Species diversity indices and community completeness index as indicators of short-term success of semi-natural grassland restoration

the case of GrassLIFE project

Martina Marei Viti[1], Solvita Rūsiņa[2] , Madara Krūzmane[2] , Līga Gavare[2] , Marks Arnolds Župerka[2]

[1]University of Bologna
[2] University of Latvia

Preface

Introduction

Methods

Results

Discussion

Conclusions

grasslife

Restoring EU priority grasslands and promoting their multiple use

- Xeric sand calcareous grasslands (6120)
- Semi-natural dry grasslands and scrubland facies on calcareous substrates (6210)
- Species-rich Nardus grasslands, on siliceous substrates in mountain areas (6230)
- Fennoscandian lowland species-rich dry to mesic grasslands (6270)
- Fennoscandian wooded meadows (6530)

GrassLIFE LIFE16NAT/LV/262

Preface

Introduction

Methods

Results

Discussion

Conclusions

SEMI-NATURAL GRASSLANDS

threatened hotspots of biodiversity

- Record of **biodiversity** at small scale (up to 49m^2 → 131 species)
- **Ecosystem services**
- On-going **global change** processes

abandonment

intensification

decrease of **area** and **diversity** → All habitat types: unfavourable status and negative trend

Preface

Introduction

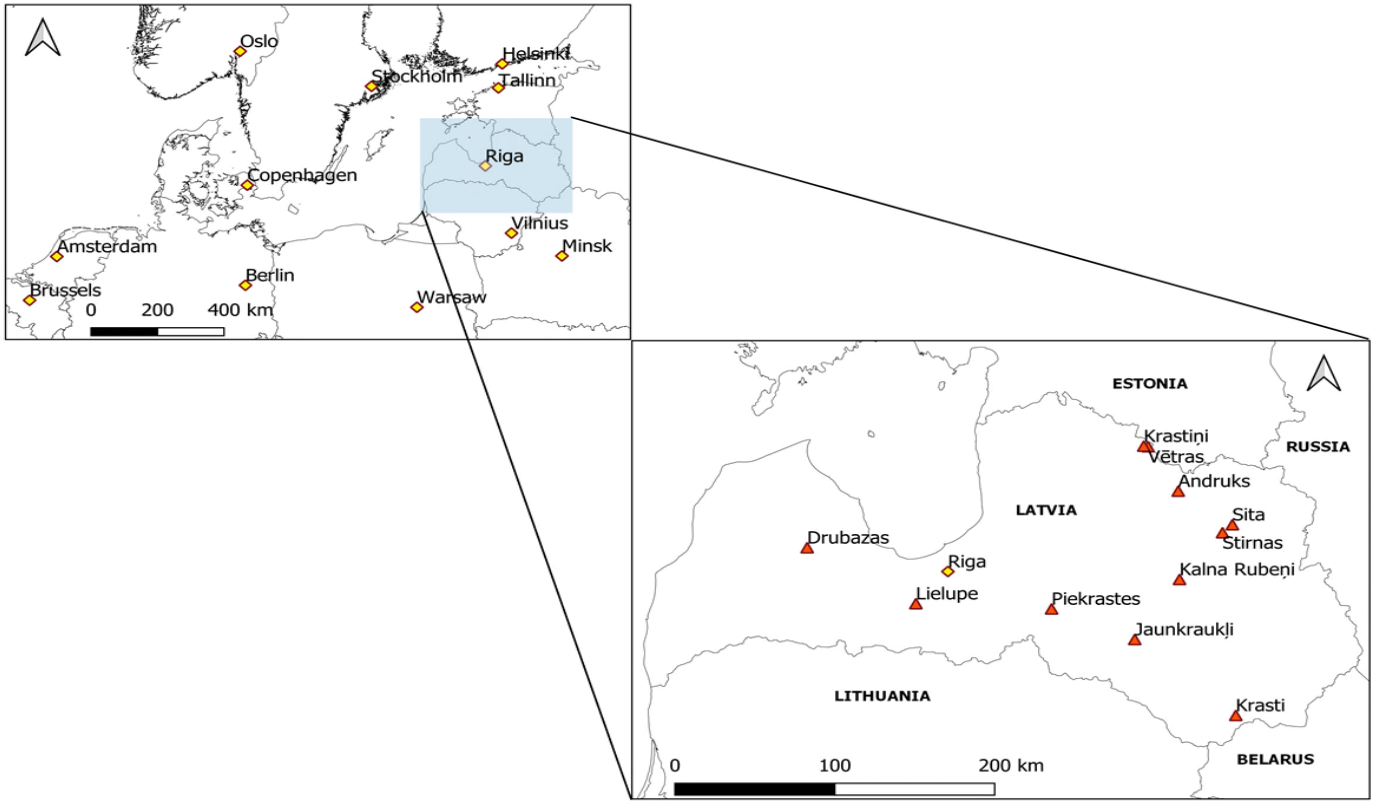
Methods

Results

Discussion

Conclusions

STUDY AREA


Oslo
Helsinki
Stockholm
Tallinn
Riga
Copenhagen
Vilnius
Amsterdam
Minsk
Berlin
Brussels
Warsaw
0 200 400 km
ESTONIA
RUSSIA
Krastiņi
Vētras
Andruks
LATVIA
Sita
Stirnas
Drubazas
Riga
Kalna Rubeņi
Lielupe
Piekrastes
Jaunkraukļi
LITHUANIA
Krasti
BELARUS
0 100 200 km

