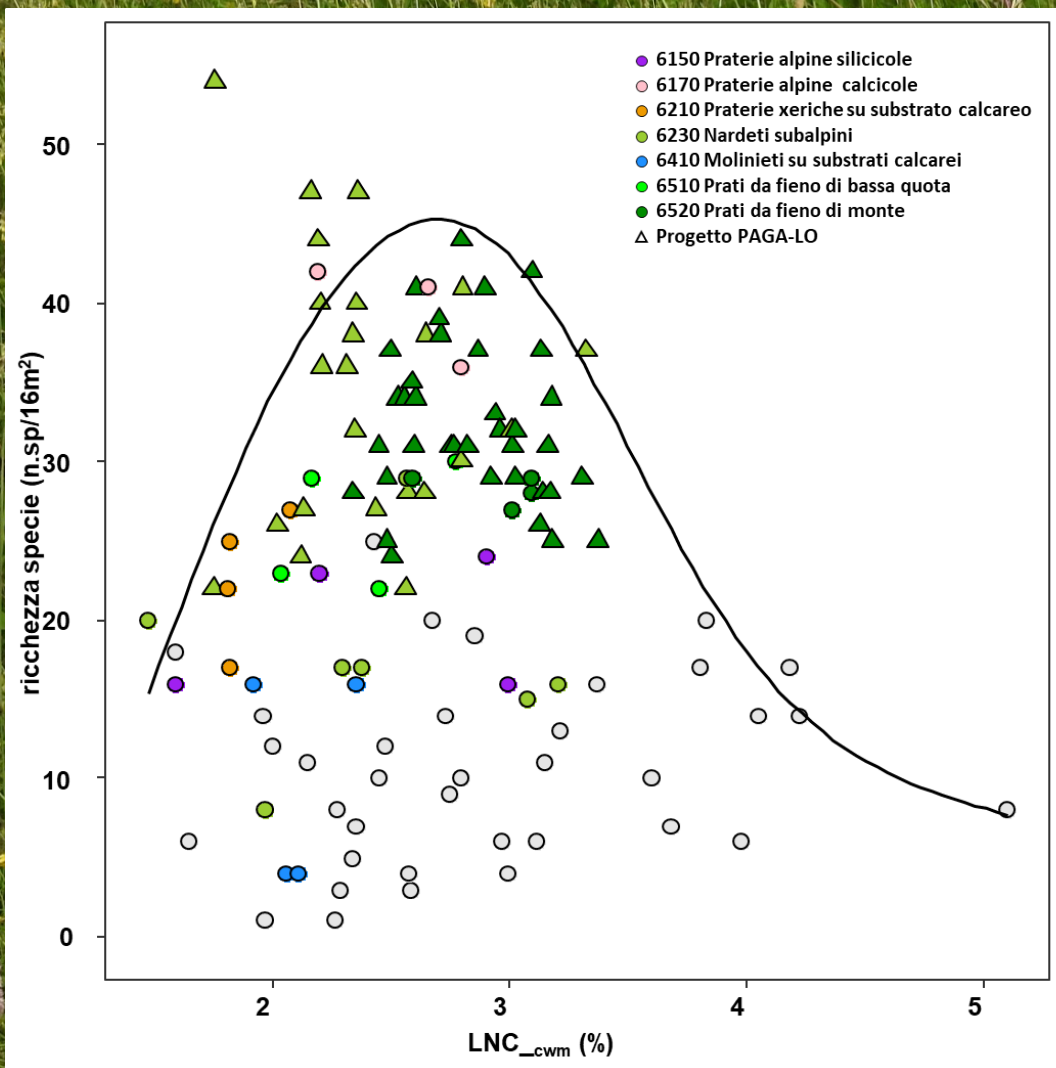
Vol. 150, No. 3, 550–557, <http://dx.doi.org/10.1080/11263504.2014.987848>



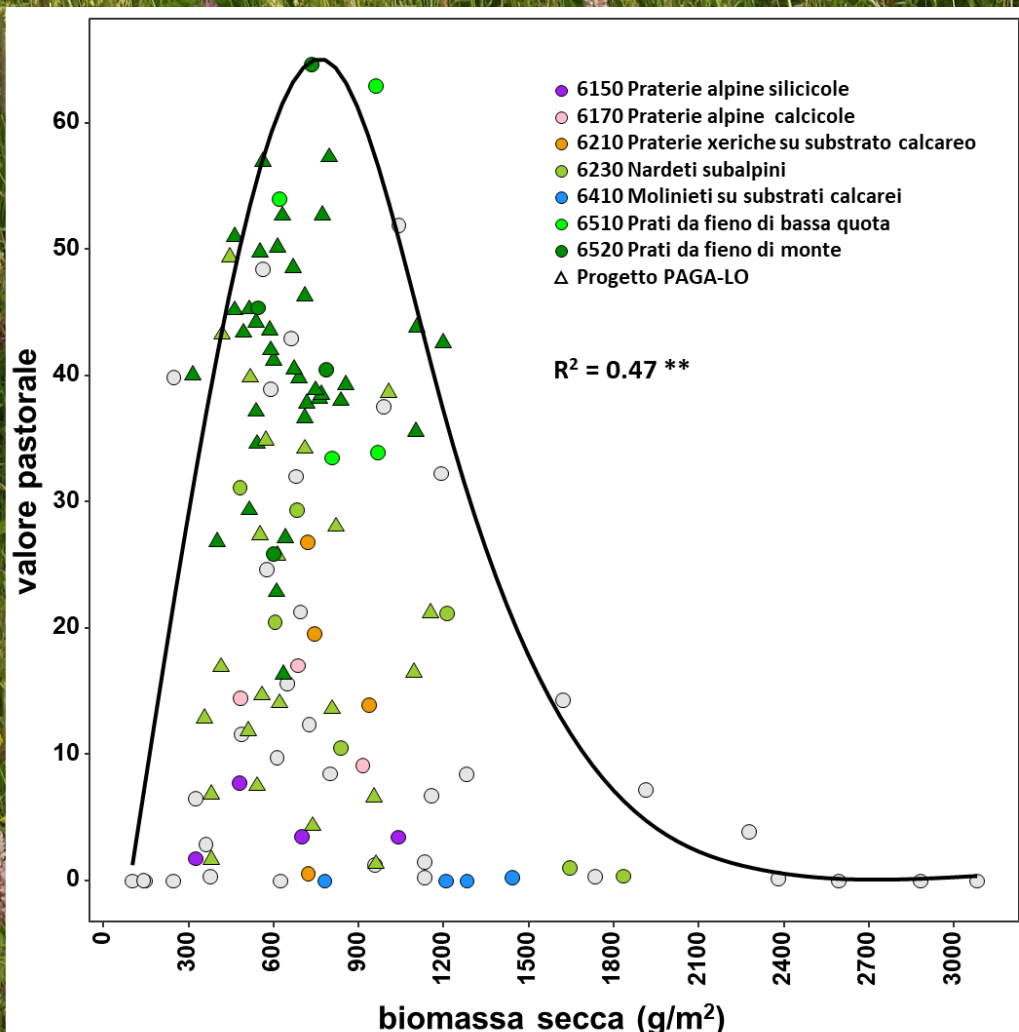
Why are many anthropogenic agroecosystems particularly species-rich?

B. E. L. CERABOLINI¹, S. PIERCE², A. VERGINELLA^{1,3}, G. BRUSA¹, R. M. CERIANI⁴, & S. ARMIRAGLIO³

per conservare la biodiversità, si devono mantenere gli habitat a livelli intermedi di produttività



...e di carico trofico...



Ann. agron., 1971, 22 (1), 5-41.



UNE MÉTHODE D'ANALYSE PHYTOLOGIQUE DES PRAIRIES.

