

“Progettare con i principi dell’Ingegneria Naturalistica in aree protette e Rete Natura 2000”

La vegetazione nell’ingegneria naturalistica

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Brinzio (VA), 4.10.2019

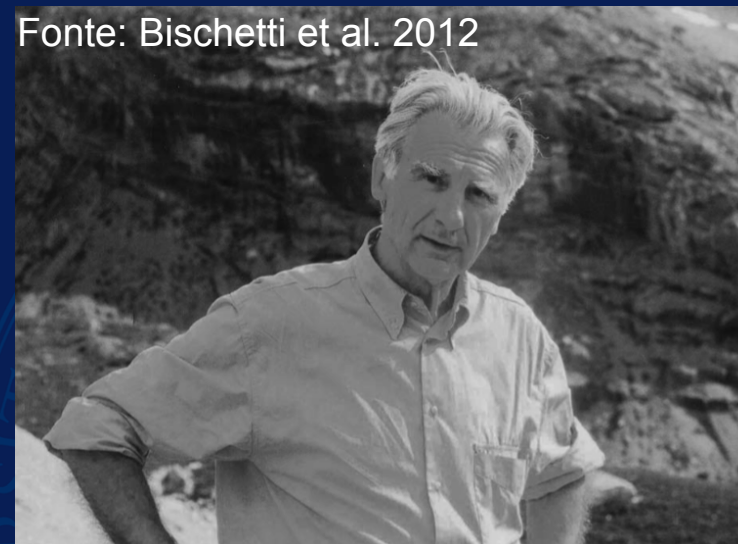
Soil bioengineering

Soil bioengineering is a relatively recent discipline that uses low-impact measures which utilize live plants (or parts thereof) as building materials in combination with other materials (such as stones, soil, timber, steel, etc.) for soil stabilization.



Soil bioengineering work (Alpe Mola).

Fonte: Bischetti et al. 2012



Hugo Meinhard Schiechl (1922-2002), one of the leading exponents of soil bioengineering.

Soil bioengineering

Landscape Research,
2012, 1–13, iFirst article

 **Routledge**
Taylor & Francis Group

On the Origin of Soil Bioengineering

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FLORIN FLORINETH**

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ABSTRACT *Soil bioengineering is a discipline dealing with hill slopes, riverbanks, and earth embankment stabilisation, which in recent decades has gained worldwide popularity. Its peculiarity consists in the technical use of vegetation, sometimes coupled with other materials. Owing to aesthetic and environment-friendly characteristics of vegetation, soil bioengineering techniques are frequently adopted to achieve a low environmental impact of protective works within the fields of landscape architecture and environmental restoration. In spite of such success, the origin and the contents of soil bioengineering have not been completely investigated. This paper shows that soil bioengineering is not as old as most of the researchers think; rather, it was developed in a very specific context, the building of highways during the Nazi dictatorship, although it is the result of a longer process. The paper also shows that the contents of soil bioengineering are not related to the mere use of vegetation for stabilising purposes, but they focus on broader environmental concerns.*

Bischetti et al. (2012)

Section I

Application of floristic-vegetational indices for the analysis of soil stabilization works conducted in Val Camonica (Northern Italy)

This research has led to the formulation of two floristic-vegetational indices:

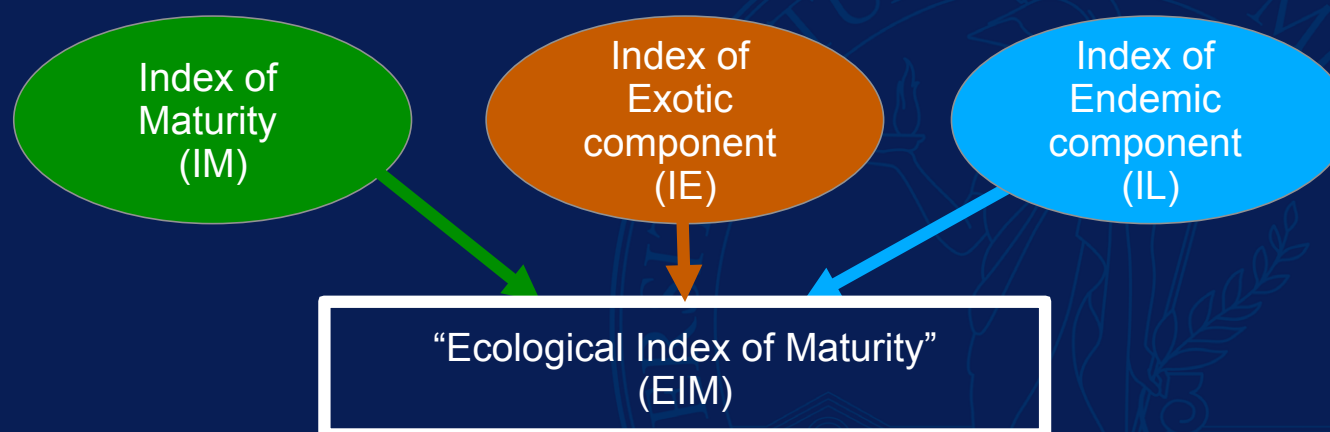
1) Ecological Index of Maturity (EIM) (Giupponi et al. 2015)

2) Index of Ecological Success (IES) (Giupponi et al. 2017c)

These indices are based on the study of the vegetation according to the phytosociological method

Ecological Index of Maturity (EIM)

The Ecological Index of Maturity (EIM) (Giupponi et al. 2015) measures the level of disturbance affecting a plant community considering: phytosociological class, chorotype and coverage of each species present.



Ecological Index of Maturity (EIM)

Index of
Maturity
(IM)

Index of
Exotic
component
(IE)

Index of
Endemic
component
(IL)

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Vegetation Science

Application of the floristic-vegetational indexes system for the evaluation of the environmental quality of a semi-natural area of the Po Valley (Piacenza, Italy).

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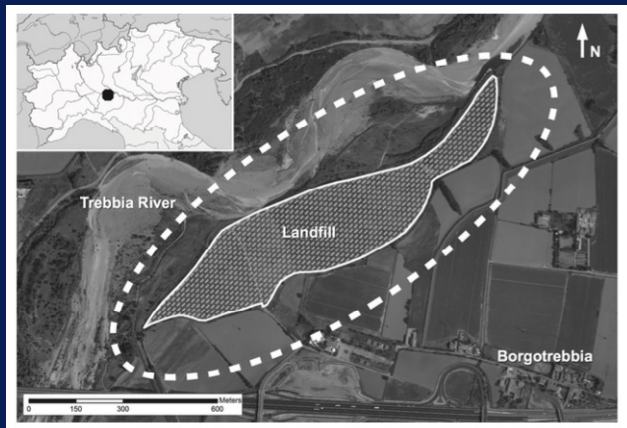
³ Istituto di Chimica Agraria ed Ambientale, Università Cattolica del Sacro Cuore, via Emilia Parmense 84, I-29122 Piacenza, Italy.

Abstract

The floristic-vegetational indexes proposed by Taffetani & Rismondo (2009) and updated by Rismondo *et al.* (2011) were used to assess the environmental quality of a semi-natural area located on the outskirts of Piacenza (Emilia-Romagna, Italy), the site of a closed landfill of Municipal Solid Waste (MSW). This method was created and perfected to analyze the ecological functionality of agro-ecosystems and permits simple and rapid

Giupponi et al. (2013)

Ecological Index of Maturity (EIM)



“Application of the floristic-vegetational indexes system for the evaluation of the environmental quality of a semi-natural area of the Po Valley (Piacenza, Italy)”

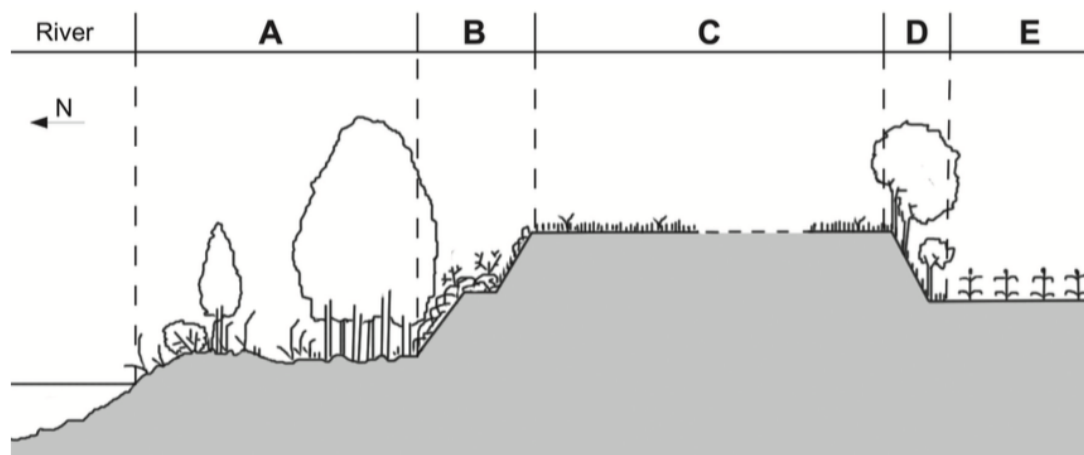
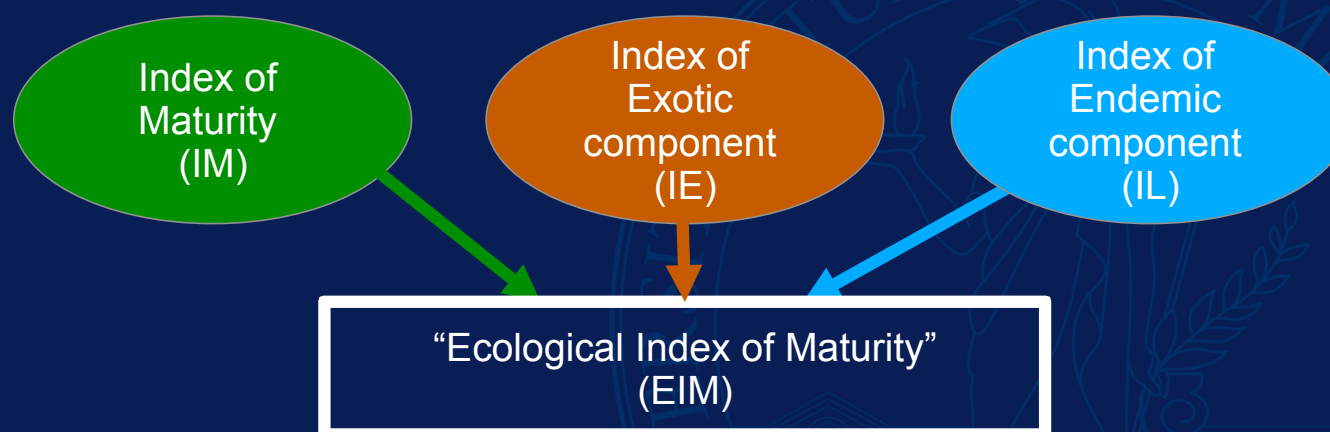


Fig. 2 - North-south vegetation transect of the study area. The letters indicate the different areas where phytosociological relevés were conducted: A = riverside area; B = northern edge of the landfill; C = landfill, D = southern edge of the landfill, E = cultivated fields.

Giupponi et al. (2013)

Ecological Index of Maturity (EIM)

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Ecological Index of Maturity (EIM)

EIM is calculated using the following formula developed by Giupponi et al. (2015):

$$EIM = \frac{IM \cdot \left[\left(1 - \frac{IE}{100} \right) + \frac{IL}{100} \right]}{1 + \frac{IL}{100}}$$

where EIM is the ecological index of maturity, IM is the index of maturity, IE is the index of the exotic component and IL is the index of the endemic component.

EIM values can range from 0 (high vegetation disturbance) to 9 (undisturbed vegetation)

Restoration Ecology

THE JOURNAL OF THE SOCIETY FOR ECOLOGICAL RESTORATION

RESEARCH ARTICLE

Ecological index of maturity to evaluate the vegetation disturbance of areas affected by restoration work: a practical example of its application in an area of the Southern Alps

Luca Giupponi^{1,2}, Gian Battista Bischetti³, Annamaria Giorgi^{1,3}

Giupponi et al. (2015)

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where EIM is the ecological index of maturity, IM is the index of maturity, IE is the index of the exotic component and IL is the index of the endemic component.

The **Index of Maturity (IM)** measures the actual dynamic stage of succession in relation to the coverage and phytosociological class to which each species of a plant community belongs. IM is expressed by the following formula (Taffetani & Rismondo 2009):

$$IM = \frac{\sum_{i=1}^n (c_i \cdot m)}{C}$$

where IM is the index of maturity, c_i is the coverage value of each single species, i ($i = 1, 2, \dots, n$) is the number of species, m is the coefficient of maturity of the phytosociological class to which each species belongs, C is the total coverage value obtained by summing the values of c for all the species present.

Coefficient of maturity (m)

$$IM = \frac{\sum_{i=1}^n (c_i \cdot m)}{C}$$

The coefficient of maturity (m) is the value assigned by Taffetani & Rismondo (2009) and Rismondo et al. (2011) to the main phytosociological classes of European vegetation according to the physiognomic-structural, synecological characteristics and the syndynamic role of the vegetation of each class.

Phytosociological class	m
* cultivated or exotic species	0
STELLARITEA MEDIAE	1
ORYZETEA SATIVAE	1
CAKILETEA MARITIMAE	2
ARTEMISIETEA VULGARIS	3
MOLINIO-ARRHENATHERETEA	4
BIDENTETEA TRIPARTITAE	4
FESTUCO VALESIIACAE-BROMETEA ERECTI	5
NARDETEA STRICTAE	5
ASPLENIETEA TRICHOMANIS	5
FESTUCO-SESLERIETEA	5
THLASPIETEA ROTUNDIFOLII	5
GALIO APARINES-URTICETEA DIOICAE	6
MONTIO FONTANAE-CARDAMINETEA AMARAE	6
SCHEUCHZERIO PALUSTRIS-CARICETEA NIGRAE	6
EPILOBIETEA ANGUSTIFOLII	7
MULGEDIO ALPINI-ACONITETEA VARIEGATI	7
TRIFOLIO MEDII-GERANIETEA SANGUINEI	7
BETULO CRPATICAЕ-ALNETEA VIRIDIS	7
RHAMNO CATHARTICAЕ-PRUNETEA SPINOSAE	8
ROSMARINETEA OFFICINALIS	8
ROBINIETEA	8
ERICO CARNEAE-PINETEA SYLVESTRIS	9
QUERCO ROBORIS-FAGETEA SYLVATICAЕ	9
QUERCETEA ILICIS	9
VACCINIO MYRTILLI-PICEETEA ABIETIS	9
...	

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where EIM is the ecological index of maturity, IM is the index of maturity, IE is the index of the exotic component and IL is the index of the endemic component.

The **index of exotic component (IE)** provides the percentage of exotic species of a plant community considering exotic species coverage compared to total coverage. It measures the degree of exotic contamination and artificiality of the plant coenoses in relation to human pressure (human disturbance) in the territory.

$$IE = \frac{\sum_{i=1}^n [c_{(e)}]_i}{C} \cdot 100$$

IE is the index of exotic component, $c_{(e)}$ is the coverage value of each exotic species, i ($i = 1, 2, \dots, n$) is the number of exotic species and C is the total coverage value

Ecological Index of Maturity (EIM)

EIM is calculated using the following formula developed by Giupponi et al. (2015):

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where EIM is the ecological index of maturity, IM is the index of maturity, IE is the index of the exotic component and IL is the index of the endemic component.