STUDY SITES

69 grasslands

16 *reference*

- Extensively managed by at least 30 years

- < 25 mg/kg^{-1} soil phosphorus
- < 25 % expansive spp. cover
- ≥ 5 indicator species

Thymus serpyllum, Viscaria vulgaris

Reference grassland with *Helictotrichon pratense* and *Filipendula vulgaris*

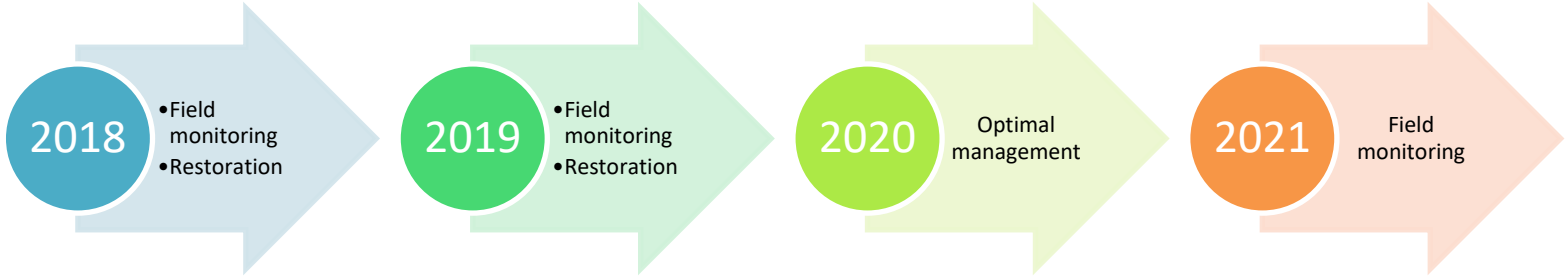
53 *degraded*

- Ex-arable land ploughed 20 years ago or more
- No addition of fertilizers since conversion from arable land to grassland

- > 25 mg/kg^{-1} soil phosphorus
- > 25 % expansive spp. cover
- < 5 indicator species

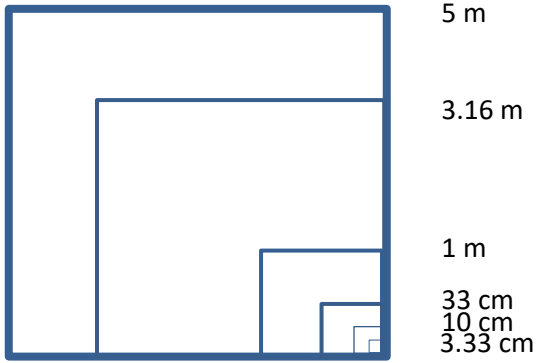
Dominance of *Anthryscus sylvestris, Dactylis glomerata , Elytrigia repens*

SAMPLING DESIGN



69 plots

- Semi-permanent
- Herbaceous species % cover → square-rooted
- Nested design



RESTORATION INTENSITY

Vegetation manipulation

Soil disturbance

Species addition

Reference

- Traditional management – 16 sites

Mild

- Adaptive mowing/grazing - 17

Moderate

- Reintroduction of mowing/grazing - 13
- Green hay/*Rhinanthus* sowing - 10
- Disc harrowing - 5

High

- Cutting and shredding of shrubs/trees - 4
- Grassland recreation by reseeding - 3
- Turf cutting - 1

Adaptive grazing

Disc harrowing

Hay transfer

Rhinantus sp.