CRITÈRES D'APPLICATION

FICHÉ

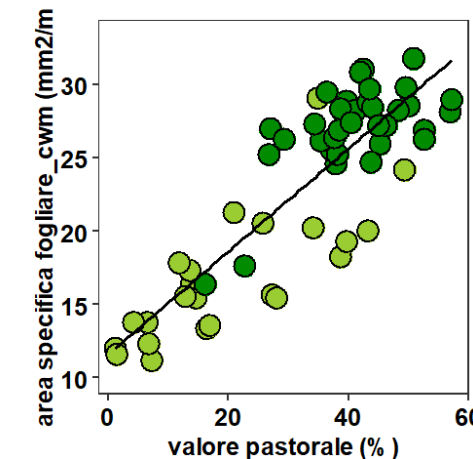
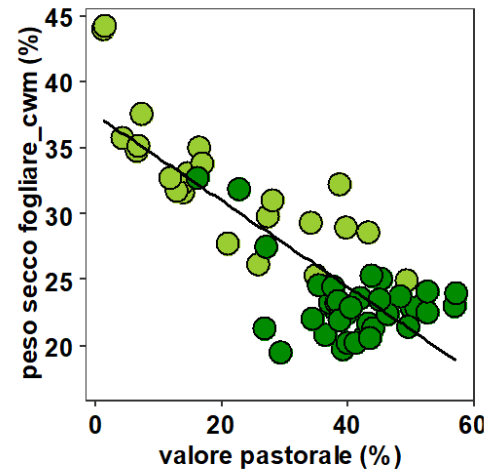
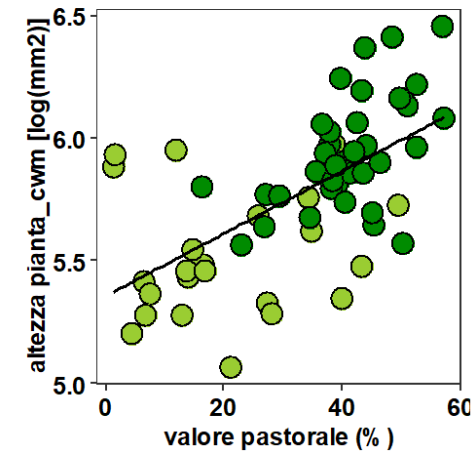
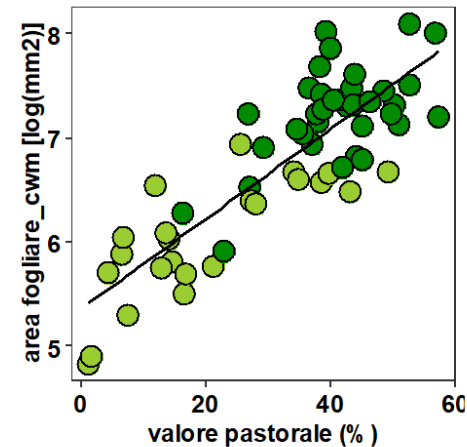
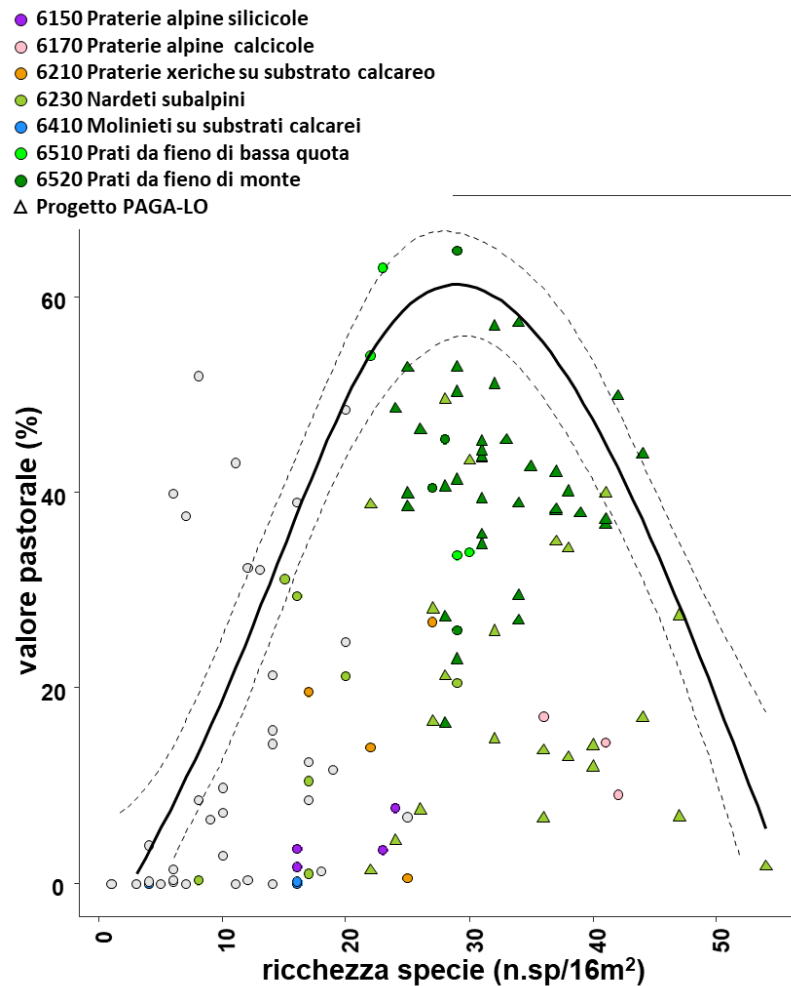
• Ph. DAGET et J. POISSONET

Centre d'Études phytosociologiques et écologiques, 34 - Montpellier
Centre national de la Recherche scientifique

$$VP = 0,2 \sum_{i=1}^n CS_i \times Is_i$$

Favorendo anche il valore pastorale!

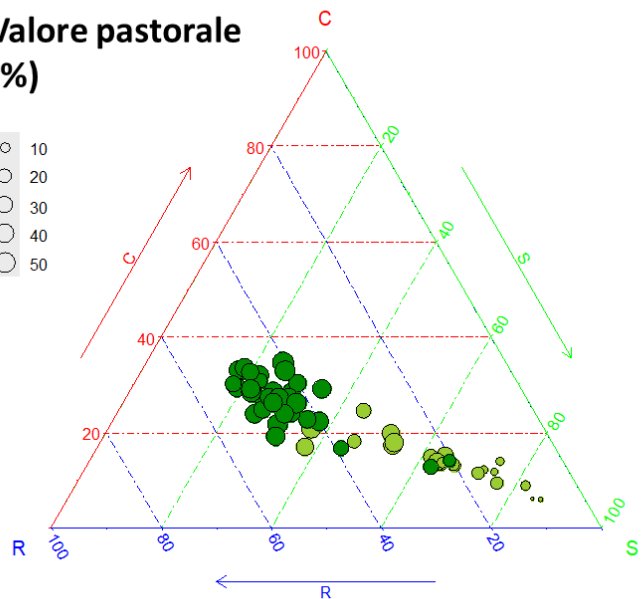
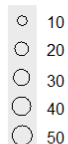
Relazione tra valore pastorale e biodiversità



● 6230* Nardeti subalpini
 ● 6520 Prati da fieno di monte

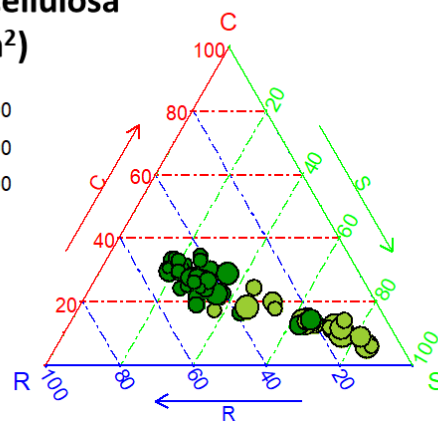
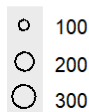
Relazione tra valore pastorale e biodiversità

Valore pastorale (%)

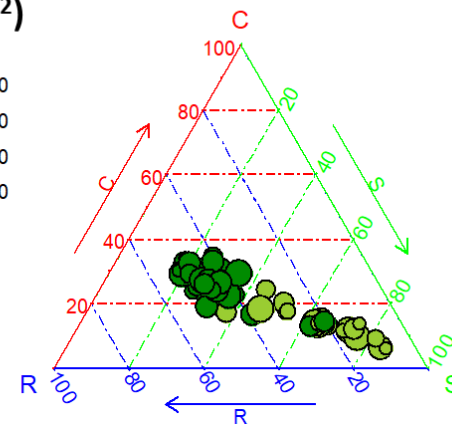
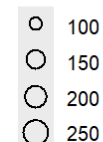


● 6230* Nardeti subalpini
● 6520 Prati da fieno di monte

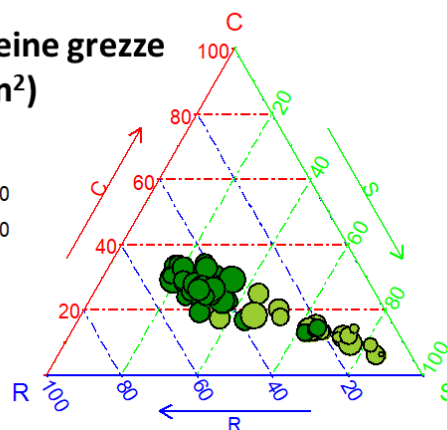
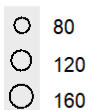
Emicellulosa (g/m²)



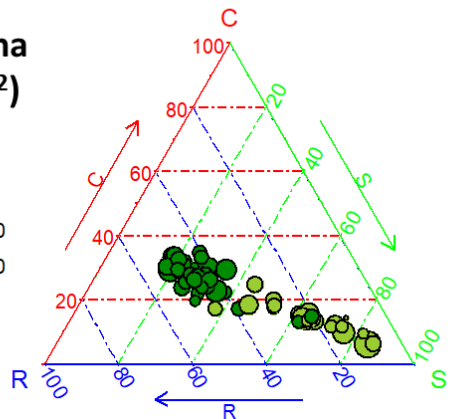
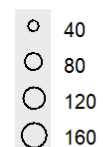
Cellulosa (g/m²)