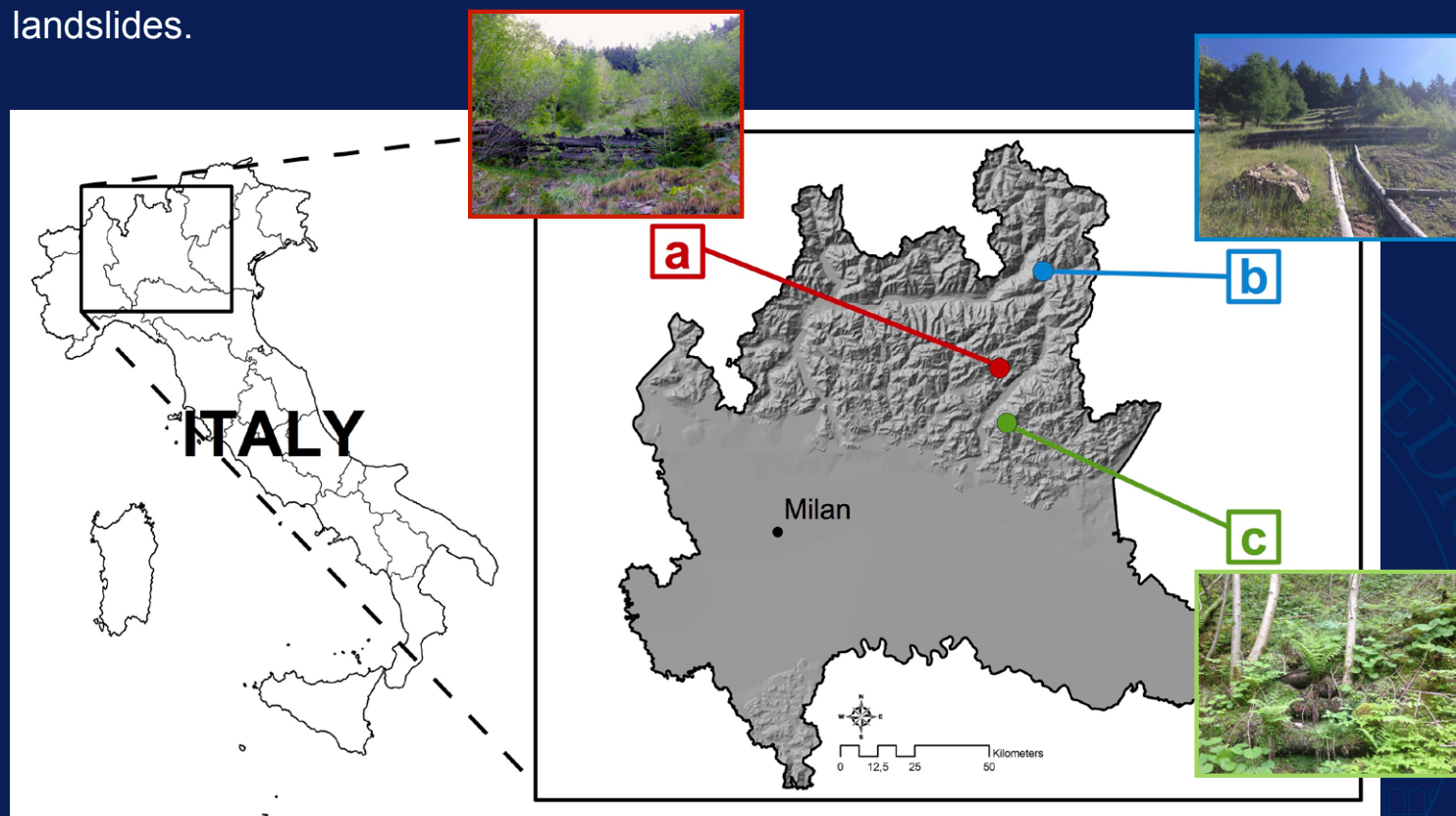
The index of **endemic component (IL)** gives the percentage of endemic species of a community considering their coverage compared to that of all the species present. The index of endemic component is calculated according to the following formula:

$$IL = \frac{\sum_{i=1}^n [c_{(i)}]_i}{C} \cdot 100$$

where IL is the index of endemic component, $c_{(i)}$ is the coverage value of each endemic species, i ($i = 1, 2, \dots, n$) is the number of endemic species and C is the total coverage value obtained by summing the values of c

Study areas

EIM was applied to three study areas located in mountain areas of Lombardy affected by landslides.



Location of the study areas: **Azzone (a)**, **Val Dorena (b)** and **Val Palot (c)**

Study area: Azzone (a)

The study area is located in Azzone (Scalve Valley, Lombardy, Northern Italy; coordinates: 45°58'34.1" N, 10°07'15.5" E), has an area of 13.000 m² and is localized at an altitude which ranges from 1.000 to 1.150 m. It has undergone stabilization work using soil bioengineering techniques, following a landslide occurred in April 1992



Study area in Azzone after the landslide (1992), at the time of soil stabilization (1995) and at the time of vegetation monitoring (2014)

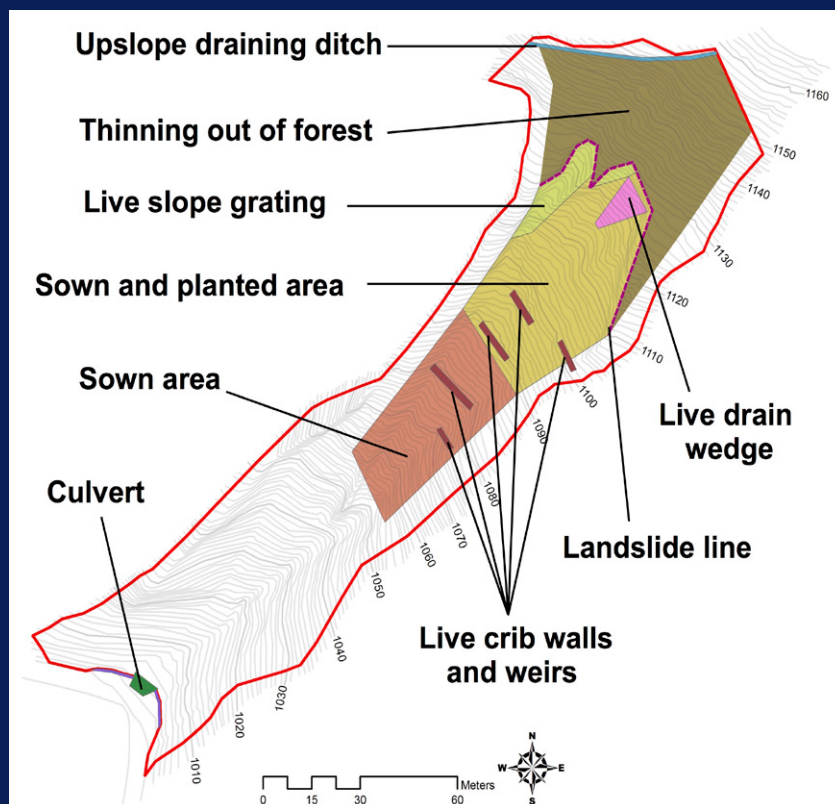
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Study area in Azzone after the landslide (1992), at the time of soil stabilization (1995) and at the time of vegetation monitoring (2014)

Study area: Azzone (a)



Map of soil stabilization works of Azzone

Upon completion of soil bioengineering works, vegetation was restored by planting some tree species and sowing various grass species (including exotic species).

Species	%
<i>Festuca rubra</i> L.	32
<i>Festuca cinerea</i> Vill.	28
<i>Trifolium repens</i> L.	7
<i>Lotus corniculatus</i> L.	6
<i>Poa pratensis</i> L.	5
<i>Lolium perenne</i> L.	4
<i>Dactylis glomerata</i> L.	3
<i>Achillea millefolium</i> L.	2
<i>Medicago lupulina</i> L.	2
<i>Onobrychis viciifolia</i> Scop.	2
<i>Phleum pratense</i> L.	2
<i>Sanguisorba minor</i> Scop.	2
<i>Trifolium pratense</i> L.	2
<i>Anthyllis vulneraria</i> group	1
<i>Lathyrus pratensis</i> L.	1
<i>Lupinus polyphyllus</i> Lindl.	1

Composition of seed mixture

Study area: Val Dorena (b)

Val Dorena is located within the municipality of Monno (high Val Camonica; altitude: 1600 m a.s.l.) and has a catchment area of about 2.5 km² of which 0.12 km² still under active erosion. The area considered in this study includes only a part of the whole area of instability – the area in which the most recent works were carried out in 2000 according to soil bioengineering criteria.

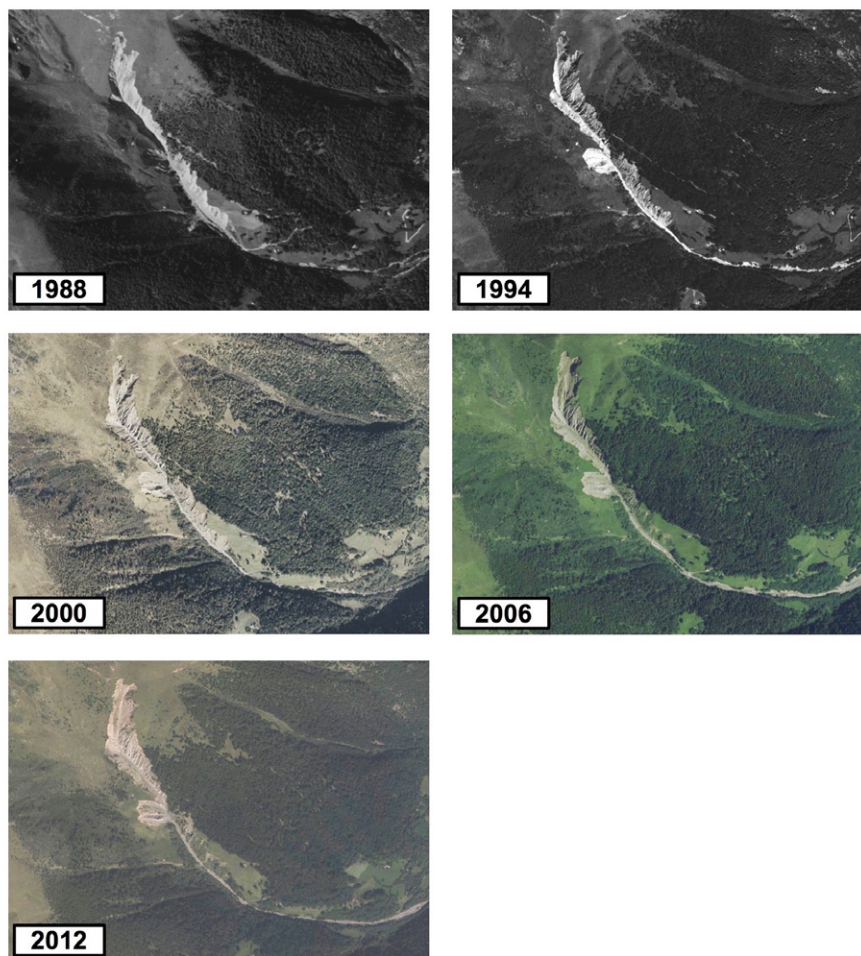


Before soil stabilization work



Fonte: Giupponi 2017

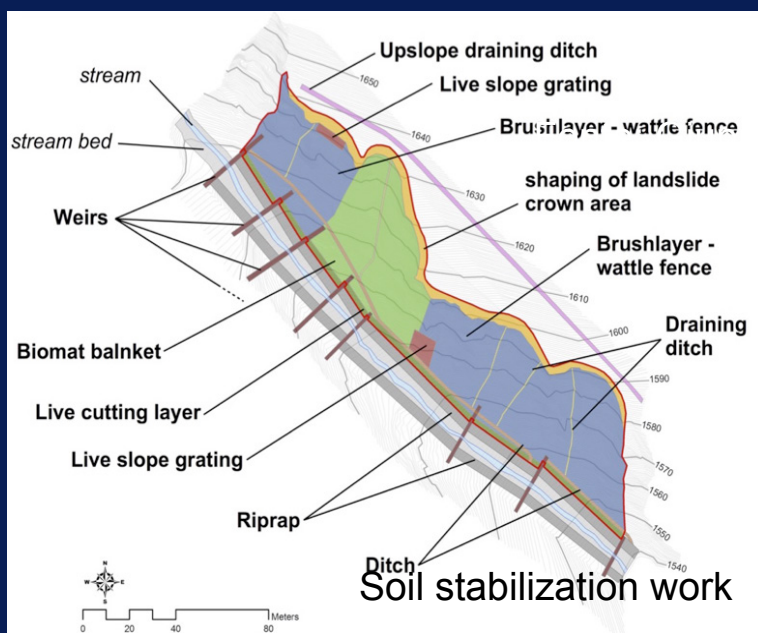
Study area: Val Dorena (b)



Study area in the year 1988,
1994, 2000, 2006, 2012. Data
source: Geoportale Nazionale

Study area: Val Dorena (b)

In Val Dorena no exotic species were sown and further landslides occurred (and still occur) after soil stabilization work.



Map of soil stabilization work



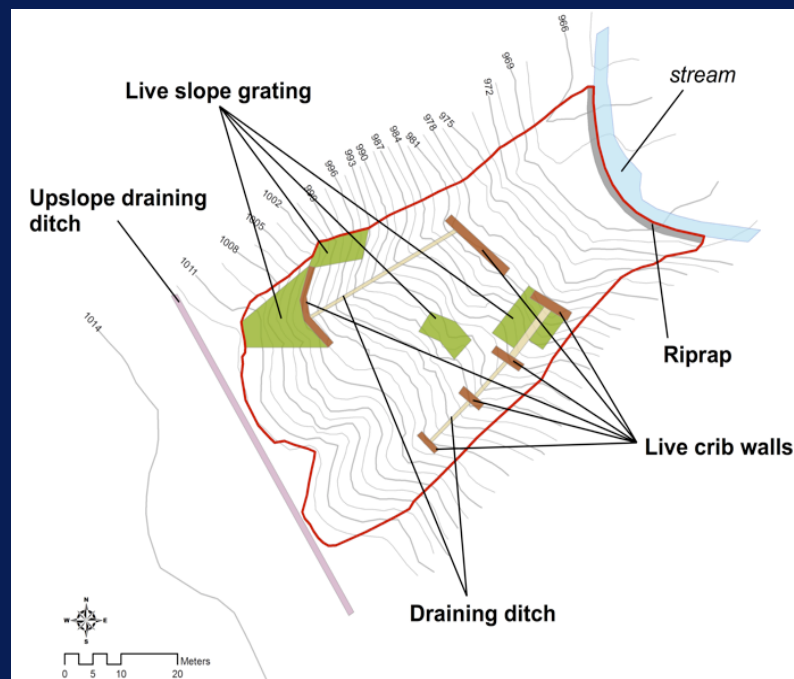
oni et al. 2017



Landslide

Study area: Val Palot (c)

Val Palot is located in the municipality of Pisogne in the Prealps of the province of Brescia (altitude: 1000 m a.s.l.). In 1993 it was affected by extensive instability over an area of approximately 4000 m². Slope stabilization work was performed in 1996 using soil bioengineering techniques



Map of soil stabilization work

In Val Palot no exotic species were sown and no further landslides occurred after soil stabilization work.

Materials and methods

Data on the vegetation of the three study areas were collected by performing phytosociological relevés (15 in Azzone, 16 in Val Dorena and 12 in Val Palot) in accordance with the method of the Zurigo-Montpellier Sigmatis school (Braun-Blanquet 1964).

Vegetation data were analysed statistically using cluster analysis in order to highlight the floristic and physiognomic similarities of the relevés.

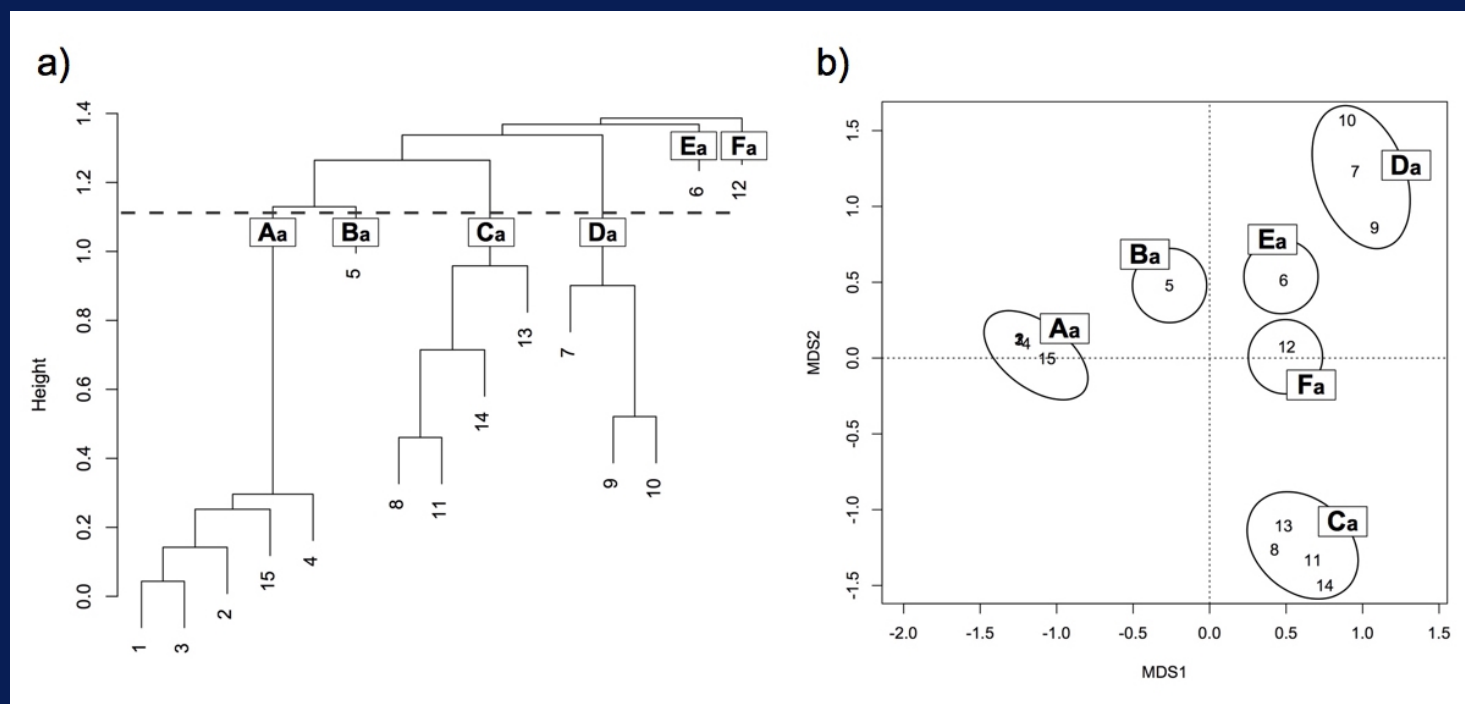
Vegetation map of the study areas was drawn up using ArcGIS 10 software.