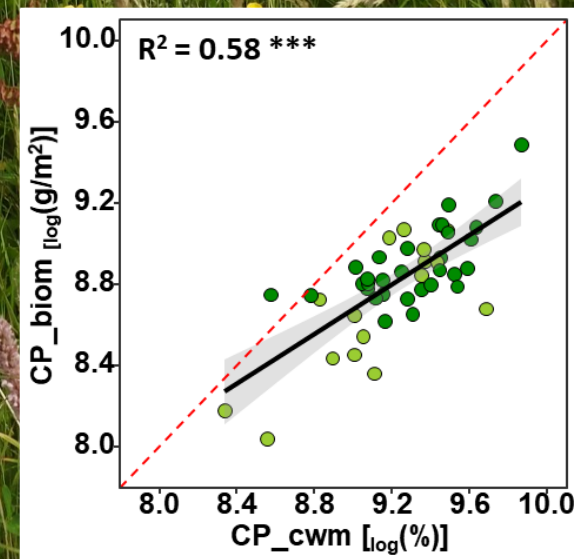
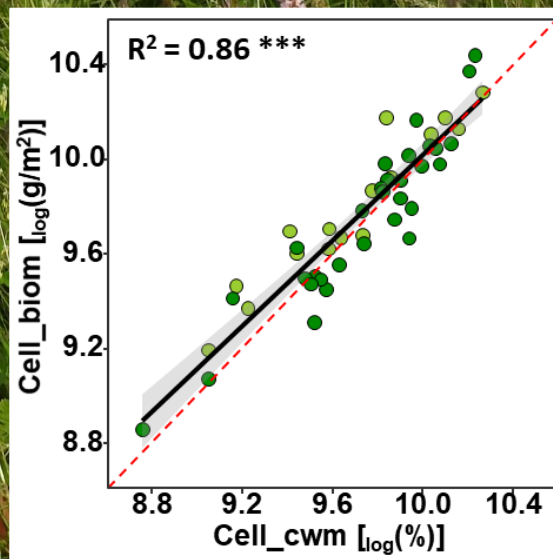
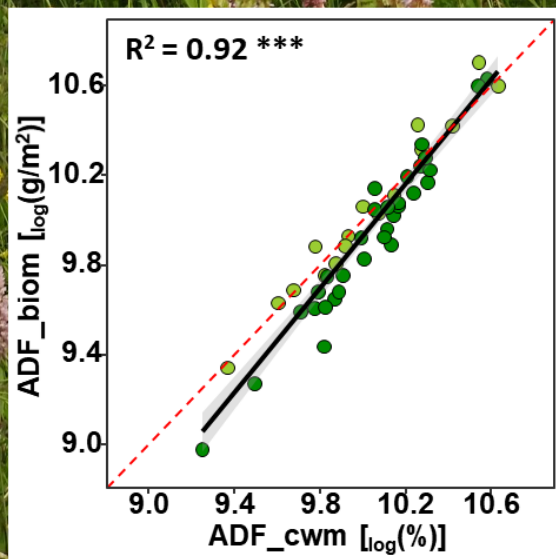
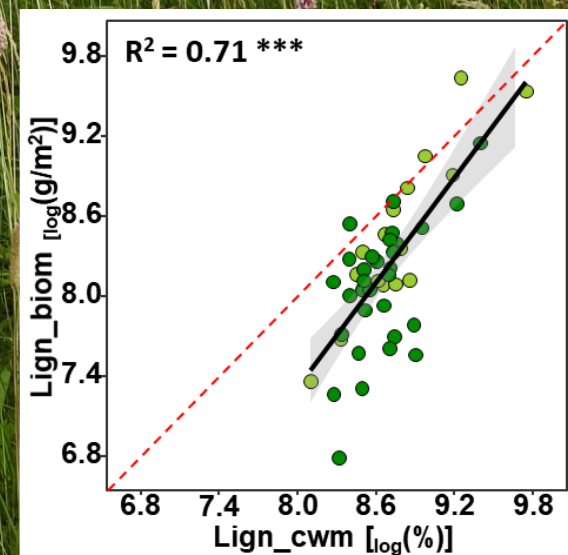
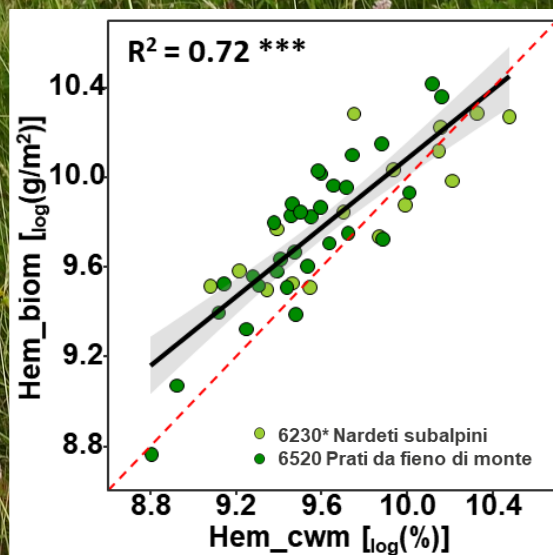
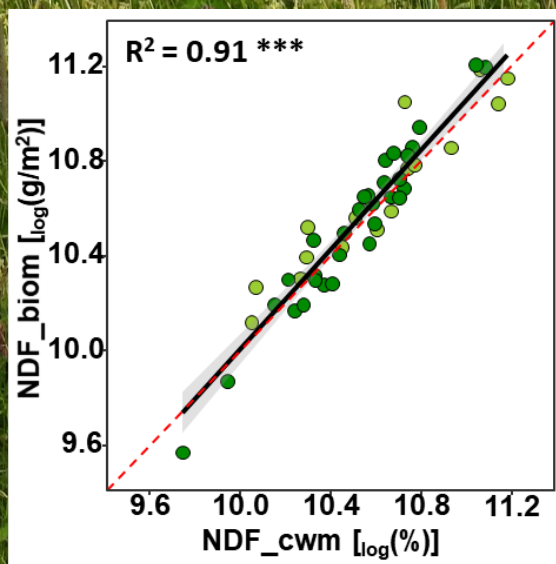
Proteine grezze (g/m²)



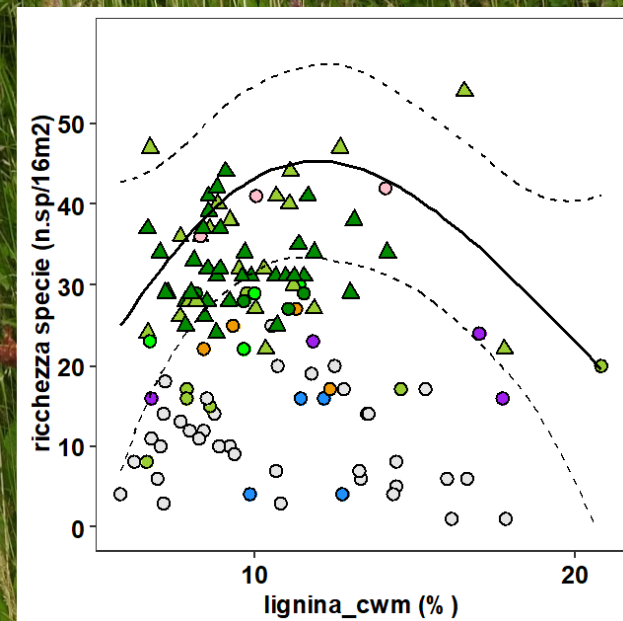
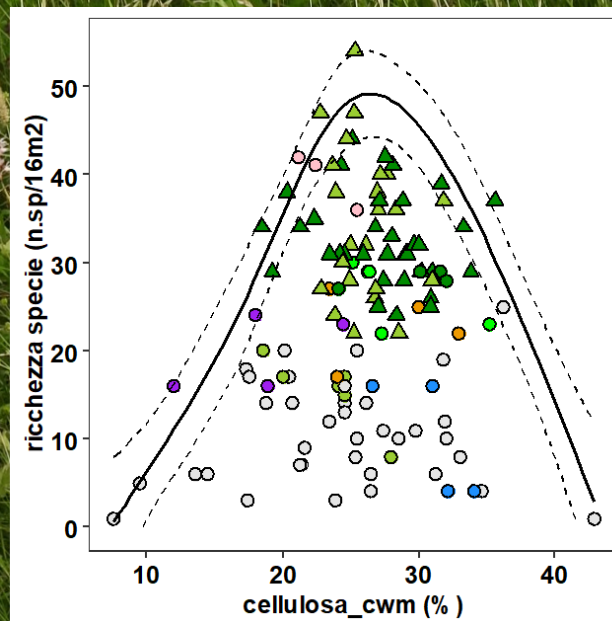
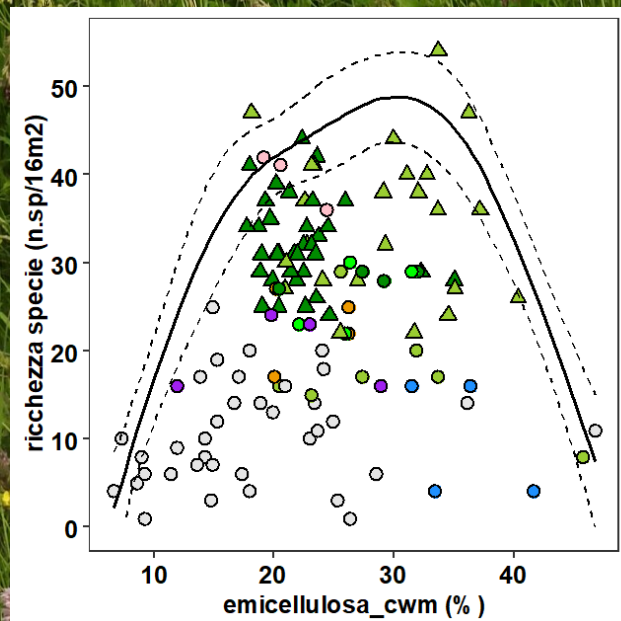
Lignina (g/m²)



Buona confidenza nell'utilizzo del dato di fibre delle singole specie per stimare contenuto di fibre della biomassa

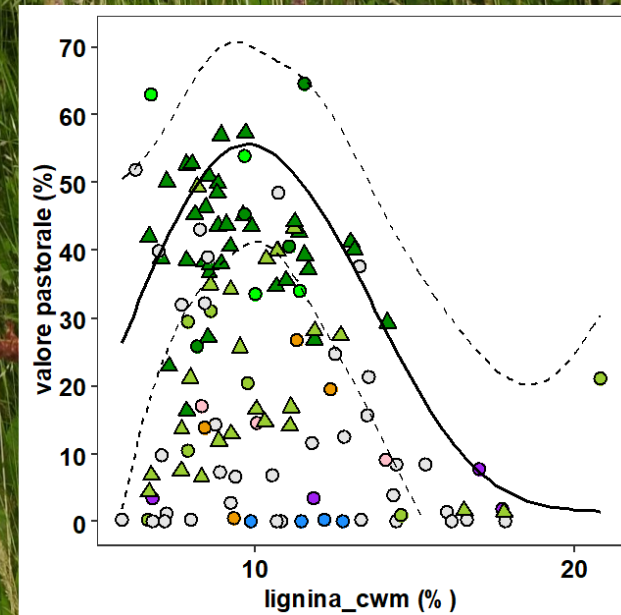
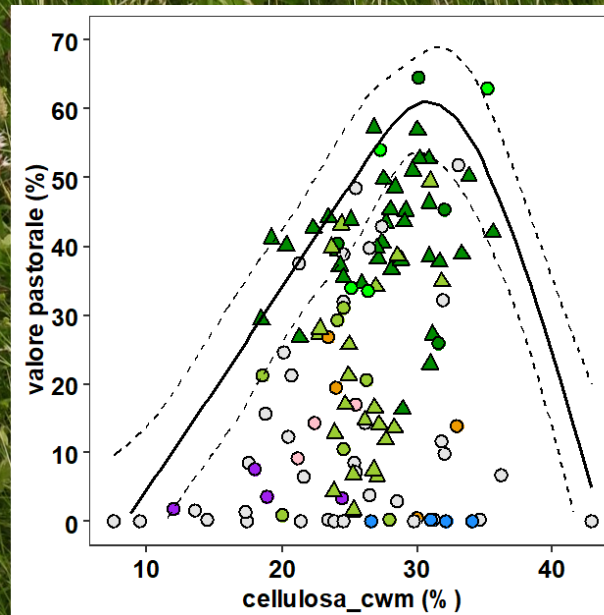
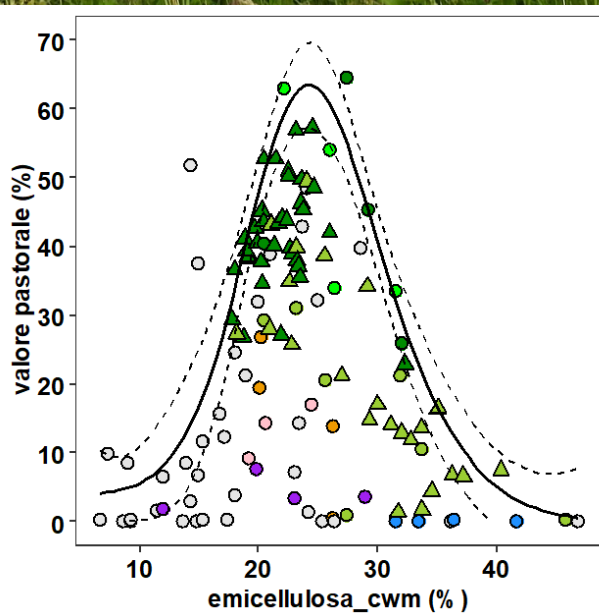


Elevata biodiversità tendenzialmente a livelli intermedi di contenuto di fibre



- 6150 Praterie alpine silicicole
- 6170 Praterie alpine calcicole
- 6210 Praterie xeriche su substrato calcareo
- 6230 Nardeti subalpini
- 6410 Molinieti su substrati calcarei
- 6510 Prati da fieno di bassa quota
- 6520 Prati da fieno di monte
- △ Progetto PAGA-LO

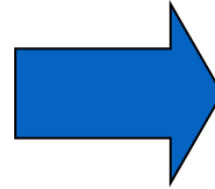
E il valore pastorale?



- 6150 Praterie alpine silicicole
- 6170 Praterie alpine calcicole
- 6210 Praterie xeriche su substrato calcareo
- 6230 Nardeti subalpini
- 6410 Molinieti su substrati calcarei
- 6510 Prati da fieno di bassa quota
- 6520 Prati da fieno di monte
- △ Progetto PAGA-LO

Valutazione dello stato di conservazione

~~-AREA~~
~~-RANGE~~
-STRUCTURE and FUNCTIONS
(TYPICAL SPECIES)



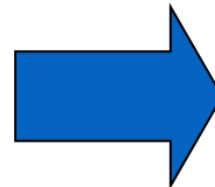
FAVOURABLE
REFERENCE
VALUE
(BASE LINES)



FUTURE PROSPECTS



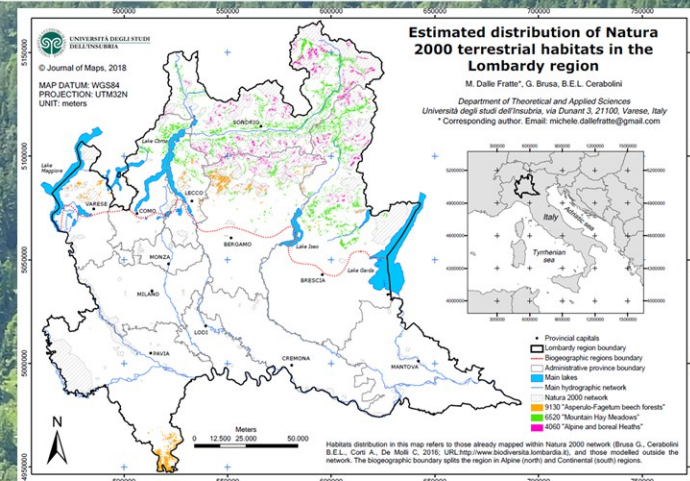
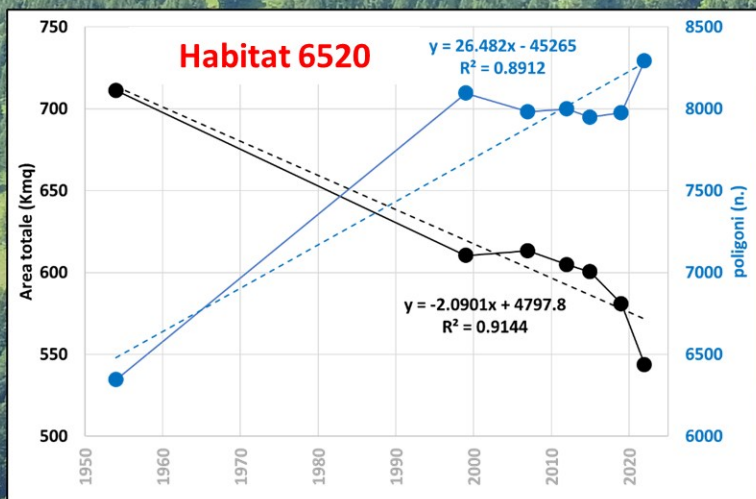
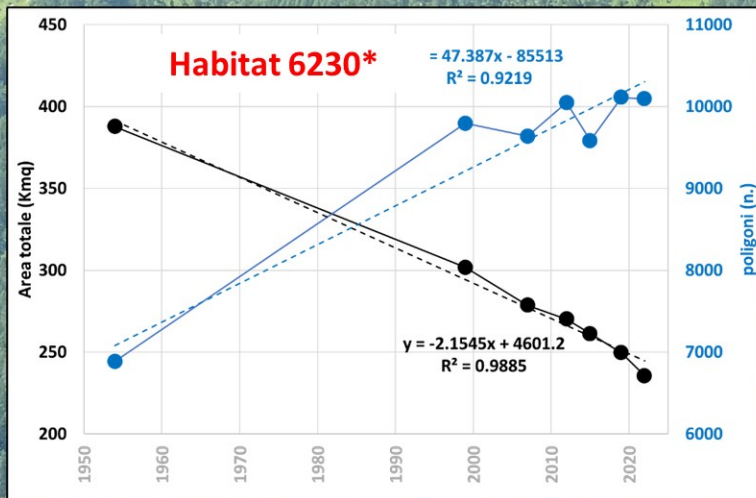
OVERALL ASSESSMENT



OVERALL
TRENDS



Valutazione dello stato di conservazione



Valutazione dello stato di conservazione



Indicators	
Structure	Total coverage (%)
	Floristic richness (n)
	Dominance of typical species (%)
Functions	Frequency of typical species (%)
	Early warning species (n)
	Significant species for conservation (n)
Future prospects	Woody encroachment (%)
	Eutrophication (%)
	Floristic degradation (%)

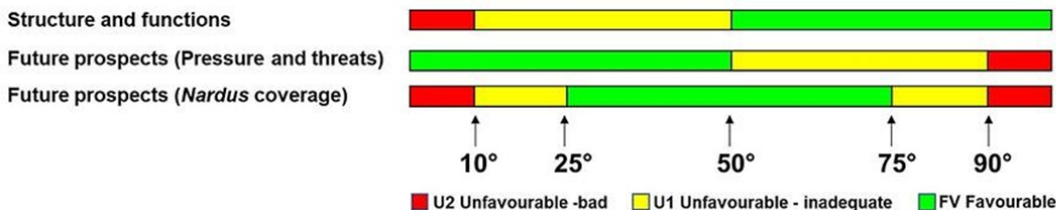


Table 4

Threshold values of conservation status identified for the indicators of structure, functions and future prospects according to the percentile analysis (see also Figure 6) for the target relevés of the habitat sub-type 6230*-C (*Geo montani-Nardetum*). The full description of each indicator is reported in Table 2. Legend: U2 = Unfavourable-bad, U1 = Unfavourable-inadequate, FV = Favourable.

Type	Indicator	U2	U1	FV
Structure	Total coverage (%)	< 101	≥ 101	≥ 123
	Floristic richness (n)	< 27	≥ 27	≥ 38
	Dominance of typical species (%)	< 61	≥ 61	≥ 81
Functions	Frequency of typical species (%)	< 49	≥ 49	≥ 57
	Early warning species (n)	= 0	> 0	≥ 2
	Significant species for conservation (n)	< 2	≥ 2	≥ 3
Future prospects	Woody encroachment (%)	≥ 9	≥ 1	< 1
	Eutrophication (%)	≥ 15	≥ 4	< 4
	Floristic degradation (%)	< 19 U ≥ 88	< 38 U ≥ 63	≥ 38 n < 63



Extending the interpretation of Natura 2000 habitat types beyond their definition can bias their conservation status assessment: An example with species-rich *Nardus* grasslands (6230*)

Michele Dalle Fratte*, Bruno E.L. Cerabolini

Valutazione dello stato di conservazione

Table 5

Conservation status of the plant communities representing ecological extremes of the subalpine habitat sub-type 6230*-C: subalpine carbonate (*Nardetum alpinum* on carbonate substrates); subalpine high-nutrient (*Nardetum alpinum trifolietosum*); alpine high-grazed (*Festucetum halleri nardetosum*); alpine low-grazed (*Caricetum curvulae nardetosum strictae*). The full description of each indicator is reported in Table 2. Legend: U2 = Unfavourable bad; U1 = Unfavourable inadequate; FV = Favourable.