The IE, IL, IM and EIM were calculated for each vegetation type using the above mentioned formulas.



Results: Azzone (a)

The results provided by the statistical analysis (cluster analysis and PCoA) of the 15 relevés conducted in the study area of Azzone identified six types of vegetation.



Dendrogram of relevés (a) performed in the study area of Azzone provided by cluster analysis and ordering of the relevés according to PCoA (b). The numbers indicate the codes of each relevé and the letters in the boxes identify the groups of vegetation (clusters). Variance justified by the PCoA axes: MDS1 = 33,53%; MDS2 = 20,66%

Results: Azzone (a)

Aa = montane *Picea abies* forest

Ba = *Festuca cinerea* grassland

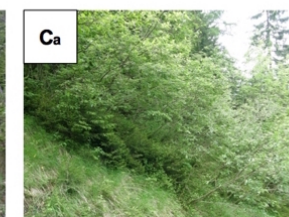
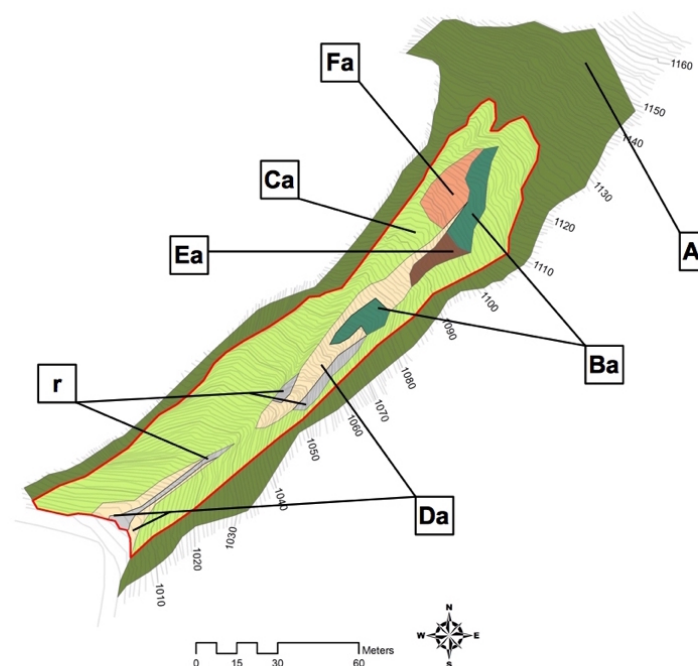
Ca = vegetation dominated by shrubs and broadleaf trees

Da = *Calamagrostis varia* grassland

Ea = *Hieracium tenuiflorum*-*Origanum vulgare* community

Fa = *Lupinus polyphyllus*-*Fraxinus excelsior* community

r = rocks



Results: Azzone (a)

Aa = montane *Picea abies* forest

Ba = *Festuca cinerea* grassland

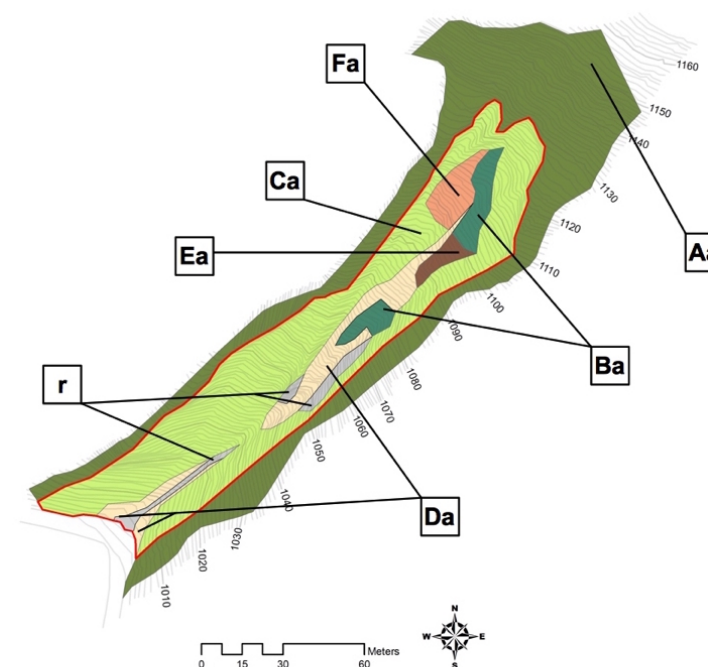
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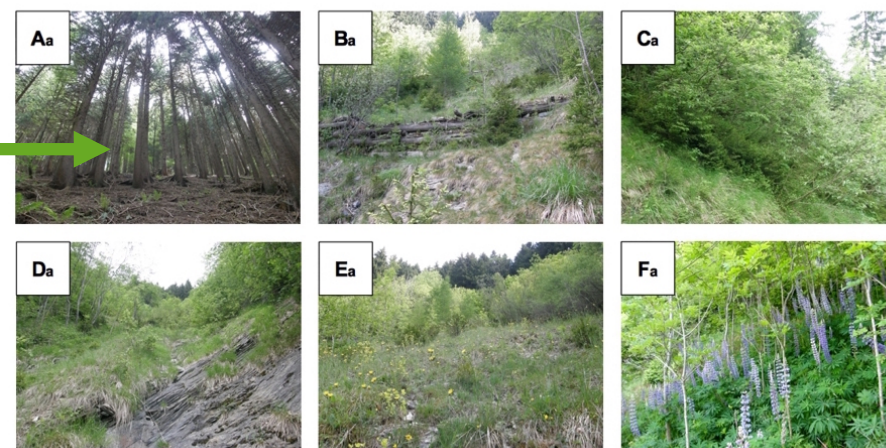
Ea = *Hieracium tenuiflorum*-*Origanum vulgare* community

Fa = *Lupinus polyphyllus*-*Fraxinus excelsior* community

r = rocks



Vegetation	EIM
Aa	8,79
Ba	3,06
Ca	7,89
Da	6,33
Ea	6,86
Fa	3,56



Results: Azzone (a)

Aa = montane *Picea abies* forest

Ba = *Festuca cinerea* grassland

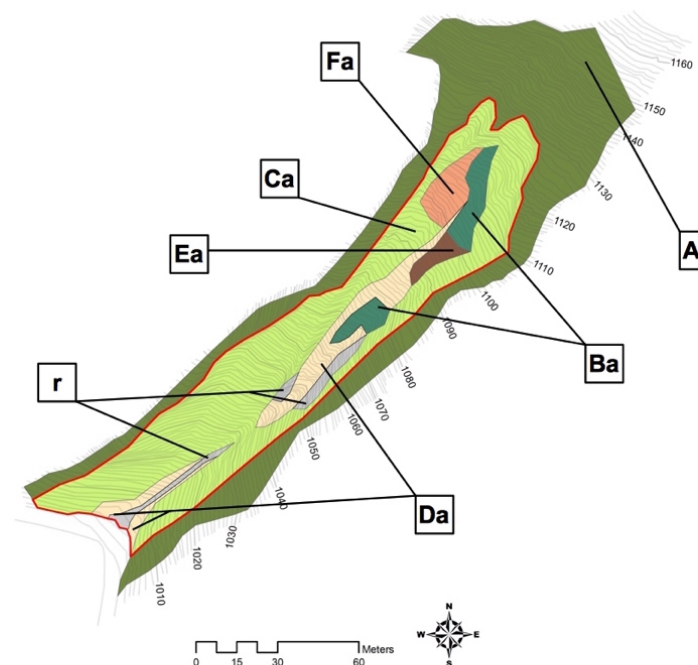
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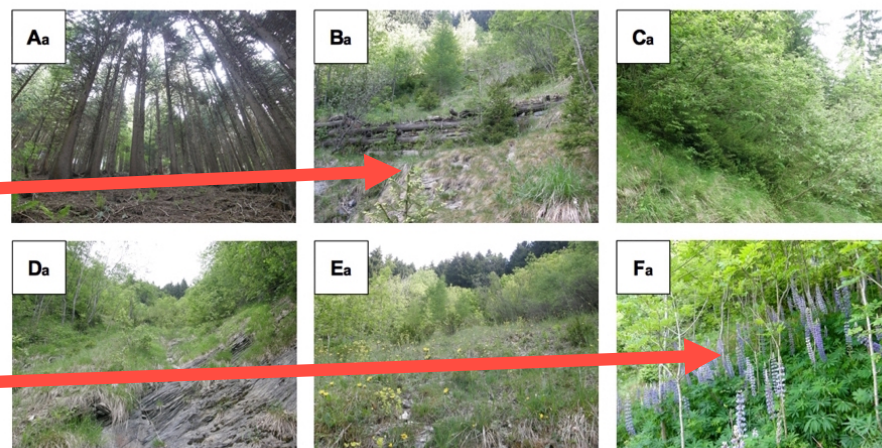
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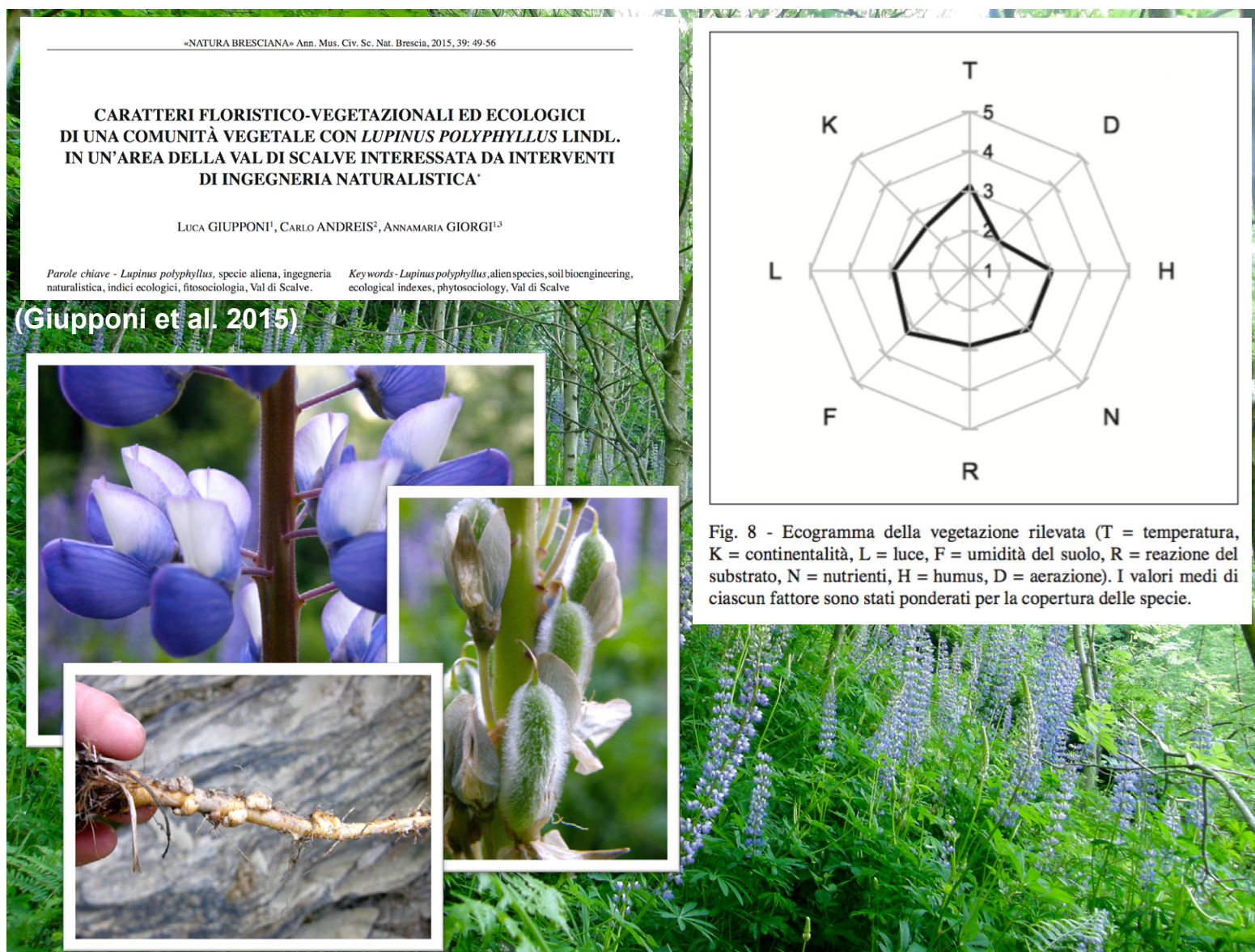


Vegetation	EIM
Aa	8.79
Ba	3.06
Ca	7.89
Da	6.33
Ea	6.86
Fa	3.56





Lupinus polyphyllus-Fraxinus excelsior
community (Giupponi et al. 2015b)



Results: Val Dorena

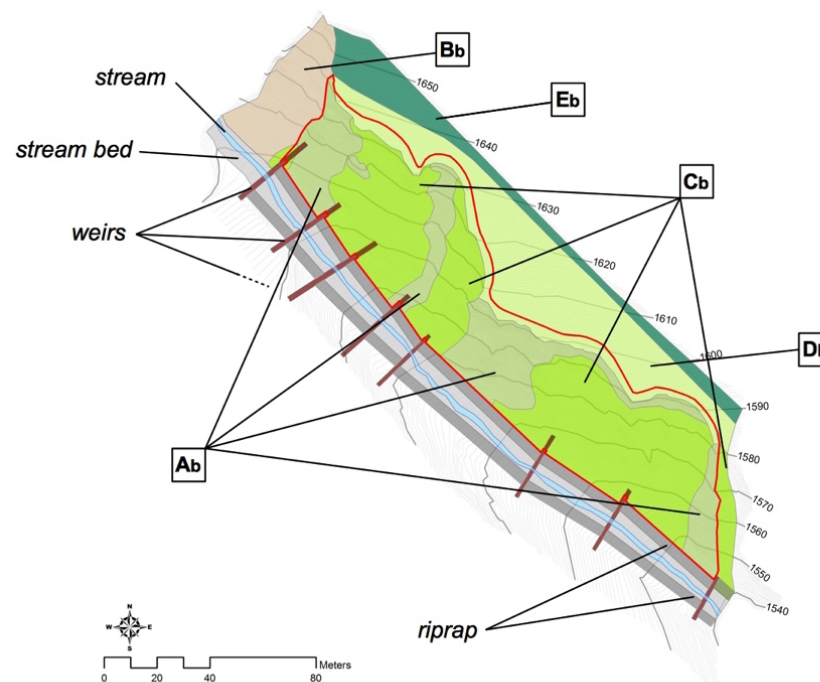
Ab = *Trifolium repens*-*Festuca laevigata* community

Bb = *Tolpis staticifolia*-*Poa glauca* community

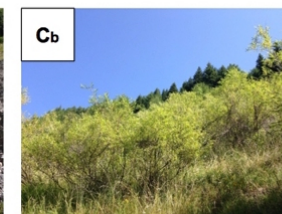
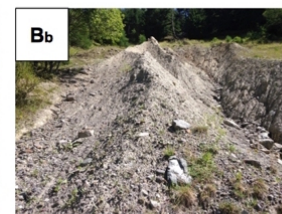
Cb = willow shrubland

Db = mountain meadow

Eb = montane *Picea abies* forest



Vegetation	EIM
Ab	4,49
Bb	4,90
Cb	8,12
Db	4,40
Eb	8,99



Results: Val Palot (c)