Type	Indicator	Subalpine carbonate	Subalpine high nutrient	Alpine high-grazed	Alpine low-grazed
Structure	Total coverage (%)	FV	U2	FV	U1
	Floristic richness (n)	U1	FV	U2	U2
	Dominance of typical species (%)	U2	U2	U1	U2
Functions	Frequency of typical species (%)	U2	U2	FV	U2
	Early warning species (n)	U1	U1	U1	U1
	Significant species for conservation (n)	FV	FV	U2	U2
Future prospects	Woody encroachment (%)	FV	U1	FV	U2
	Eutrophication (%)	U1	U1	U1	U1
	Floristic degradation (%)	U1	FV	U1	U2
OVERALL		U2	U2	U2	U2

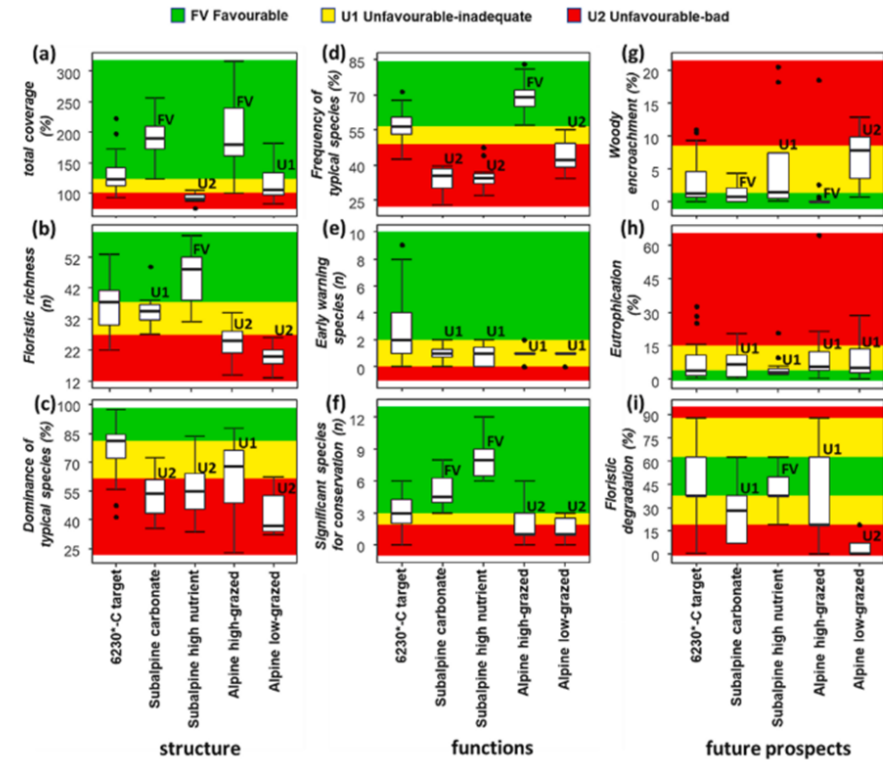


Fig. 6. Comparison between the threshold values of conservation status identified for the indicators of structure, functions and future prospects of the target relevés of the habitat sub-type 6230*-C (*Geo montani-Nardetum*) and those calculated for plant communities at the extremes: subalpine carbonate (*Nardetum alpinum* on carbonate substrates); subalpine high-nutrient (*Nardetum alpinum trifolietosum*); alpine high-grazed (*Festucetum halleri nardetosum*); alpine low-grazed (*Caricetum curvulae nardetosum strictae*). The full description of each indicator is reported in Table 2. Boxplots indicate the median (line in the middle of the boxes), interquartile range (boxes), ± 1.5 times the interquartile range (whiskers) and outliers (circles).

6230*-C

6520A

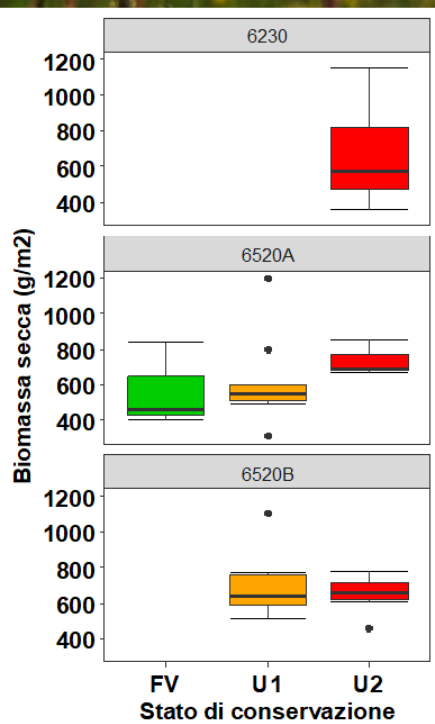
6520B

ID	Comlessivo	Struttura	Funzioni	Prospettive future	Struttura			Funzioni		Prospettive future		
					Copertura totale	Tipiche copertura	N.sp	Tipiche frequenza	Specie significative	Evoluzione	Eutrofizzazione	Nardus
					%	%	n	%	n	%	%	%
PAGA-01	U2	FV	U1	U2	FV	FV	FV	FV	U1	U2	FV	U1
PAGA-02	U2	FV	U1	U2	FV	FV	FV	FV	U1	U2	FV	U2
PAGA-03	U2	U1	U2	U2	FV	FV	U1	FV	U2	U1	U2	U2
PAGA-04	U2	U1	U2	U2	FV	FV	U1	FV	U2	U1	FV	U2
PAGA-05	U2	FV	U1	U2	FV	FV	FV	FV	U1	U1	U2	U1
PAGA-06	U2	U1	U1	U2	FV	FV	U1	FV	U1	U2	U2	FV
PAGA-07	U2	U1	FV	U2	FV	FV	U1	FV	FV	U2	FV	FV
PAGA-09	U2	U1	U2	U1	FV	FV	U1	FV	U2	U1	FV	FV
PAGA-10	U2	U1	U2	U2	FV	FV	U1	FV	U2	U2	FV	U2
PAGA-11	U2	FV	FV	U2	FV	FV	FV	FV	FV	U1	FV	U2
PAGA-12	U2	FV	FV	U2	FV	FV	FV	FV	FV	U1	U1	U2
PAGA-13	U2	U1	U2	U2	FV	FV	U1	FV	U2	U2	FV	U1
PAGA-14	U2	U1	U1	U2	FV	FV	U1	FV	U1	U2	FV	U2
PAGA-15	U2	FV	FV	U2	FV	FV	FV	FV	FV	U2	U1	U1
PAGA-16	U2	FV	U1	U2	FV	FV	FV	FV	U1	U2	U2	FV
PAGA-17	U2	FV	U1	U2	FV	FV	FV	FV	U1	FV	FV	U2
PAGA-18	U2	U1	U2	U1	FV	FV	U1	FV	U2	U1	U1	U1
PAGA-19	U2	U1	U1	U2	FV	FV	U1	FV	U1	U1	U1	U2
PAGA-20	U2	FV	U1	U2	FV	FV	FV	FV	U1	U2	U2	U1
PAGA-21	U2	U1	U2	U2	FV	FV	U1	FV	U2	U2	U2	U1
PAGA-23	U2	FV	U2	U2	FV	FV	FV	FV	U2	U2	U1	U1
PAGA-25	U2	FV	U2	U1	FV	FV	FV	FV	U2	U1	U1	U1
PAGA-27	U2	FV	U1	U1	FV	FV	FV	FV	U1	U1	U1	U1

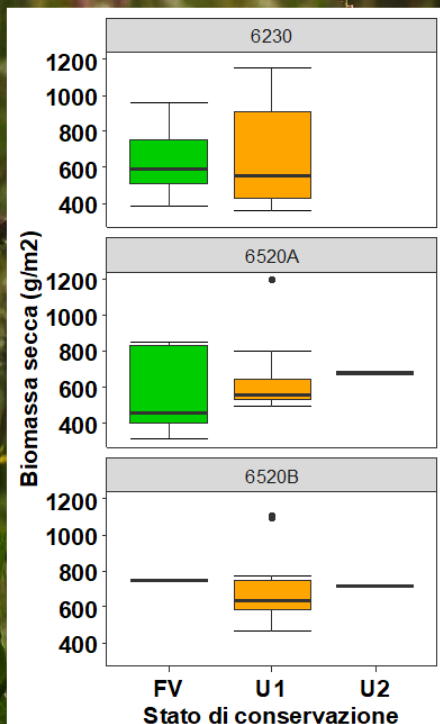
ID	Comlessivo	Struttura	Funzioni	Prospettive future	Struttura			Funzioni		Prospettive future		
					Copertura totale	Tipiche copertura	erbe perenni	Tipiche frequenza	Specie significative	Evoluzione	Eutrofizzazione	
					%	%	n	%	n	%	%	
PAGA-28	FV	FV	FV	FV	FV	FV	FV	FV	FV	FV	FV	FV
PAGA-29	U2	FV	FV	U2	FV	FV	FV	FV	FV	U2	FV	FV
PAGA-30	U2	U2	U1	U1	FV	U1	U2	FV	U1	U1	FV	FV
PAGA-31	U2	U2	U1	U2	FV	U2	U2	U1	U1	U1	U2	FV
PAGA-32	U1	FV	FV	U1	FV	FV	FV	FV	FV	U1	FV	FV
PAGA-33	U1	U1	U1	U1	FV	U1	U1	U1	FV	U1	FV	FV
PAGA-34	U1	U1	FV	FV	FV	FV	U1	FV	FV	FV	FV	FV
PAGA-35	U1	U1	U1	U1	FV	U1	U1	FV	U1	U1	FV	FV
PAGA-36	U1	U1	FV	FV	FV	U1	FV	FV	FV	FV	FV	FV
PAGA-37	FV	FV	FV	FV	FV	FV	FV	FV	FV	FV	FV	FV
PAGA-38	U1	U1	FV	FV	FV	U1	FV	FV	FV	FV	FV	FV
PAGA-39	FV	FV	FV	FV	FV	FV	FV	FV	FV	FV	FV	FV
PAGA-40	U1	U1	U1	U1	FV	U1	U1	FV	U1	U1	U1	FV
PAGA-43	U1	U1	FV	FV	FV	U1	FV	FV	FV	FV	FV	FV
PAGA-44	U1	U1	U1	U1	FV	U1	FV	U1	FV	U1	FV	FV

ID	Comlessivo	Struttura	Funzioni	Prospettive future	Struttura			Funzioni		Prospettive future		
					Copertura totale	Tipiche copertura	erbe perenni	Tipiche frequenza	Specie significative	Evoluzione	Eutrofizzazione	
					%	%	n	%	n	%	%	
PAGA-08	U1	U1	U1	FV	FV	U1	U1	FV	U1	FV	FV	FV
PAGA-22	U2	U1	U2	FV	FV	FV	U1	FV	U2	FV	FV	FV
PAGA-24	U1	U1	U1	U1	FV	FV	U1	FV	U1	U1	FV	FV
PAGA-26	U2	U1	U1	U2	FV	U1	FV	FV	U1	U2	FV	FV
PAGA-42	U1	U1	FV	U1	FV	U1	FV	FV	FV	U1	FV	FV
PAGA-45	U1	U1	U1	FV	FV	U1	FV	U1	U1	FV	FV	FV
PAGA-46	U1	U1	U1	U2	FV	U1	FV	FV	U1	U2	FV	FV
PAGA-47	U1	U1	FV	U2	FV	U1	FV	FV	FV	U2	FV	FV
PAGA-48	U1	U1	FV	FV	FV	U1	FV	FV	FV	FV	FV	FV
PAGA-49	U2	U2	FV	U1	FV	U2	FV	FV	FV	U1	FV	FV
PAGA-50	U1	U1	FV	FV	FV	U1	FV	FV	FV	FV	FV	FV
PAGA-51	U1	U1	U1	FV	FV	U1	U1	FV	U1	FV	FV	FV
PAGA-52	U1	U1	U1	U1	FV	U1	FV	FV	U1	U1	FV	FV
PAGA-53	U1	U1	FV	FV	FV	U1	FV	FV	FV	FV	FV	FV
PAGA-54	U1	FV	FV	U1	FV	FV	FV	FV	FV	U1	FV	FV
PAGA-55	U2	U1	U1	U2	FV	U1	U1	FV	U1	U2	FV	FV
PAGA-57	U2	U1	U1	U2	FV	U1	FV	FV	U1	U2	FV	FV
PAGA-58	U2	U1	U1	U2	FV	U1	FV	FV	U1	U2	FV	FV
PAGA-59	U2	U1	U1	U2	FV	U1	U1	FV	U1	U2	FV	FV
PAGA-56	U2	U2	U1	U1	FV	FV	U2	FV	U1	U1	FV	FV
PAGA-41	U1	U1	FV	FV	FV	U1	FV	FV	FV	FV	FV	FV

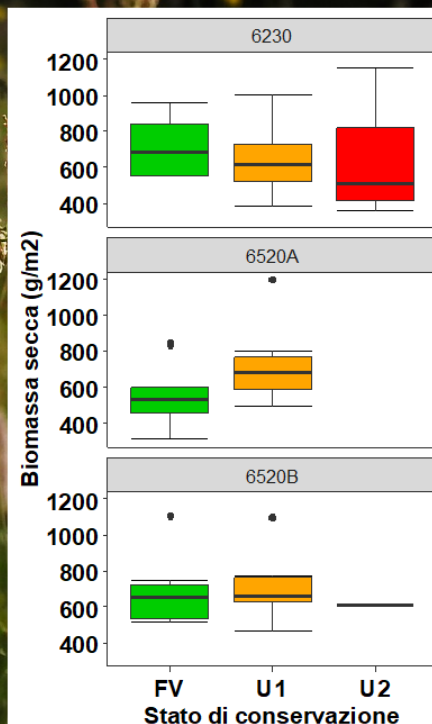
COMPLESSIVO



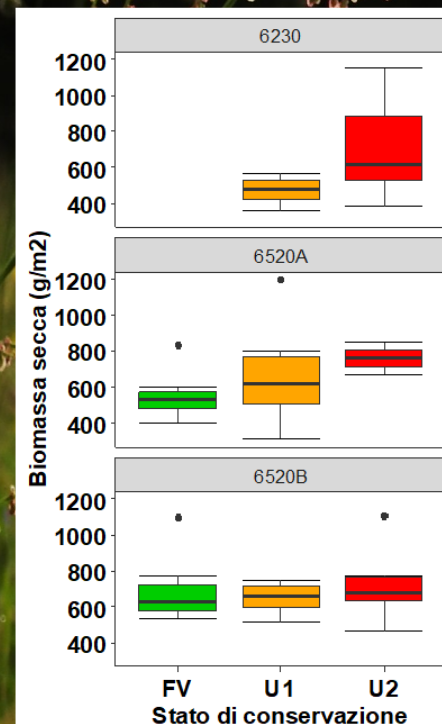
STRUTTURA



FUNZIONI



PROSPETTIVE FUTURE



Elevata produttività minaccia le prospettive future !!

6230*-C → max 600 g/m²

6520-A → max 800 g/m²

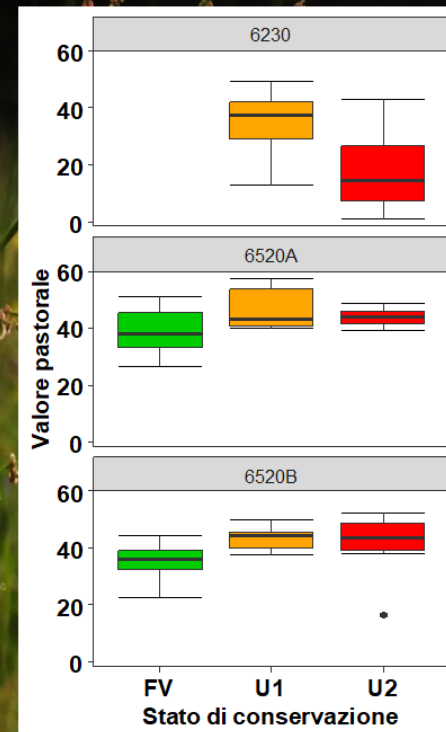
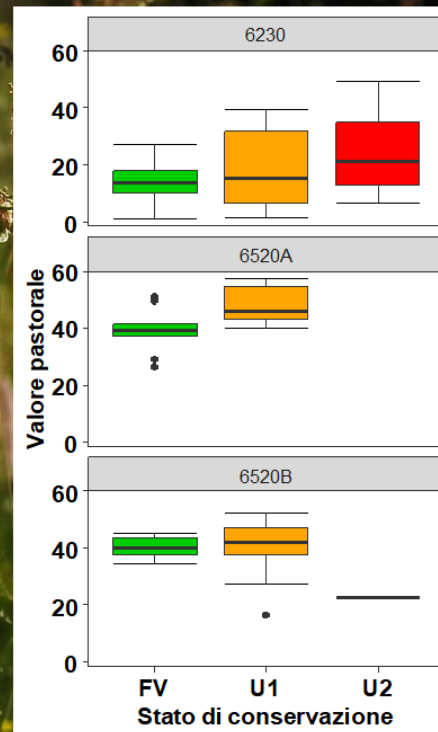
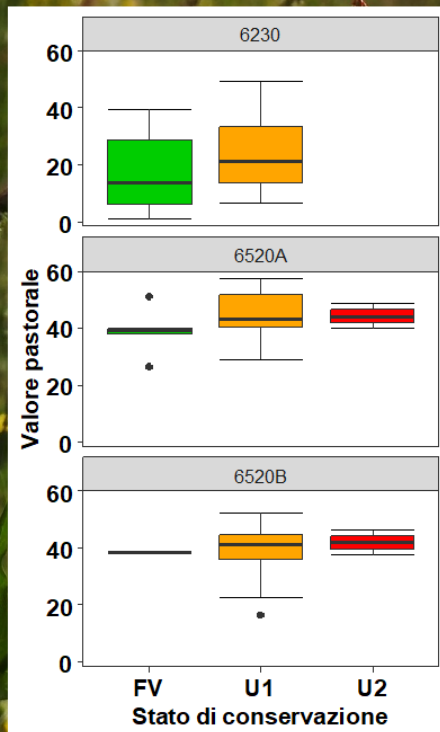
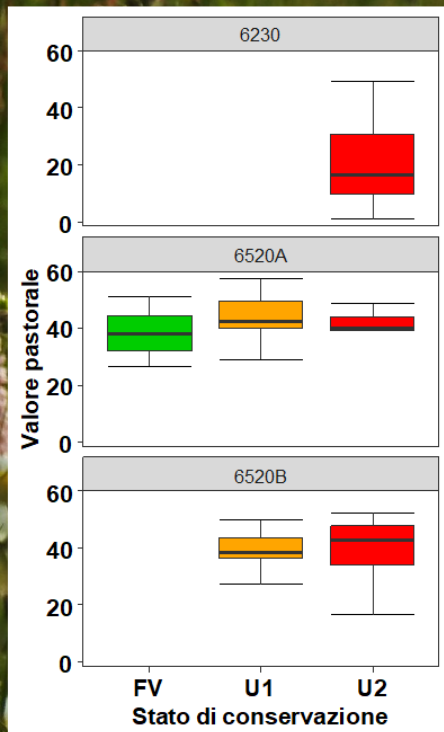
6520-B → max 700 g/m²