Ac = montane *Picea abies* forest

Bc = *Matteuccia struthiopteris*-*Cirsium montanum* community

Cc = *Fraxinus excelsior*-*Aruncus dioicus* community

Dc = *Petasites albus*-*Impatiens noli-tangere* community

Ec = young broad-leaved wood

Fc = bramble shrubland

Gc = mountain meadow

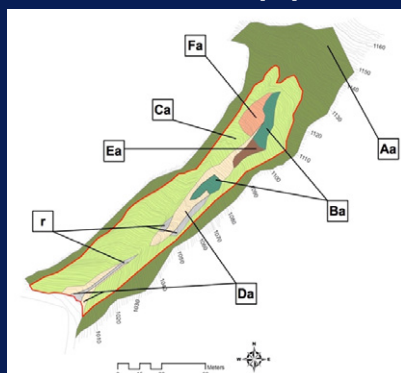
Vegetation	EIM
Ac	8,98
Bc	8,73
Cc	8,73
Dc	8,77
Ec	8,56
Fc	7,94
Gc	4,05



Results

Comparison between the values of EIM of the three study areas

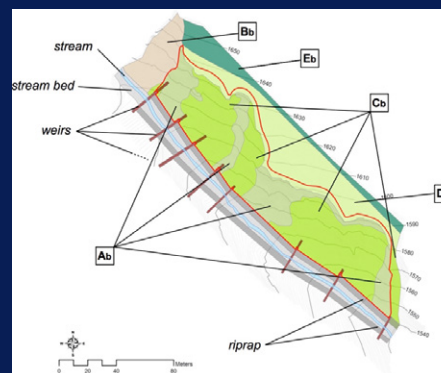
Azzone (a)



EIM = 6,91

Years elapsed after
the end of the work: 19

Val Dorena (b)



EIM = 6,67

Years elapsed after
the end of the work: 15

Val Palot (c)



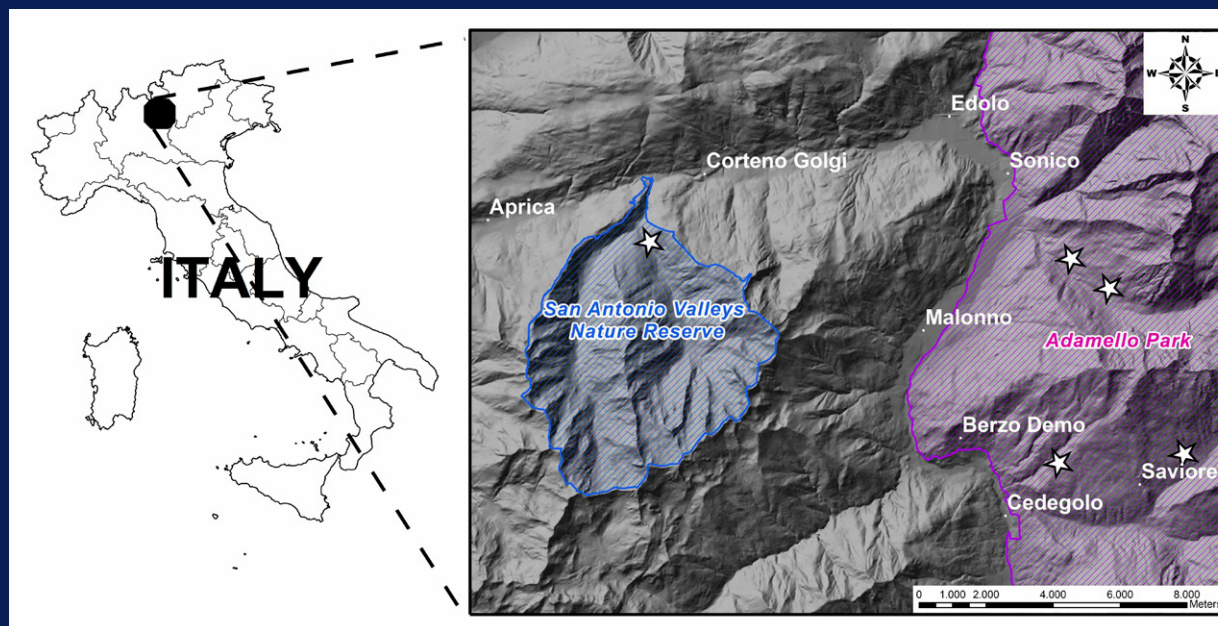
EIM = 8,58

Years after after
the end of the work: 19

The EIM does not considers the time elapsed after the end of the works (vegetation dynamic).

Vegetation analysis of a chronosequence and EIM trend

This study was conducted by analyzing the vegetation of five sites situated in upper Val Camonica. These sites have similar environmental characteristics and were subject to soil stabilization work (Giupponi et al. 2017a).

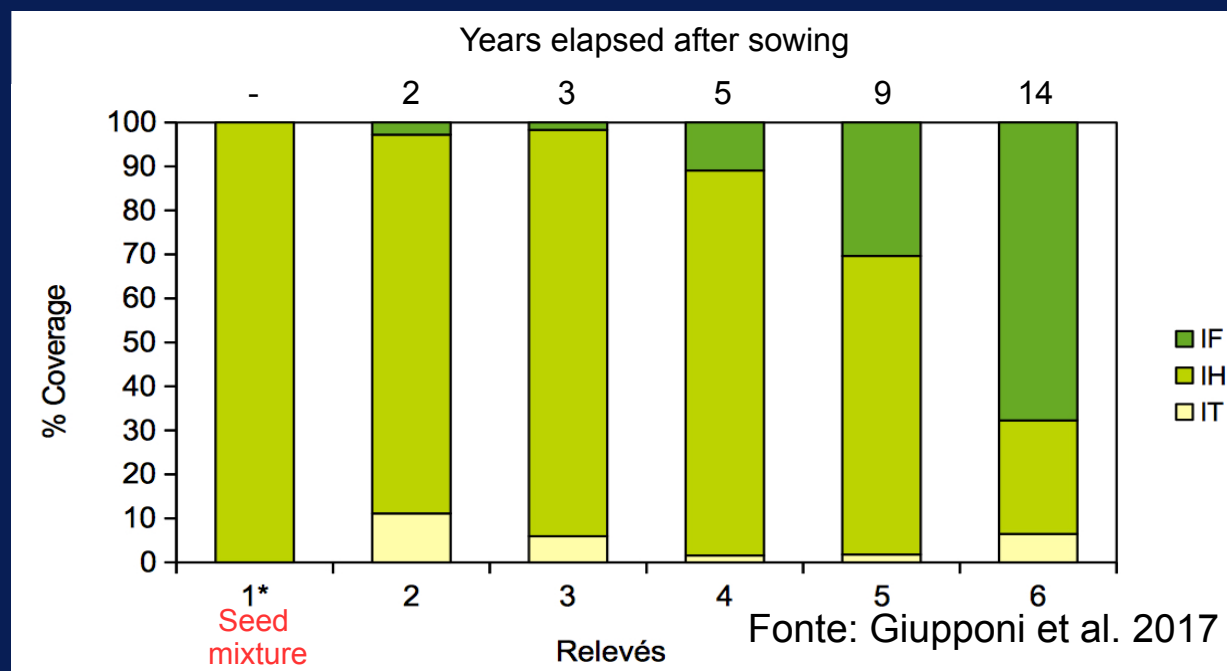


Study area (latitude: 46°07'48,87"N, longitude: 10°18'38,59"E). The stars indicate the five sites where the phytosociological relevés were performed.

Vegetation analysis of a chronosequence and EIM trend

The percentage of phanerophytes increases over time (years elapsed after sowing).

The percentage of therophytes and hemicryptophytes decrease over time.



Histogram of life forms indices of relevés and seed mixture (1*). IT = index of therophytic component; IH = index of hemicryptophytic component; IF = index of perennial non-hemicryptophytic component (geophytes, chamaephytes, nano-phanerophytes and phanerophytes).

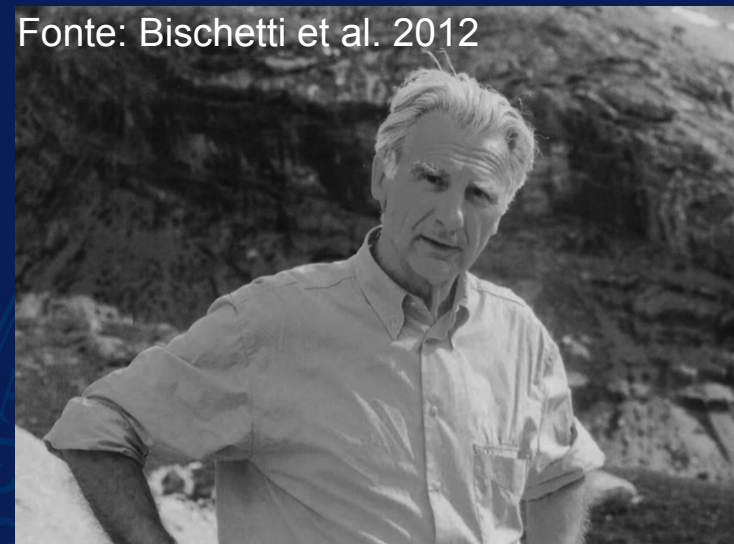
Soil bioengineering

Soil bioengineering is a relatively recent discipline that uses low-impact measures which utilize live plants (or parts thereof) as building materials in combination with other materials (such as stones, soil, timber, steel, etc.) for soil stabilization.



Soil bioengineering work (Alpe Mola).

Fonte: Bischetti et al. 2012



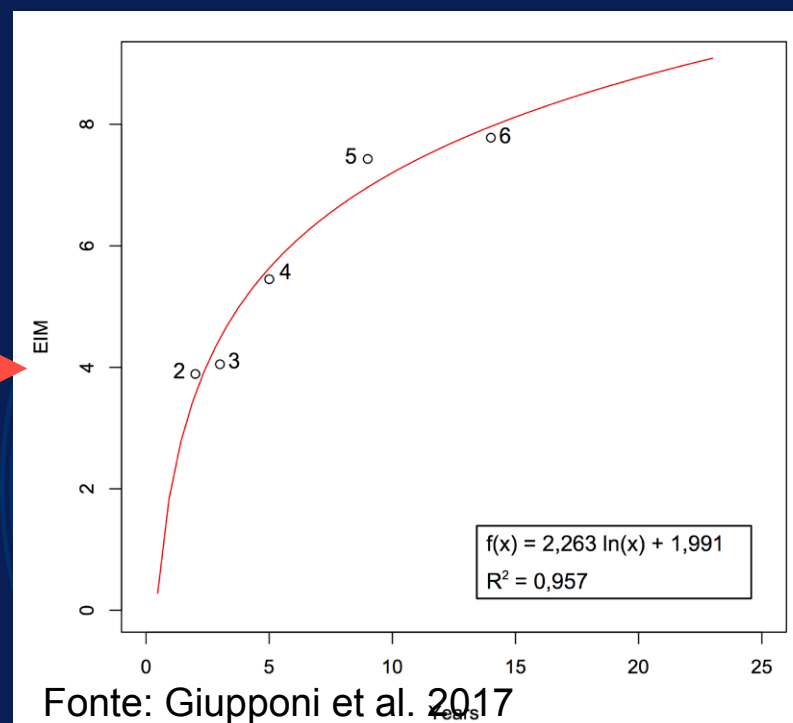
Hugo Meinhard Schiechl (1922-2002), one of the leading exponents of soil bioengineering.

Vegetation analysis of a chronosequence and EIM trend

The graph in Figure 2.5 compares the time elapsed after sowing with the EIM values of the five phytocoenoses, and shows the model which describes the trend of the EIM according to time.

Relevé code	Years elapsed after sowing	EIM
2	2	3,89
3	3	4,05
4	5	5,45
5	9	7,43
6	14	7,78

Trend of the ecological index of maturity (EIM) over time (x) (years elapsed after sowing) of the chronosequence. Shown: relationship between the two variables, coefficient of determination (R^2) and function trend line. The numbers refer to the relevés.



Vegetation analysis of a chronosequence and EIM trend

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Research

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<https://dx.doi.org/10.1553/eco.mont-9-1s22>

Vegetation analysis and estimation of forest reconstitution time in protected areas of Val Camonica (Southern Alps) where a commercial mixture of seeds was sown

Luca Giupponi, Gian Battista Bischetti & Annamaria Giorgi

Keywords: chronosequence, floristic-vegetational indices, maturity, restoration, seed mixture

Abstract

This study examined the vegetation composition of five sites of the Southern Alps (Val Camonica, Italy) where a commercial seed mixture had been used to restore vegetation at the end of soil stabilization works. The five sites are located in two protected areas of the Alps (the Parco dell'Adamello and the Riserva Naturale delle Valli di Sant'Antonio), and represent a chronosequence of year of sowing. We used a set of floristic-vegetational indices (index of maturity, indices of the life forms, and Landolt ecological indices) to analyse the characteristics of the vegetation of the five sites and to find a model that would allow an estimation of forest reconstitution time. From data analysis we found that, in areas which have had more recovery time, the sown heliophilous species and the ruderal herbaceous species decrease, while shrubs, trees and typical species of mature forests increase. The values of the index of maturity also increase according to time elapsed after sowing; the relationship that, in the present case, links the index of maturity to time was expressed formulaically. This model provided an estimation of the time required for the reconstitution of the forest community which, in this case, was about twenty years. This research, prompted by a request from the managing institutions of the two protected areas for a botanical investigation into the outcome of using the seed mixture, provided information that will enable them to assess whether to use the mixture in future environmental restoration work in the same areas.

Introduction

whether these seed mixtures are effective for the re-constitution of structurally more complex and more

Profile

Protected area

Parco dell'Adamello

and the Riserva Na-

turale delle Valli di

Sant'Antonio

Mountain range

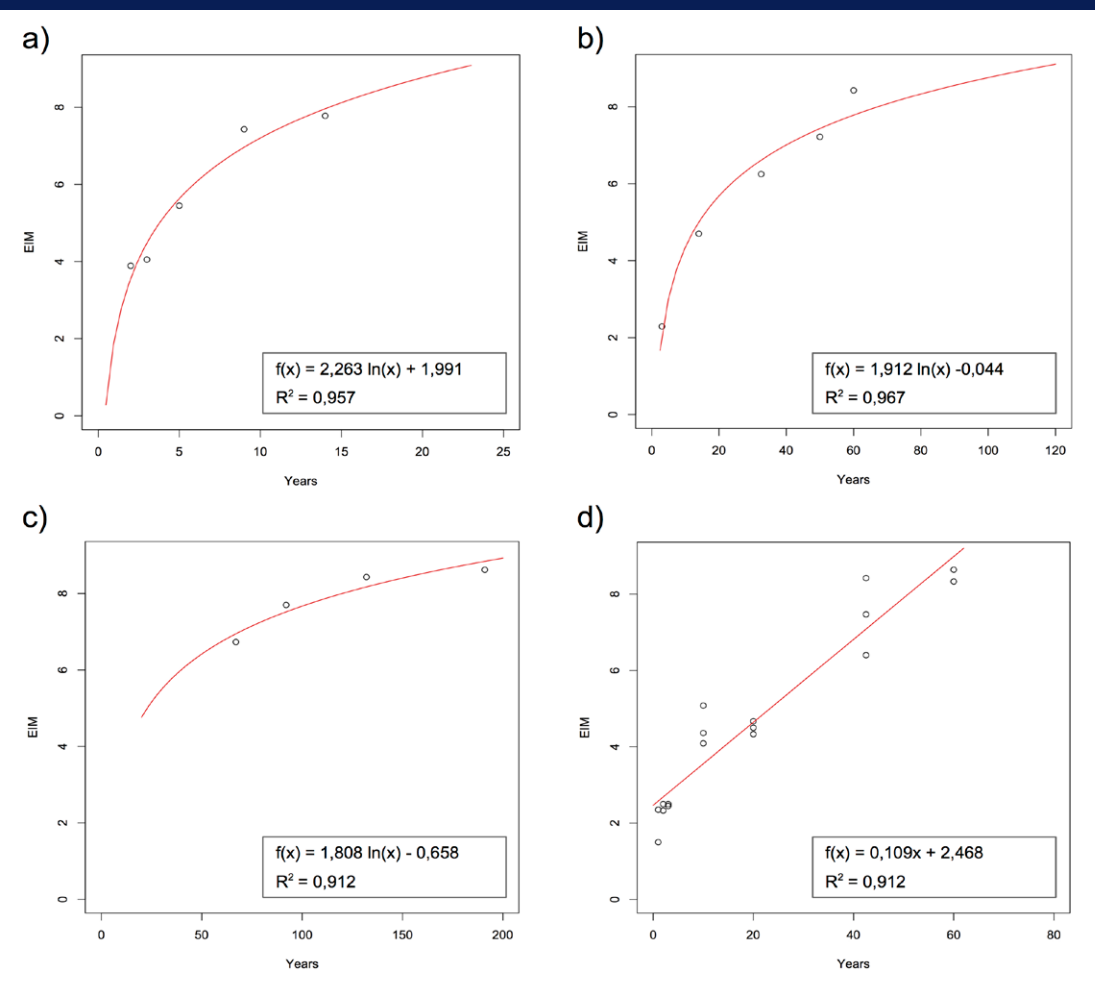
Alps

Country

Italy

Giupponi et al. (2017a)