COMPLESSIVO

STRUTTURA

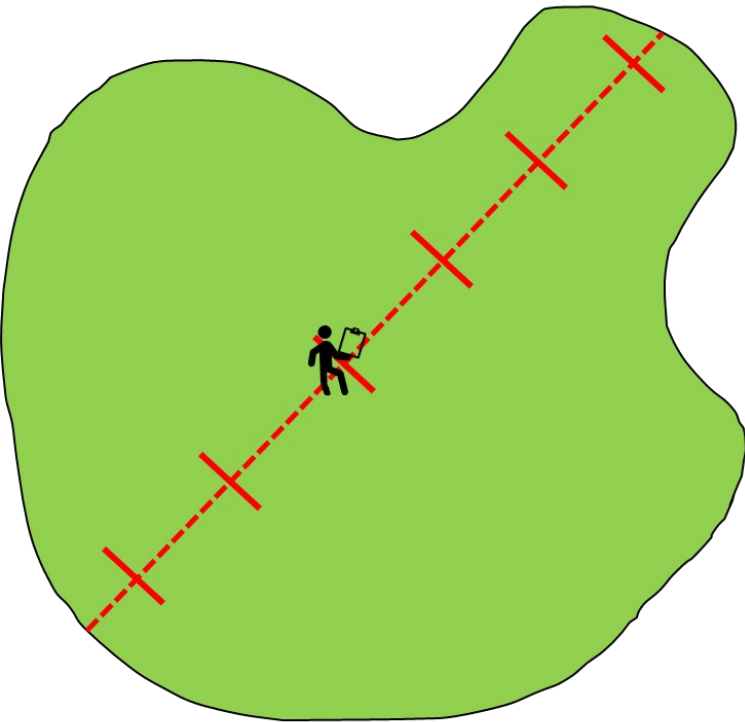
FUNZIONI

PROSPETTIVE FUTURE



Poche differenze significative → valore pastorale può essere elevato può coincidere anche con uno stato di conservazione favorevole!

Ma quali indicatori usare?



1) COPERTURA TOTALE (COP. > 90 %)

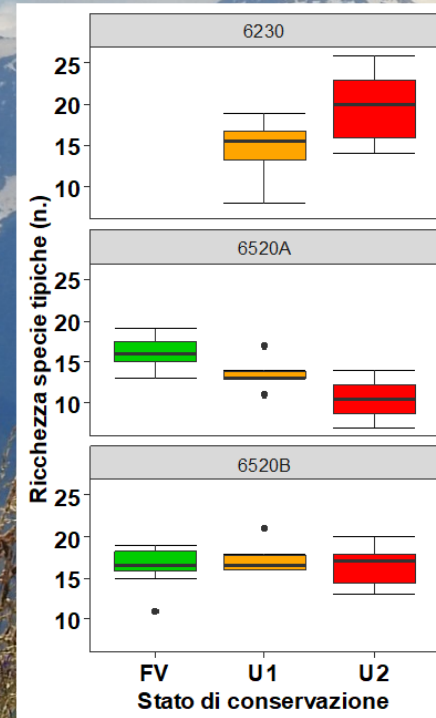
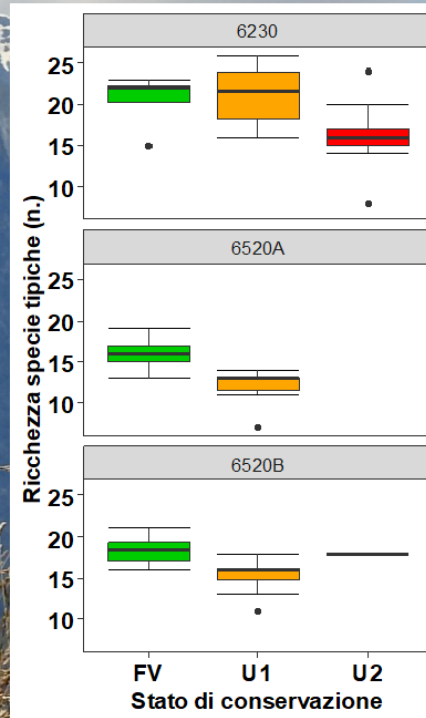
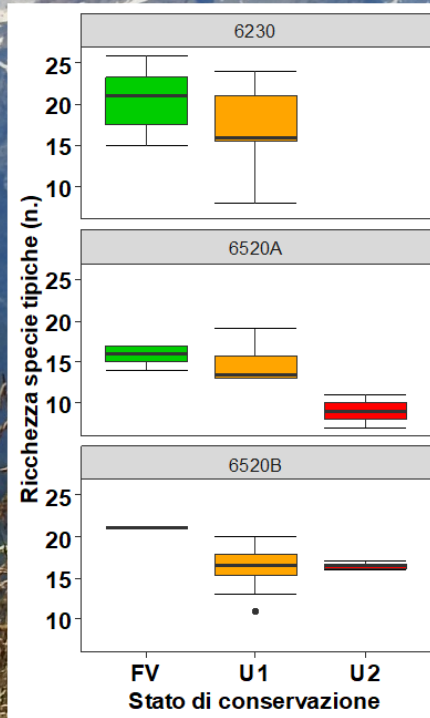
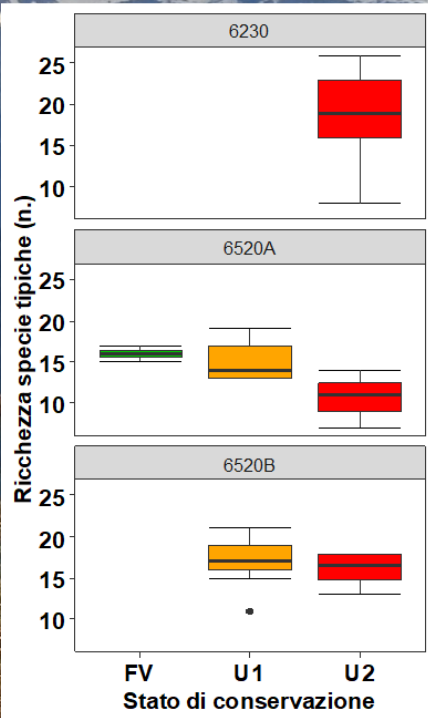


COMPLESSIVO

STRUTTURA

FUNZIONI

PROSPETTIVE FUTURE



2) NUMERO DI SPECIE TIPICHE (COP. > 60 %)

6230*-C → almeno 17 specie tipiche

6520-A → almeno 13 specie tipiche

6520-B → almeno 18 specie tipiche

Specie tipiche indicatrici habitat 6230*-C



Bistorta officinalis



Ranunculus montanus



Hypericum maculatum



Trifolium alpinum



Astrantia minor



Hieracium lactucella



Nardus stricta



Crocus vernus albiflorus

Totale 38 specie (include *early warnings*)

Credits www.actaplantarum.org

Specie tipiche indicatrici habitat 6230*-C (early warnings)



Geum montanum



Gentiana acaulis



Campanula barbata



Phyteuma betonicifolium



Arnica montana



Hieracium pilosella



Luzula campestris



Phleum rhaeticum

Totale 16 specie

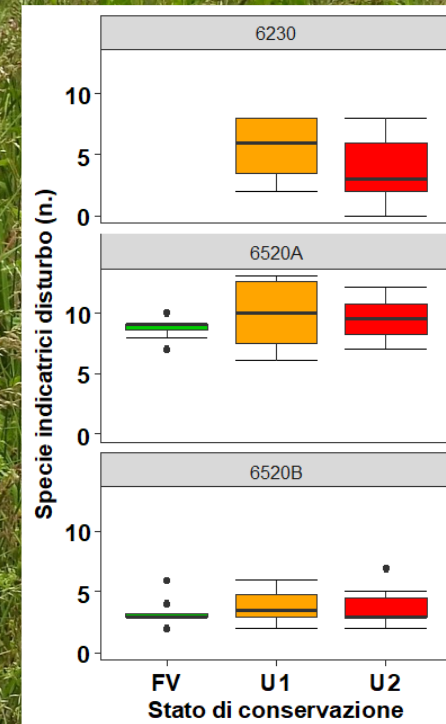
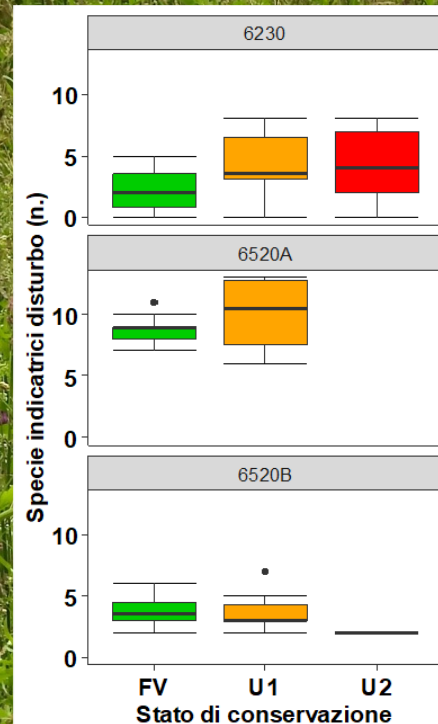
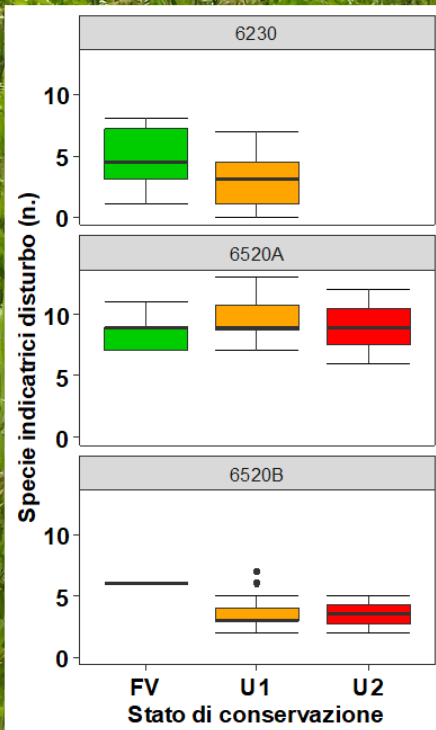
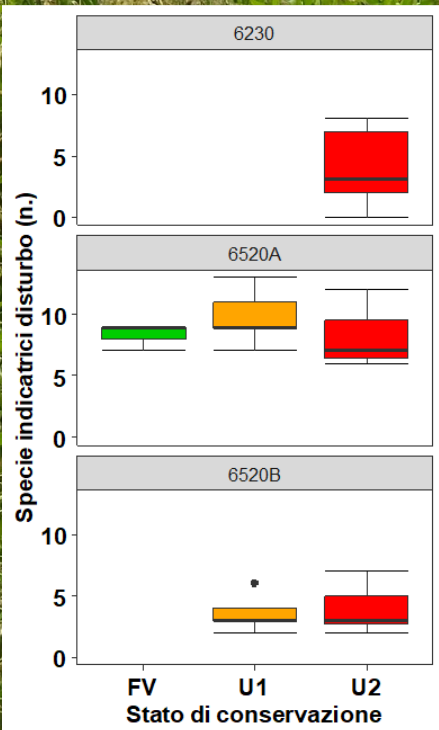
Credits www.actaplantarum.org

COMPLESSIVO

STRUTTURA

FUNZIONI

PROSPETTIVE FUTURE



3) NUMERO SPECIE INDICATRICI DI DISTURBO (COP < 10 %)

6230*-C → max 3 specie

6520-A → max 7 specie

6520-B → max 2 specie

Specie indicatrici di disturbo habitat 6230*-C



Achillea millefolium



Cirsium spinosissimum



Dactylis glomerata



Deschampsia cespitosa



Poa alpina



Ranunculus montanus



Rumex acetosa



Rumex alpestris

Totale 20 specie

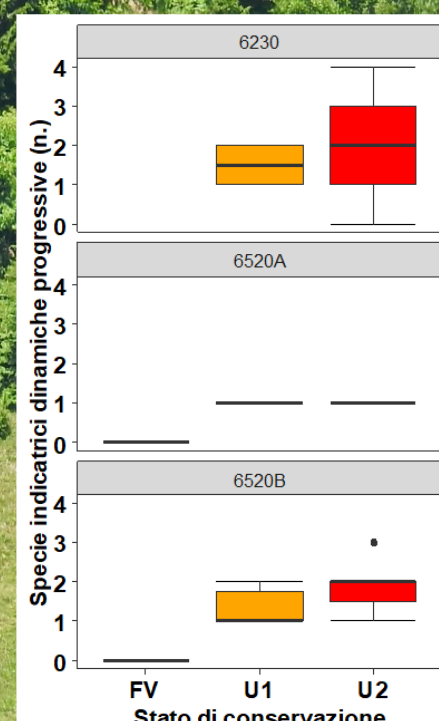
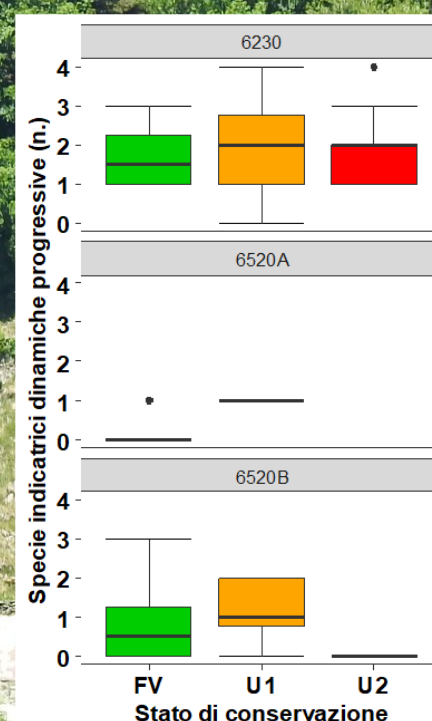
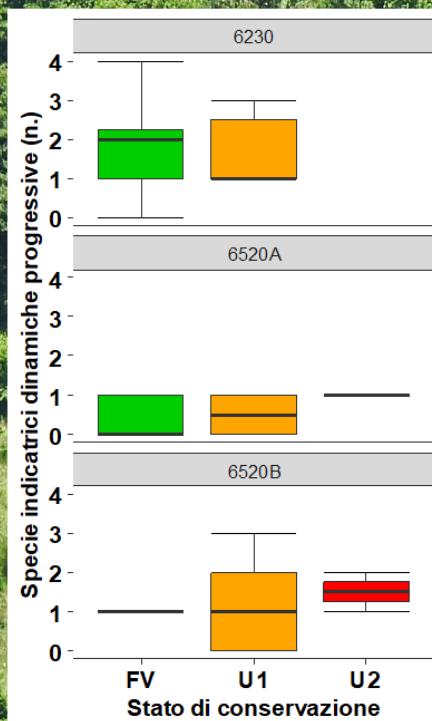
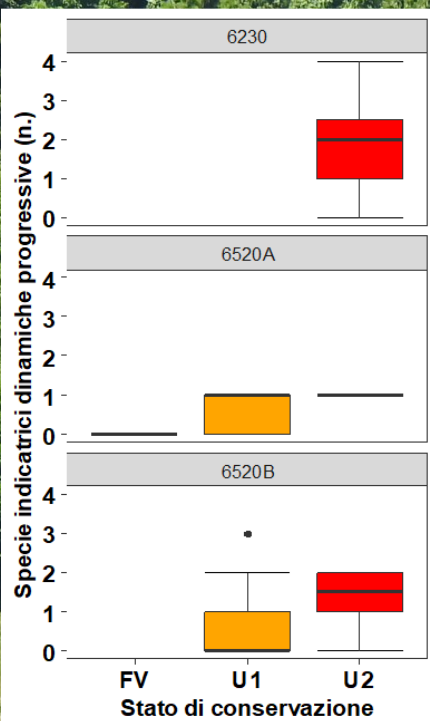
Credits www.actaplantarum.org

COMPLESSIVO

STRUTTURA

FUNZIONI

PROSPETTIVE FUTURE



4) NUMERO SPECIE INDICATRICI DI DINAMICA PROGRESSIVA (COP. < 20 % in 6230 o < 10 % in 6520)

6230*-C → max 2 specie

6520-A → max 1 specie

6520-B → max 1 specie

Specie indicatrici di dinamica progressiva habitat 6230*-C



Alnus viridis



Betula pendula



Chaerophyllum villarsii



Avenella flexuosa



Juniperus communis



Picea abies



Rhododendron ferrugineum

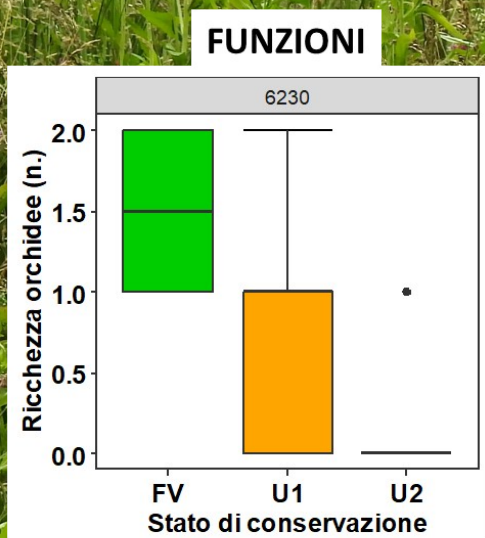


Rubus idaeus

Totale 13 specie

Credits www.actaplantarum.org

5) RICCHEZZA DI ORCHIDEE (almeno 2 generi in 6230*)



Noi abbiamo trovato max 2 specie, ma differenze solo se si valutano le funzioni...



Traunsteinera globosa



Nigritella rhellicani



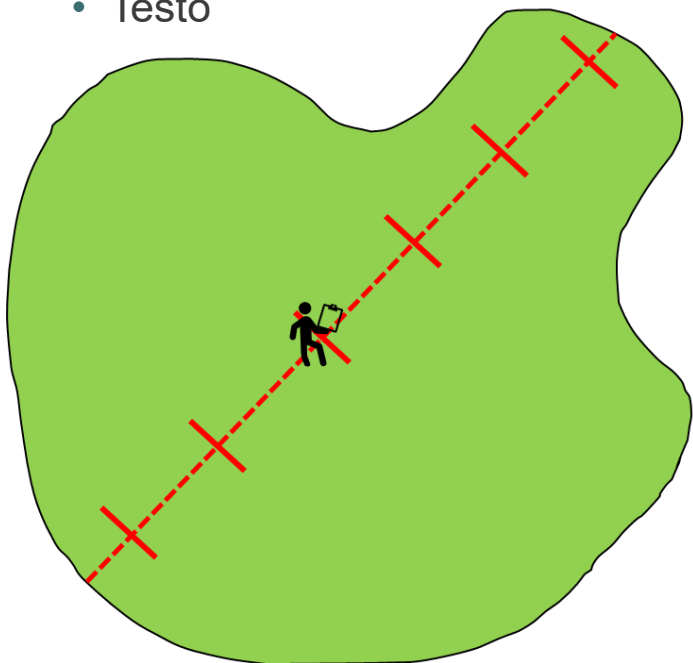
Gymnadenia conopsea



Cephalanthera longifolia

Ma quali indicatori usare?

- Testo



PUNTEGGIO	INDICATORE
0.25	1) COPERTURA TOTALE (COP. > 90 %)
0.25	2) NUMERO DI SPECIE TIPICHE (COP. > 60 %) • 6230*-C: almeno 17 specie tipiche • 6520-A: almeno 13 specie tipiche • 6520-B: almeno 18 specie tipiche
0.25	3) NUMERO SPECIE INDICATRICI DI DISTURBO (COP < 10 %) • 6230*-C: max 3 specie • 6520-A: max 7 specie • 6520-B: max 2 specie
0.25	4) NUMERO SPECIE INDICATRICI DI DINAMICA PROGRESSIVA (COP. < 20 % in 6230 o < 10 % in 6520) • 6230*-C: max 2 specie • 6520-A: max 1 specie • 6520-B: max 1 specie
1.00	TOTALE



LIFE
NatConnect
2030



Grazie!