Vegetation analysis of a chronosequence and EIM trend



Trend of the ecological index of maturity (EIM) over time (x) of the four chronosequences:

a, Val Camonica chronosequence (Giupponi et al. 2017a);

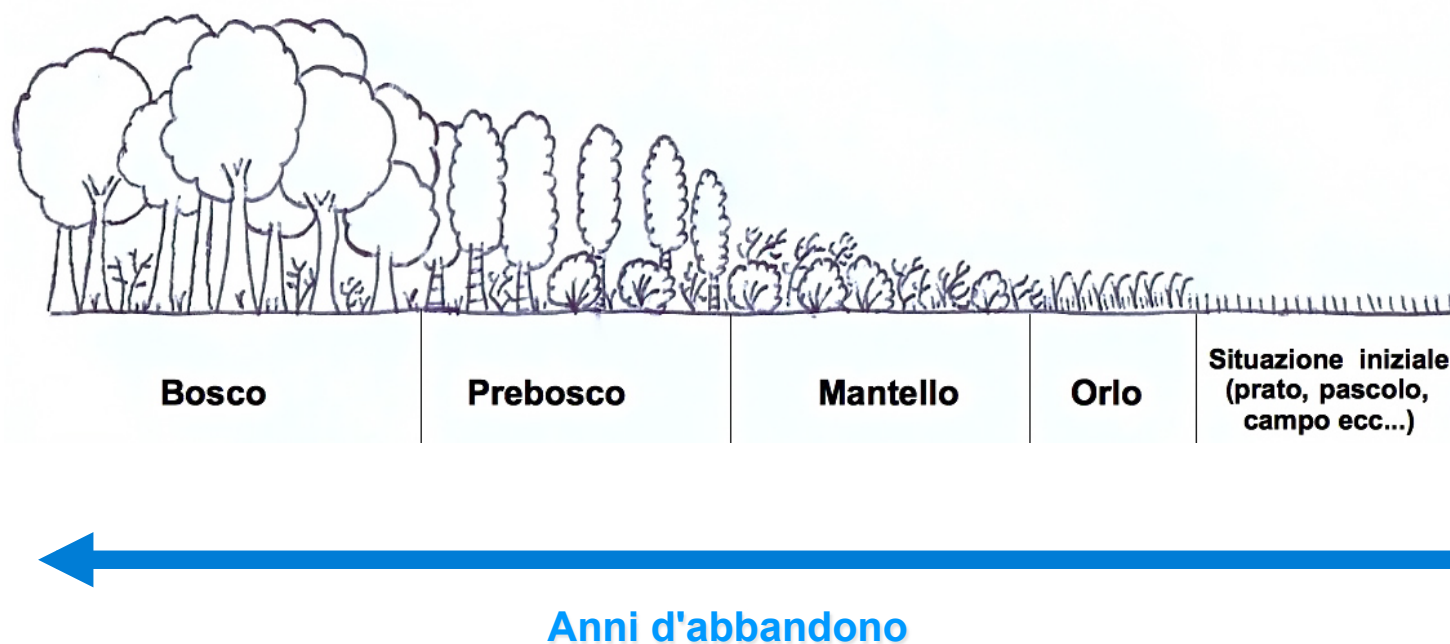
b, limestone quarries chronosequence (Gilardelli et al. 2016);

c, proglacial chronosequence (D'Amico et al. 2014);

d, abandoned fields chronosequence (Barni & Siniscalco 1999).

La dinamica di vegetazione

è “un processo attraverso il quale al passare del tempo comunità vegetali si sostituiscono l’una nell’altra in uno stesso luogo.”



La VEGETAZIONE è “Un sistema composto da piante disposte nell’ordine che esse spontaneamente assumono mediante un processo di auto-regolazione, in dipendenza dei **fattori ambientali**” (Pignatti, 1998)

Suolo, disturbi (abiotici o biotici), clima ...

La vegetazione non è stabile nel tempo. Al variare di uno o più fattori ambientali la vegetazione cambia gradualmente secondo due meccanismi principali:

1) FLUTTUAZIONI: Variazioni “quantitative” che non portano ad un cambiamento stabile della comunità (es: variazioni stagionali)

2) SUCCESSIONI (o serie dinamiche): Variazioni “qualitative” che comportano il succedersi di diverse comunità vegetali (stadi della serie) nello stesso luogo al passare del tempo.

Le SUCCESSIONI possono essere:

1) PRIMARIE:

Hanno origine a partire da suolo
sterile dopo eventi
“zero” (colate laviche, morene
glaciali ecc...)



2) SECONDARIE:

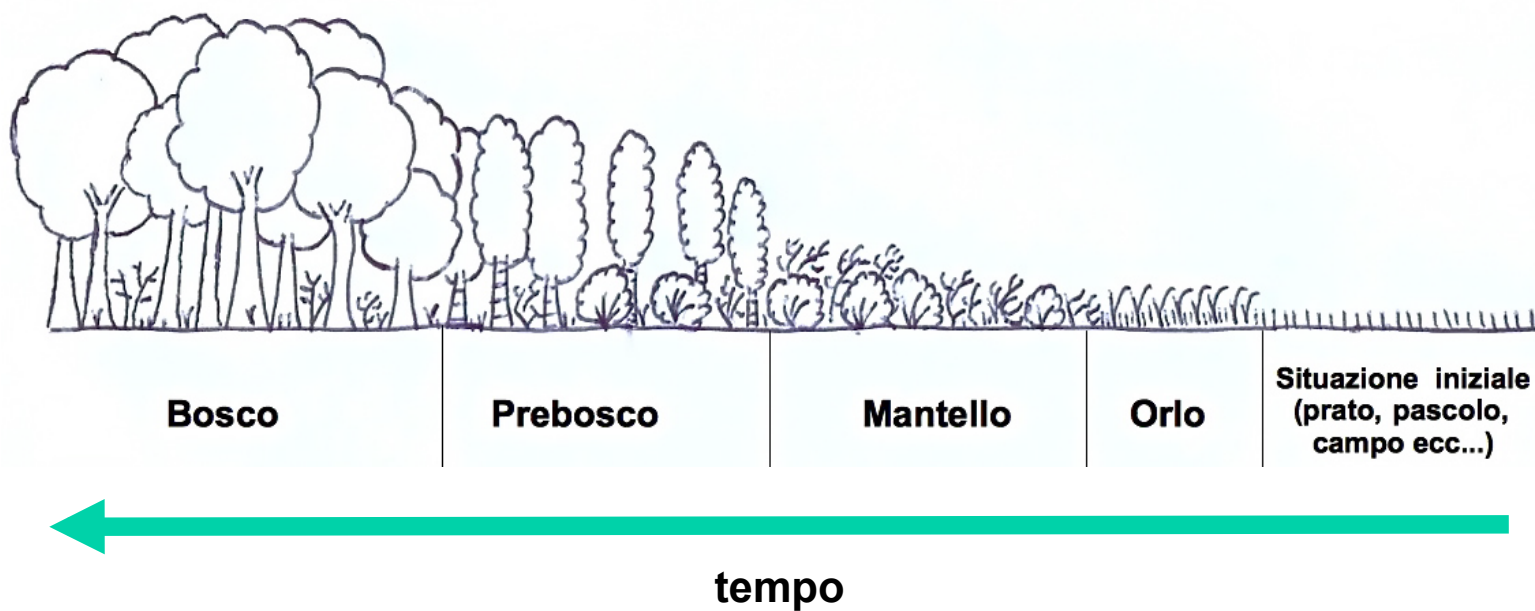
Hanno origine a partire da una
vegetazione già presente in seguito
all'intensificarsi o all'affievolirsi del
disturbo (es: abbandono di colture,
taglio bosco ecc...)



Le SUCCESSIONI SECONDARIE:

Hanno origine a partire da una vegetazione già presente in seguito all'intensificarsi o all'affievolirsi del disturbo

Esempio di successione secondaria: l'abbandono di un prato

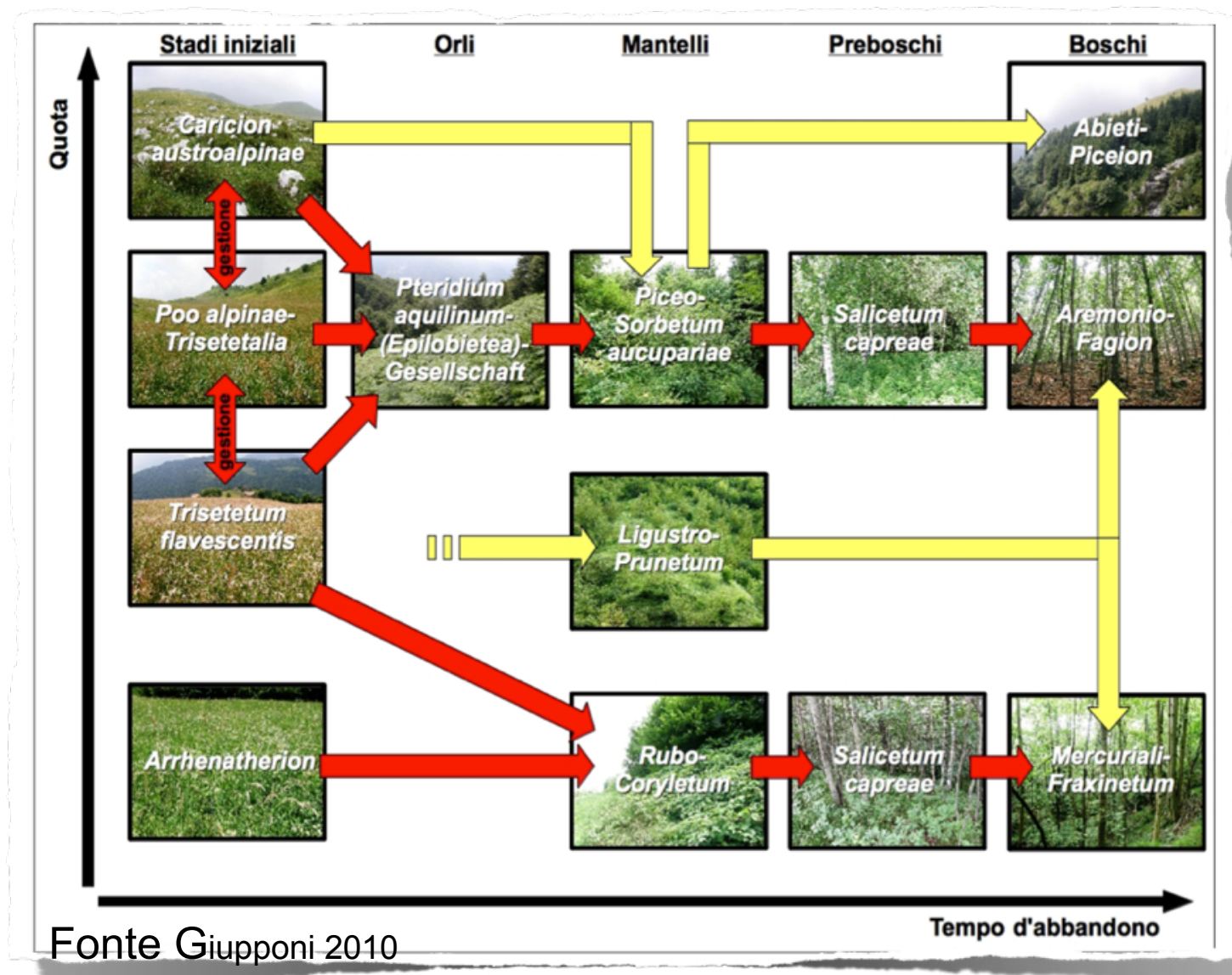




Situazione iniziale:
Prato di monte (*Trisetetum flavescens*)



**Bosco:
Faggeta (Aremonio-Fagion)**



Le comunità vegetali che costituiscono una successione possono essere anche distribuite spazialmente in un'area ecologicamente uniforme a formare una **serie di vegetazione (o sigmeto)**, definita come: l'insieme di "tutte le associazioni legate da rapporti dinamici che si rinvengono all'interno di una stessa unità ambientale" (Poldini e Sburlino, 2005).

Il sigmeto è l'unità fondamentale della fitosociologia dinamica (o sinfitosociologia) e l'insieme di sigmeti contigui presenti in un dato territorio (all'interno di una stessa unità biogeografica e piano bioclimatico) è detto **geosigmeto** (o geoserie) (Rivas-Martínez, 2005). Il geosigmeto è l'unità elementare della fitosociologia integrata (o geosinfitosociologia)



Fonte: <http://www.prodromo-vegetazione-italia.org>

la vegetazione non è un elemento statico, ma dinamico che interagisce con l'ambiente in cui si trova modificandone alcune caratteristiche (in particolare il suolo e il microclima) e di conseguenza ponendo le basi per un suo continuo cambiamento.

L'ingegneria naturalistica deve innanzitutto conoscere e per quanto possibile assecondare tale processo, e secondariamente sfruttarlo indirizzandolo e accelerandolo per ottenere i risultati desiderati in un tempo inferiore a quanto si avrebbe con un processo completamente naturale.

Il substrato di partenza nelle opere di ingegneria naturalistica

Il substrato di partenza è spesso costituito da detriti incoerenti con poca terra fine (suoli grezzi). Questo limita la crescita di specie erbacee e arboree esigenti.

... SUCCESSIONI PRIMARIE!



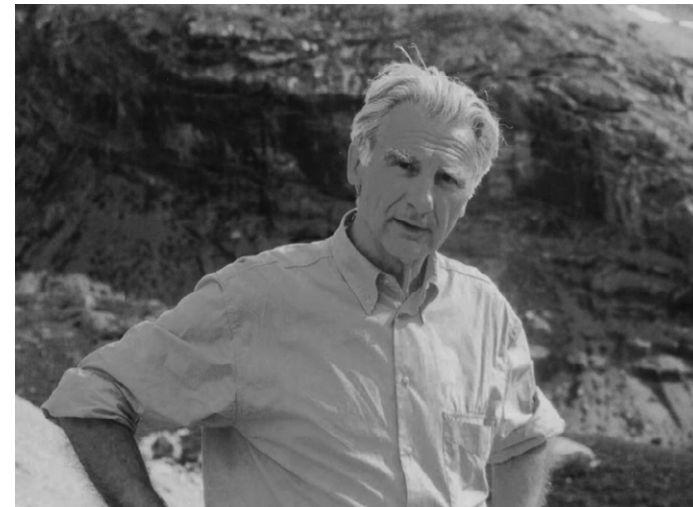
La scelta delle specie vegetali

Di particolare importanza nella scelta delle specie vegetali più adatte per la biotecnica naturalistica è la conoscenza delle associazioni pioniere su suoli grezzi e della loro successione...

I risultati più precisi, che richiedono modesto impiego di tempo, sono forniti dai rilevi fitosociologici, eseguiti su stazioni vicine o per lo meno affini.

Dall'insieme di tali rilievi otteniamo quelle specie che si dovrebbero impiegare nelle sistemazioni.

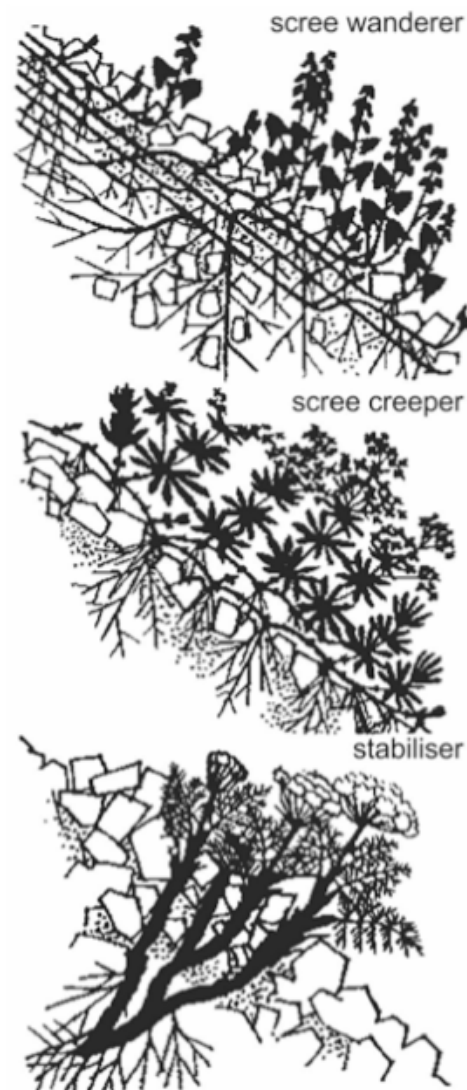
(Schiechtel 1991)



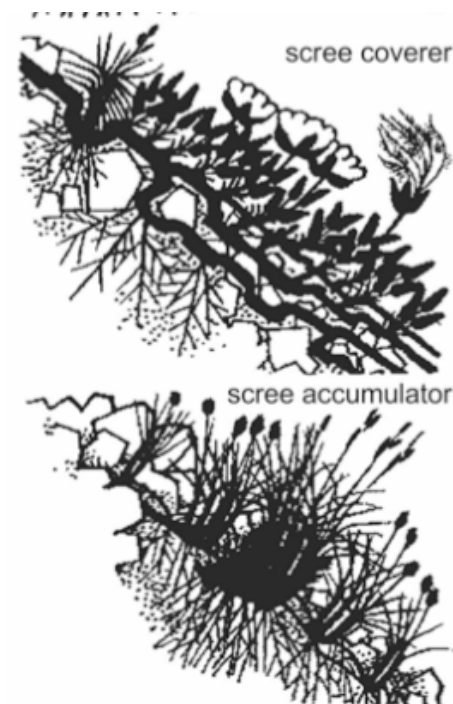
Hugo Meinhard Schiechtel (1922-2002).

Le piante dei ghiaioni

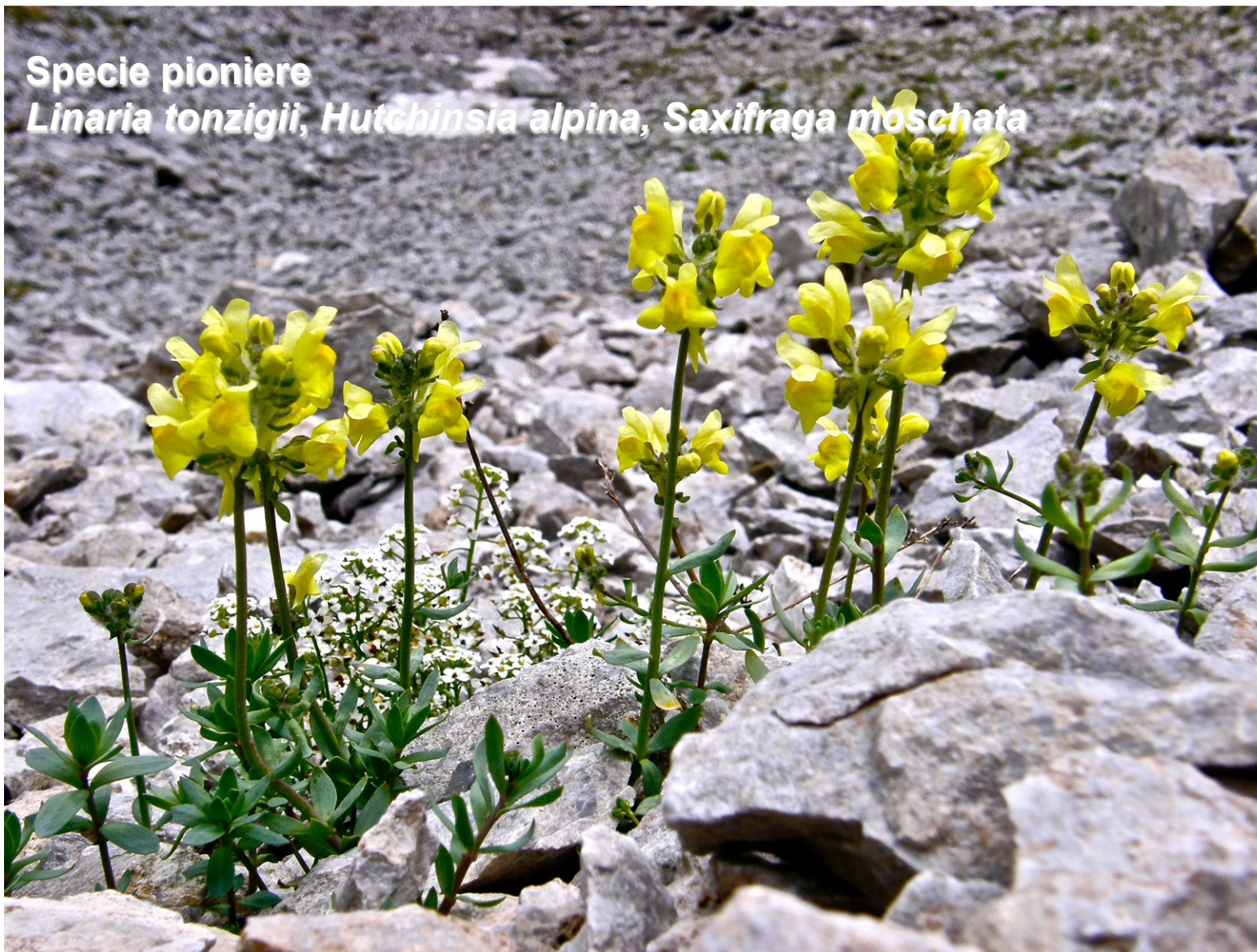
Fig. 5.70 Life forms of scree plants according to Schröter (1926) in Reisigl and Keller (1994). Examples of scree wanderers include *Thlaspi rotandifolium* and *Rumex scutatus*, scree creepers include *Arabis alpina* and *Linaria alpina*, scree stabilisers include *Oxyria digyna* and *Cystopteris fragilis*, scree coverers include *Dryas octopetala* and *Saxifraga oppositifolia* and scree accumulators particularly *Carex sempervirens* and *C. firma* as well as *Sesleria albicans*



Leuschner & Ellenberg
(2017): Ecology of Central
European Non-Forest
vegetation



Specie pioniere
Linaria tonzigii, Hutchinsia alpina, Saxifraga moschata









Dryas octopetala



Hedysarum exaltatum
Rhododendron hirsutum





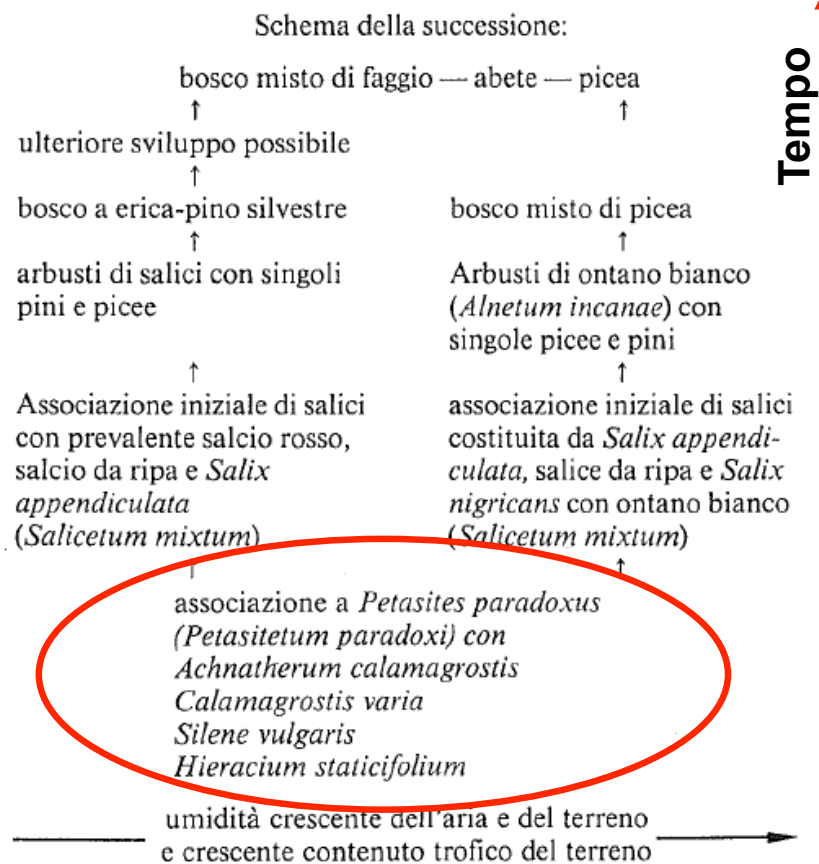
**Prateria alpina dei substrati calcarei
(seslerio-sempervireto)**

L'analisi della vegetazione

Accelerare la dinamica di vegetazione riducendo gli impatti agli ecosistemi e al paesaggio

Quale è il tempo con cui si esplicano questo tipo di successioni?

II) Frane in boschi misti di faggio e abete e nei boschi di picea del piano inferiore della picea



Schiechtl (1991).

Lo studio della dinamica della vegetazione

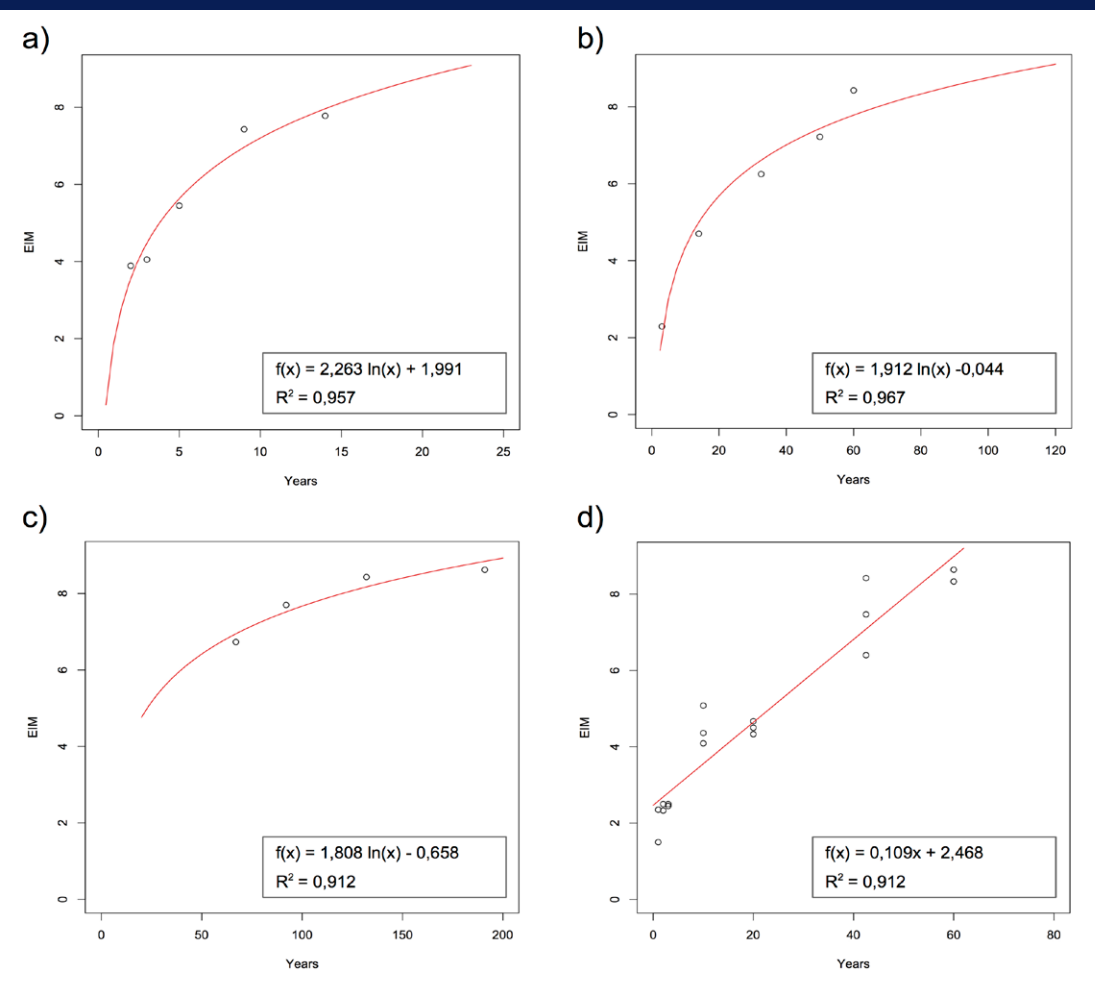
1) Metodo DIACRONICO (“quadrato permanente”)

- Pregi: Controllo diretto del fenomeno
- Difetti: tempi di analisi eccessivamente lunghi

2) Metodo SINCRONICO (ricercare i legami dinamici tra le associazioni che si trovano in un determinato territorio in un determinato momento)

- Pregi: tempi di analisi relativamente brevi
- Difetti: analisi indiretta molto spesso basata su interpretazioni

Vegetation analysis of a chronosequence and EIM trend



Trend of the ecological index of maturity (EIM) over time (x) of the four chronosequences:

a, Val Camonica chronosequence (Giupponi et al. 2017a);

b, limestone quarries chronosequence (Gilardelli et al. 2016);

c, proglacial chronosequence (D'Amico et al. 2014);

d, abandoned fields chronosequence (Barni & Siniscalco 1999).

Section I

Application of floristic-vegetational indices for the analysis of soil stabilization works conducted in Val Camonica (Northern Italy)

This research has led to the formulation of two floristic-vegetational indices:

1) Ecological Index of Maturity (EIM)

2) Index of Ecological Success (IES)

These indices are based on the study of the vegetation according to the phytosociological method

Index of Ecological Success (IES)

IES is an index for evaluating the effectiveness of soil bioengineering works in mountain areas with particular reference to slope stabilization. The IES compares the EIM values of the vegetation of an area affected by soil stabilization work with the expected EIM value at a precise time after completion of soil stabilization work. The IES is defined as follows:

$$IES = \frac{EIMc_{(t)}}{EIMe_{(t)}}$$

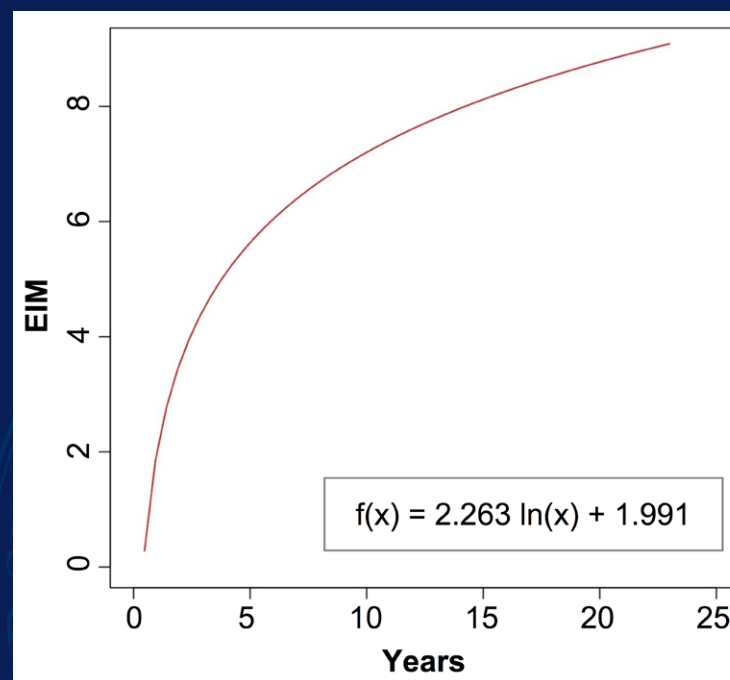
EIMc is the value provided by the calculation of the EIM (ecological index of maturity) referring to the vegetation present in the study area at a certain time t (years since the end of the soil bioengineering works) and **EIMe** is the value of EIM expected for the vegetation of that area at the time t .

IES values of around 1 mean that the calculated EIM (EIMc) is similar to the expected EIM (EIMe) and therefore that intervention has been successful.

Index of Ecological Success (IES)

IES was applied to the three study areas (Azzone, Val Dorena and Val Palot).

In this case the **EIM_e** value (expected EIM) was calculated using data published by Giupponi et al. (2017a):

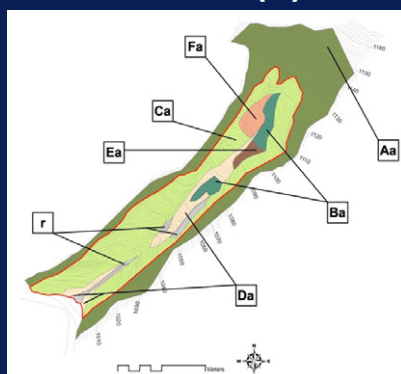


Trend of the ecological index of maturity (EIM) over time (x)

Results

Comparison between the values of IES of the three study areas

Azzone (a)



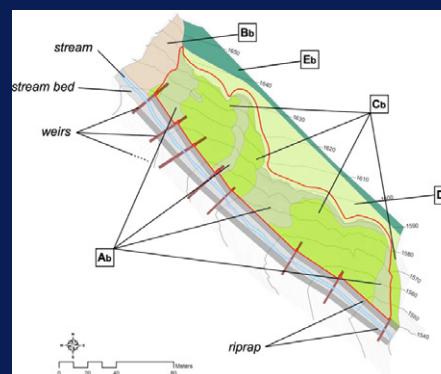
EIMc = 6,91

Years elapsed after the end of the work: 19

EIMe = 8,65

IES = 0,80

Val Dorena (b)



EIMc = 6,67

Years elapsed after the end of the work: 15

EIMe = 8,12

IES = 0,82

Val Palot (c)



EIMc = 8,58

Years elapsed after the end of the work: 19

EIMe = 8,65

IES = 0,99

The IES considers the time elapsed after the end of the works (vegetation dynamic)

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Landscape Ecol Eng
DOI 10.1007/s11355-016-0323-5



ORIGINAL PAPER

A proposal for assessing the success of soil bioengineering work by analysing vegetation: results of two case studies in the Italian Alps

Luca Giupponi¹ · Gian Battista Bischetti² · Annamaria Giorgi^{1,2}

Received: 19 July 2016 / Revised: 24 October 2016 / Accepted: 26 December 2016
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Abstract The evaluation of the success of soil bioengineering work is an issue still poorly addressed by the scientific community. Nevertheless, soil bioengineering techniques are increasingly used worldwide when mitigating the impact on the environment and the landscape is one, but not the only, goal of intervention. A tool to measure the success of soil bioengineering work, with reference to landslide stabilization, is presented in this paper: the index of ecological success (IES). The IES is based on the phytosociological analysis of vegetation and widens the potential applications of the ecological index of maturity (EIM), recently formulated by Giupponi et al. (Restor Ecol 23:635–644, 2015) to assess the degree of disturbance affecting a plant community. The IES compares the EIM values of the vegetation of an area affected by soil stabilization work with those of the expected vegetation at a precise time after completion of soil stabilization work, providing values ranging between 0 (maximum failure) and 1 (complete success). The IES was applied in two study areas located on two mountain slopes of the Southern Alps (Italy) which, as a result of landslides, were subject to soil bioengineering work aimed at slope

stabilization. The results of these first two applications confirm the efficacy of the IES in evaluating the success of soil bioengineering work in mountain areas and bode well as to its future application.

Keywords Index of ecological success · Landslide · Phytosociology · Plant community · Southern Alps

Introduction

The evaluation of the effectiveness of soil bioengineering work performed for soil stabilization and/or for ecological restoration is of great importance in order to identify and replicate the most successful approaches and techniques, as well as to analyse the causes of less successful ones. This point is especially relevant in view of the increasing awareness, throughout the world, regarding soil stabilization, nature conservation and ecosystem restoration issues (Aronson et al. 2006; Aronson and Alexander 2013). The scientific community, as a consequence, is called, today more than ever, to support land managers, planners and practitioners, providing them with new techniques and new analytical tools in order to counter the continuing loss of soil, habitats and biodiversity, associated both with natural processes and anthropogenic disturbance.

In terms of techniques adopted for soil stabilization, in the last decades low-impact measures which use living plants (or parts thereof) as stabilising materials, in combination with other materials (such as stones, soil, timber, steel, etc.), have been developed and used. These techniques are based on the principles of soil bioengineering (Schiechl 1973, 1980, 1991; Bischetti et al. 2012; Studer and Zeh 2014) and are increasing in popularity worldwide (Lewis 2000; Li and Eddleman 2002; Li et al. 2006; Wu

Electronic supplementary material The online version of this article (doi:10.1007/s11355-016-0323-5) contains supplementary material, which is available to authorized users.

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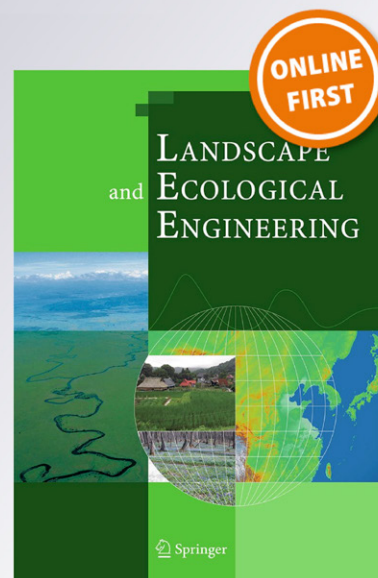
A proposal for assessing the success of soil bioengineering work by analysing vegetation: results of two case studies in the Italian Alps

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Landscape and Ecological Engineering

ISSN 1860-1871

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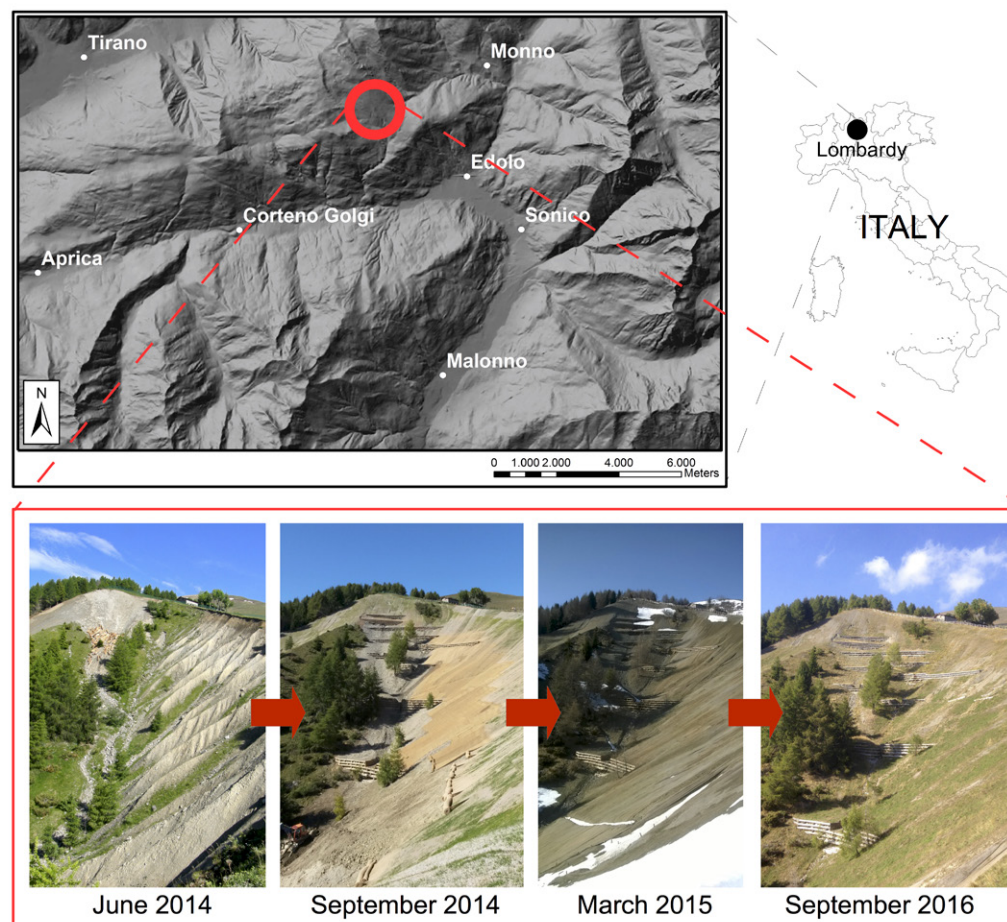
Giupponi et al. (2017)

Index of Ecological Success (IES)

Alpe Mola



EIM e IES sono stati impiegati per studiare la dinamica di un'area interessata da opere di ingegneria naturalistica



Alpe Mola

1700 m a.s.l.

Landscape and Ecological Engineering (2018) 13:37–50
https://doi.org/10.1007/s11355-018-0339-9

ORIGINAL PAPER



How to renew soil bioengineering for slope stabilization: some proposals

Luca Giupponi¹ · Gigliola Borgonovo² · Annamaria Giorgi^{1,3} · Gian Battista Bischetti^{1,3}

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Abstract

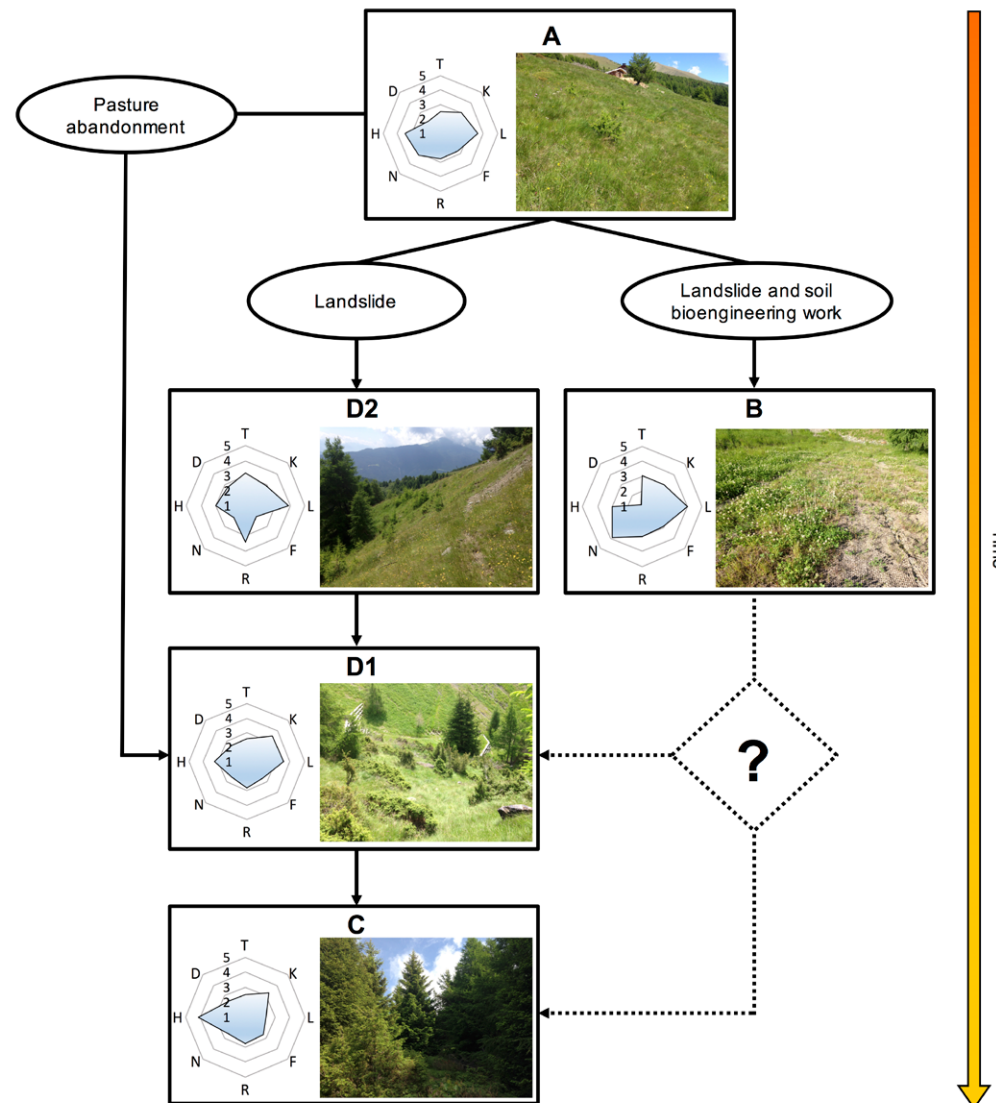
Mountain environments play a crucial role in maintaining biodiversity despite becoming more vulnerable to colluvial processes primarily induced by extreme meteorological events. Soil bioengineering stabilizes mountain slopes and limits impacts on ecosystems and is increasingly used worldwide, yet its effectiveness requires better assessment through post-intervention environmental monitoring. However such studies are only rarely performed even though they are essential to improve future intervention. This study reports soil and vegetation monitoring data of an area in the Italian Alps in which soil bioengineering work was carried out to renature an area hit by landslides. The monitoring involved an analysis of the floristic-vegetational and ecological features of the plant communities of the area of the soil bioengineering intervention (and in adjacent areas), as well as an analysis of the chemical-physical characteristics of the soils (texture, pH, organic matter, nitrogen content, root depth) where these communities were established. The results of the monitoring, analysed in the overall framework of the state of the art of the sector, have highlighted some lines of research and action that should be undertaken by technicians, researchers, and politicians to innovate and to make work aimed at the stabilization of landslides more effective. In particular, it would be extremely useful to study the biotechnical characteristics of herbaceous plants that are still “unknown” in soil bioengineering and to evaluate their possible effects on ecosystems in order to produce seed mixtures that, besides being useful for soil stabilization, can accelerate vegetation dynamics, therefore maximizing the success of such works.

Keywords Soil bioengineering · Seed mixture · Best practices · Ecological indices · Green infrastructure · Monitoring

Introduction

Alpine and mountain environments account for approximately 12% of the terrestrial area of the world (Körner et al. 2011) and they often present special and unique

environments that are the result of interaction between man and nature, as well as being biodiversity hotspots (Körner 2004). Many areas of the world are undergoing a gradual depopulation of mountain areas due mainly to industrialization and centralization of production activities in the large cities of the plains and their suburbs. This phenomenon, which for some geographical areas such as the Alps has been going on for several decades, is leading to the abandonment of many agricultural practices such as the cultivation of fields and management of pastures and woods. This economic and social process has inevitable repercussions on the territory and also increases vulnerability to landslides which are in fact increasingly widespread also because of an increase in extreme meteorological events attributable to climate change (Siot et al. 2013; Siot et al. 2016). Hydrogeological phenomena, and in particular landslides, are an obstacle to the activities of the valley floor (and a threat to human life) and impact in various ways the environment and the landscape. They mainly lead to imbalances in ecosystems, loss of biodiversity, and degradation of soil and



Alpe Mola: analisi del suolo e della vegetazione

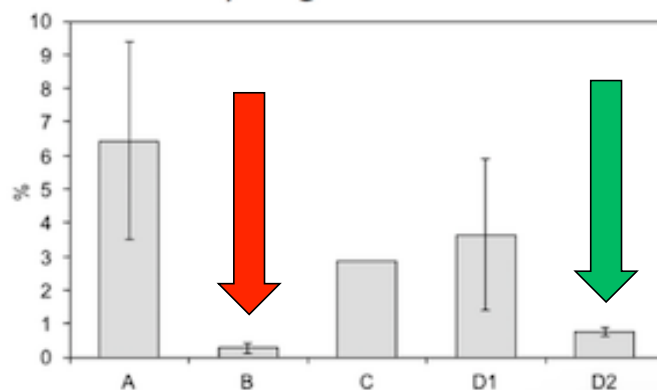


Comunità post semina

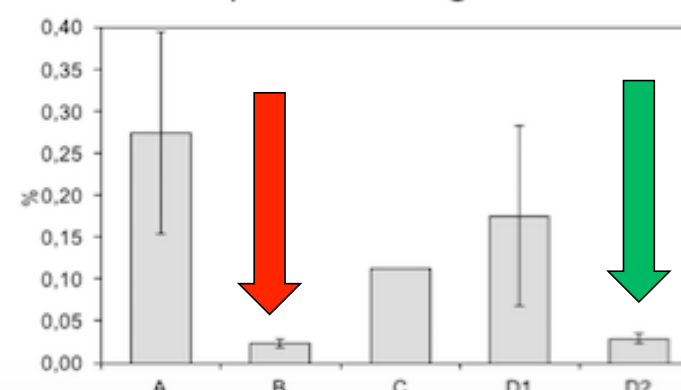


Ricolonizzazione spontanea

e) Organic Matter



f) Total Nitrogen



In conclusione

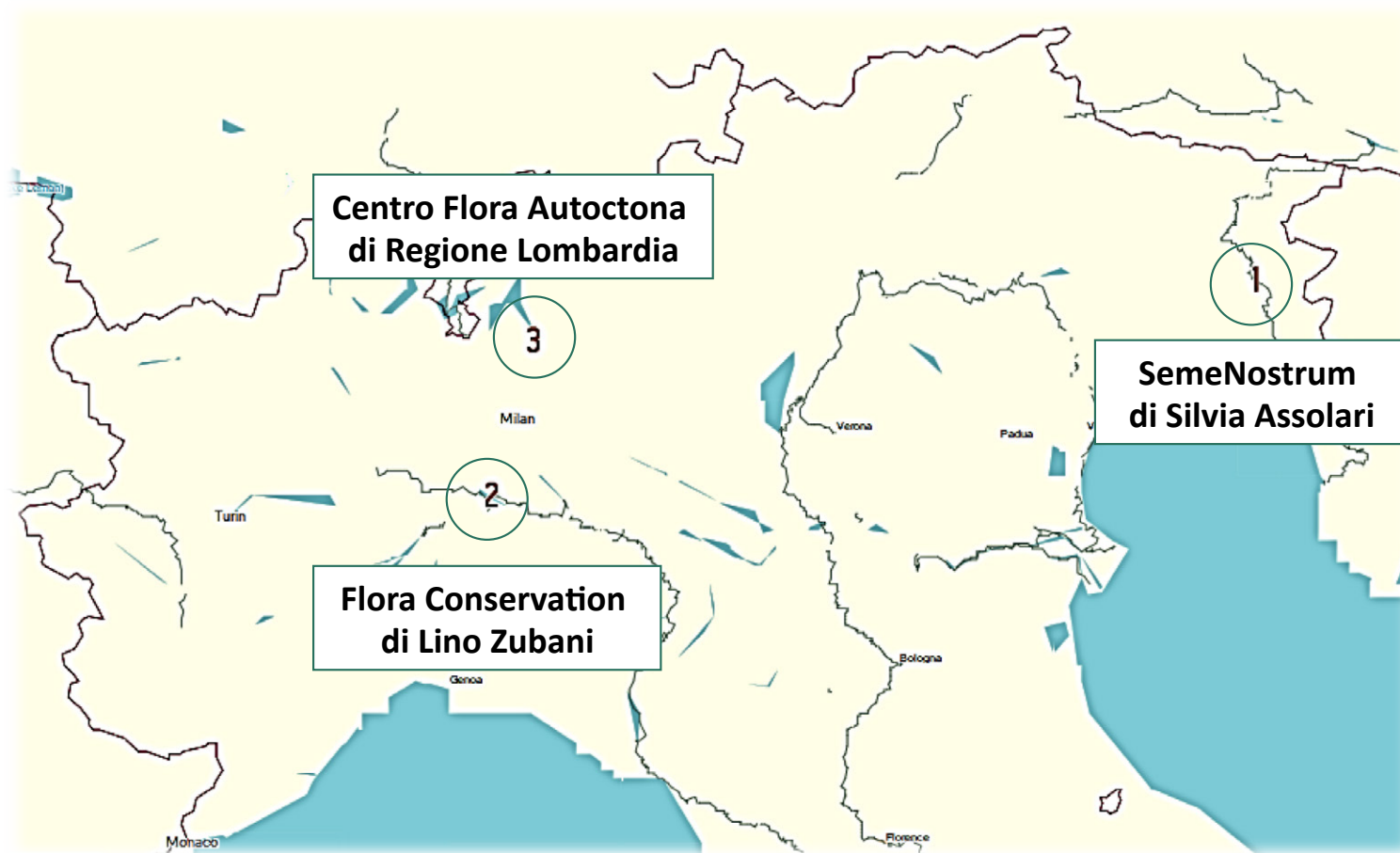
- Lo studio delle piante e della dinamica di vegetazione è tema fondamentale per l'ingegneria naturalistica e le opere di ripristino ambientale
- Durante la progettazione delle opere di IN bisogna porre più attenzione alla vegetazione (caratteristiche biotecniche + ecologia + corologia)
- Manca una normativa chiara ed efficiente
- le specie autoctone pioniere dovrebbero essere un punto di riferimento quando non si ha terra fertile ma:
 - occorrono ulteriori studi ecologici e biotecnici
 - occorre renderle reperibili sul mercato

2. Produttori di sementi autoctone in Europa

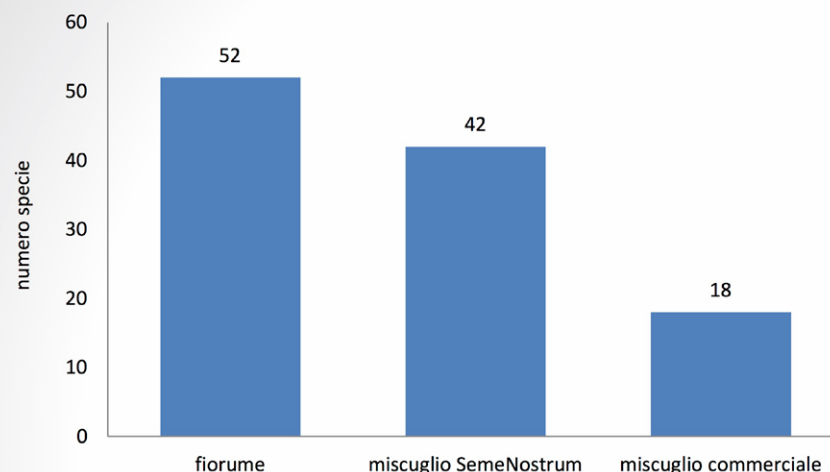
Country	Native Seed Producers				SZ ²	Zone di provenienza del seme
	NGO	Private	Public	Total		
Austria	1	9				
Belgium		3				
Bulgaria		2				
Czech Republic		3				
Denmark		2				
France		6				
Germany		12				
Greece			1			
Hungary		2				
Iceland			1			
Italy		4	1			
The Netherlands		4				
Norway		2	1			
Poland		2				
Portugal		2	1			
Republic of Ireland		2				
Romania		2				
Spain		10				
Sweden		3				
Switzerland		12				
UK	1	11				
Tot.	2	93	5			



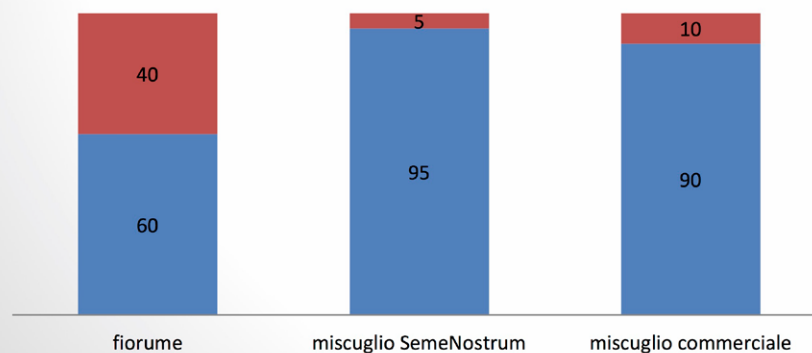
Realtà produttive in nord Italia



Composizione specifica



■ % monocotiledoni ■ % dicotiledoni

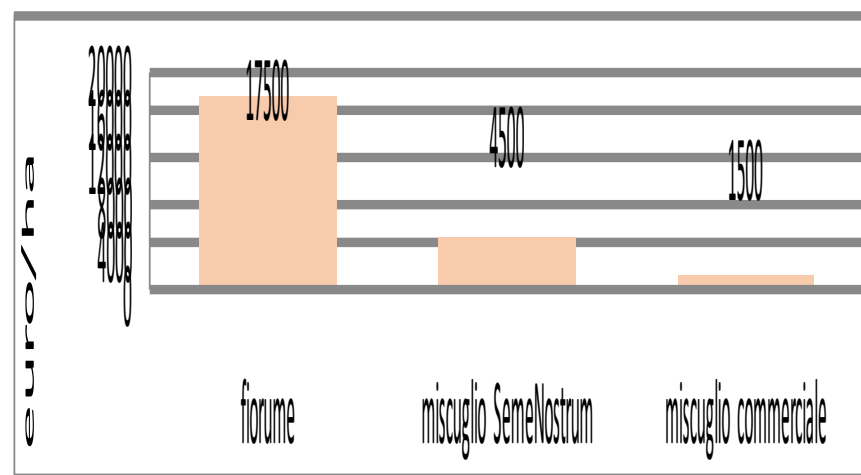
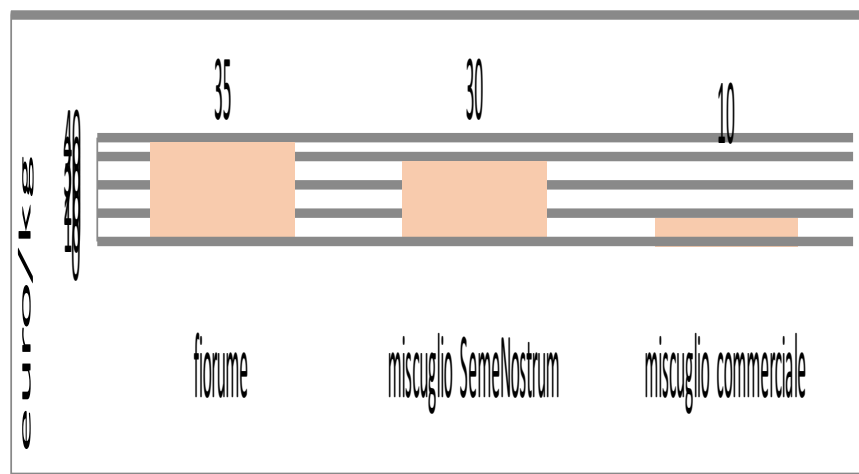


Il fiorume presenta il maggior numero di specie e molte dicotiledoni.

Il miscuglio di autoctone è composto da molte dicotiledoni ma esse sono una piccola percentuale.

composizione	%	PROV
Festuca rubra L.	42,5	DK
Bromus inermis Leyss.	1	A
Festuca arundinacea Schreb.	14	DK
Phleum pratense L.	5,5	DK
Lolium perenne L.	15	DK
Poa pratensis L.	5	DK
Dactylis glomerata L.	6,3	DK
Festuca pratensis Huds.	2	DK
Lotus corniculatus L.	0,5	CDN
Trifolium hybridum L.	1	DE
Trifolium repens L.	2	DE
Trifolium pratense L.	1	CDN
Medicago sativa L.	1	I
Onobrychis sativa L.	1	I
Vicia sativa L.	1	ES
Vicia villosa L.	1	H
Sanguisorba minor L.	0,1	DE
Plantago lanceolata L.	0,1	DE

Costi



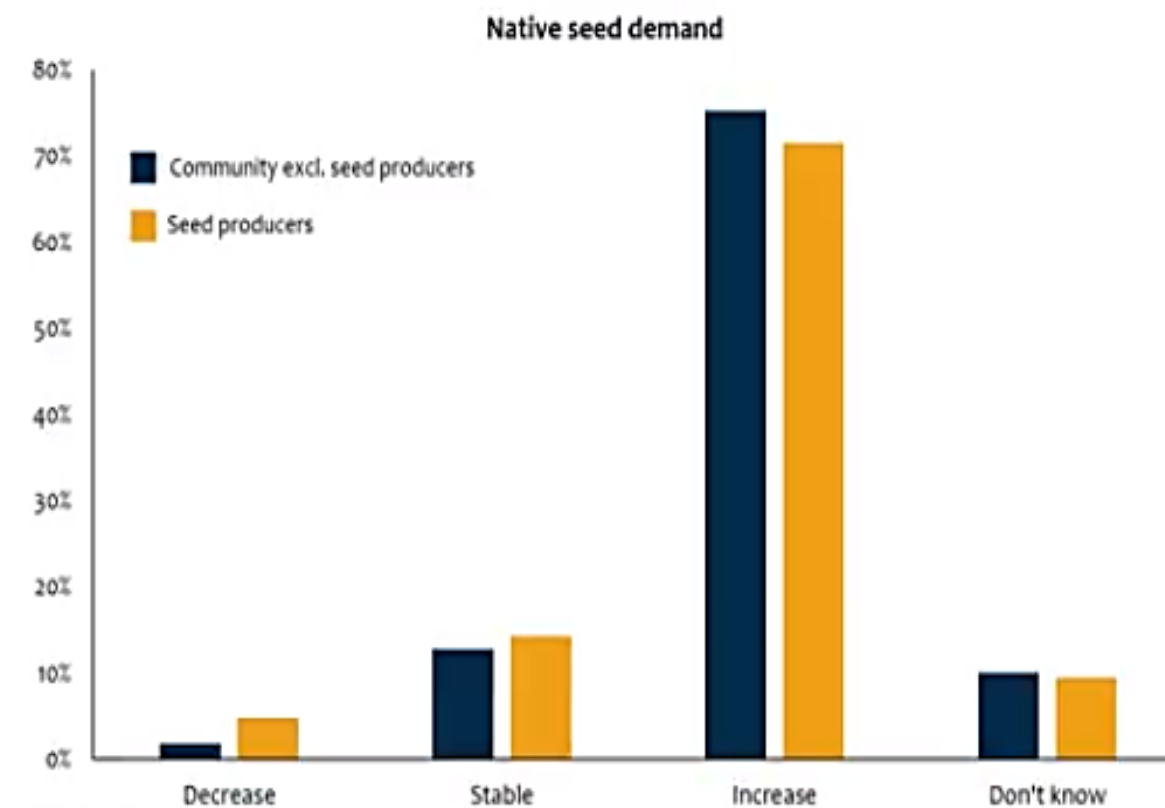
Costi elevati del materiale
autoctono



si acquistano sementi
commerciali.

La scelta delle specie
autoctone deve quindi
essere fortemente
motivata o obbligata per
trascurare l'aspetto
economico.

Domanda di semi nativi in crescita

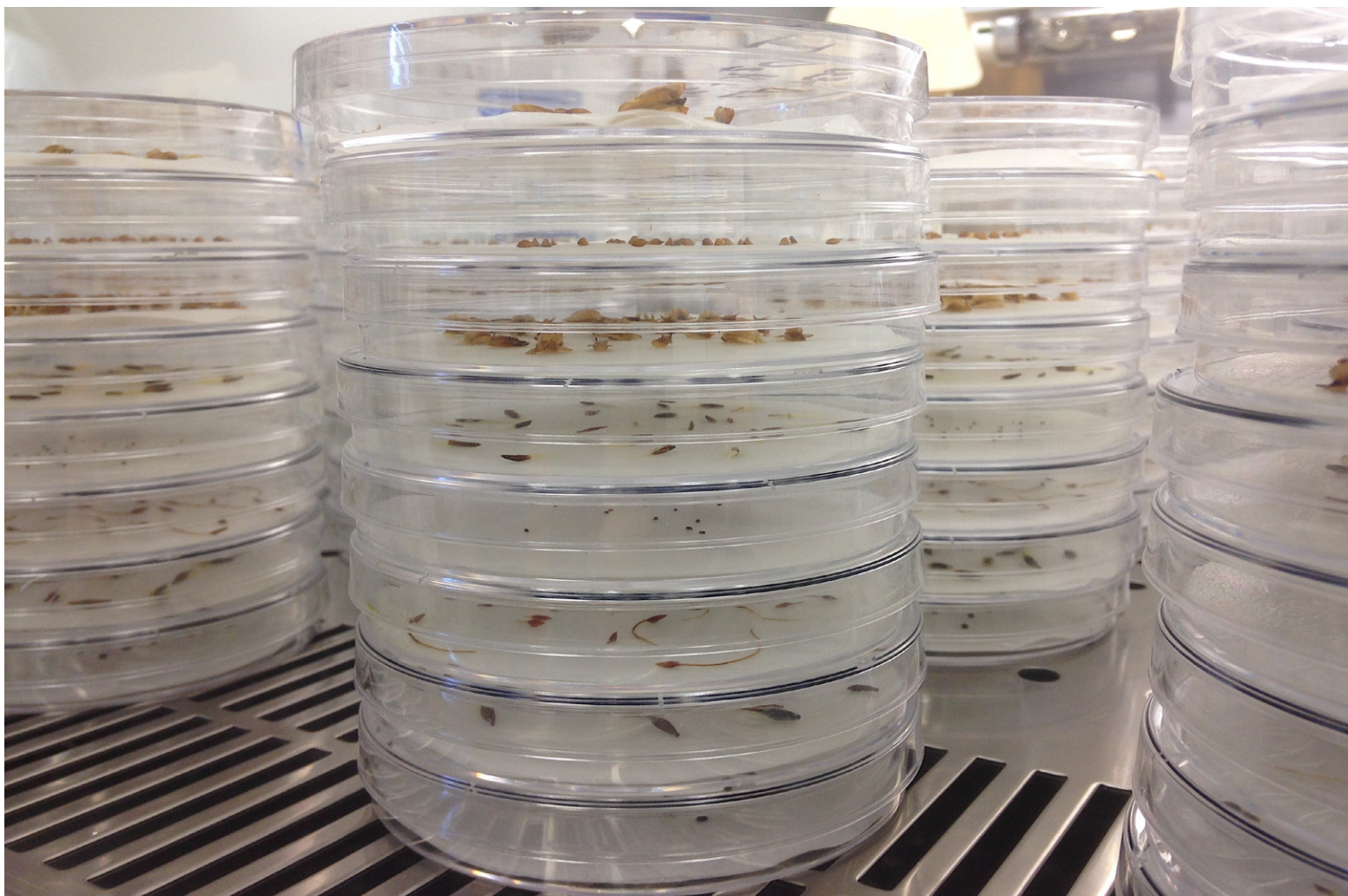


Il futuro

Punti chiave:

- Abbassare i costi delle specie autoctone.
- Dare possibilità di reddito alle imprese e agli agricoltori.
- Avere leggi che impongano l'uso di materiale vegetale autoctono e che ne agevolino la produzione, la certificazione e la commercializzazione.
- Accrescere la conoscenza e la realizzazione dei ripristini ambientali attraverso l'elaborazione di basi scientifiche.

Work in progress...





Grazie per l'attenzione

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