Plowing

Plowing and seeding

Trees overgrowth

ANALYTICAL METHODS

changes in species diversity

Species richness

Shannon index

$$H' = -\sum_{i=1}^{S} p_i \ln p_i$$

Gini-Simpson index

$$D = \sum_{i=1}^{S} p_i^2 \qquad GS = 1\text{-}D$$

Pielou's evenness index

$$J = \frac{H}{H_{max}} = \frac{H}{\log S}$$

Expansive spp. cover ratio

Indicator spp. richness

Temporal beta diversity

For each intensity group

pre *vs* post

- t-test
- paired Wilcoxon signed-rank test

For each period

reference *vs* degraded/restored

- Welch's t-test
- Mann-Whitney U test

between intensity groups

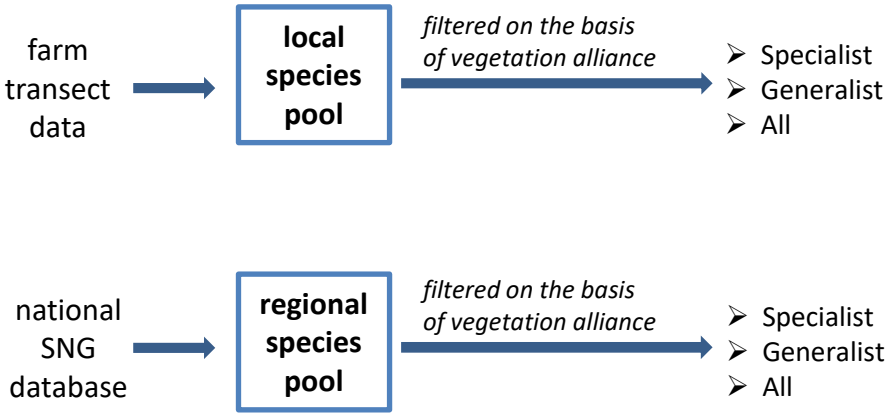
- omnibus Kruskall-Wallis
- posthoc Dunn multiple comparison (Holm correction)

ANALYTICAL METHODS

changes in community completeness

CCI=ln(observed diversity/dark diversity)

Species pool:



- **For each intensity group**
- **For each period**

Preface

Introduction

Methods

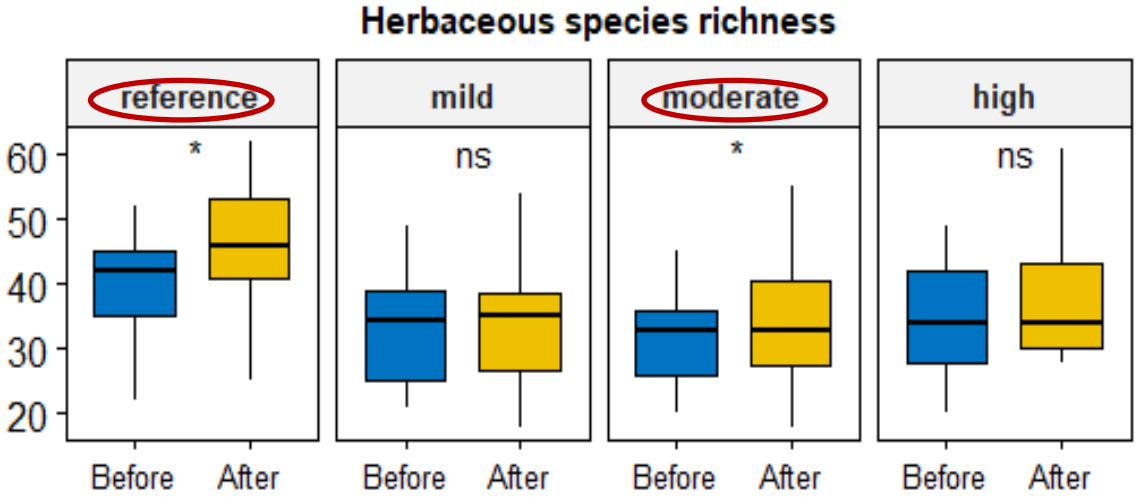
Results

Discussion

Conclusions

RESULTS

changes in species diversity



between intensity groups

- Overall significant difference

Reference

Dry grassland with *Filipendula vulgaris* and *Helictotrichon pubescens*.

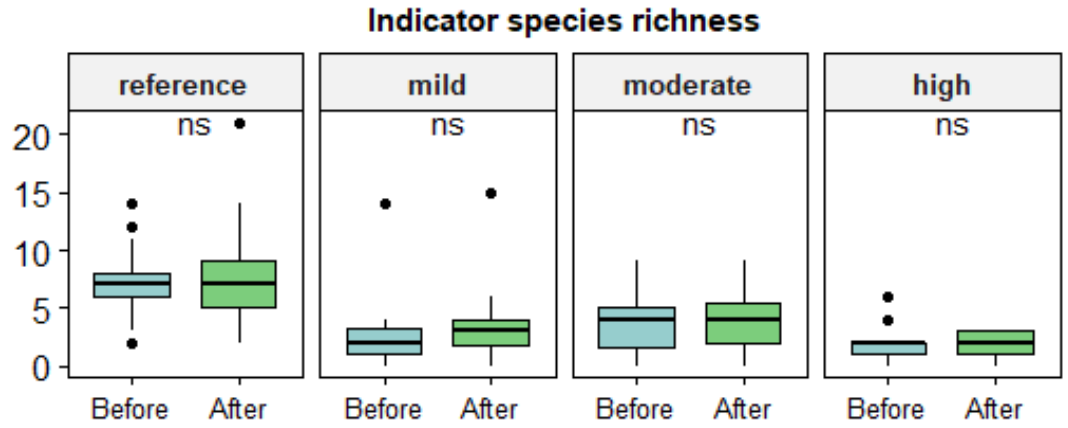
Low vegetation and low species richness in 2018 (extreme drought)

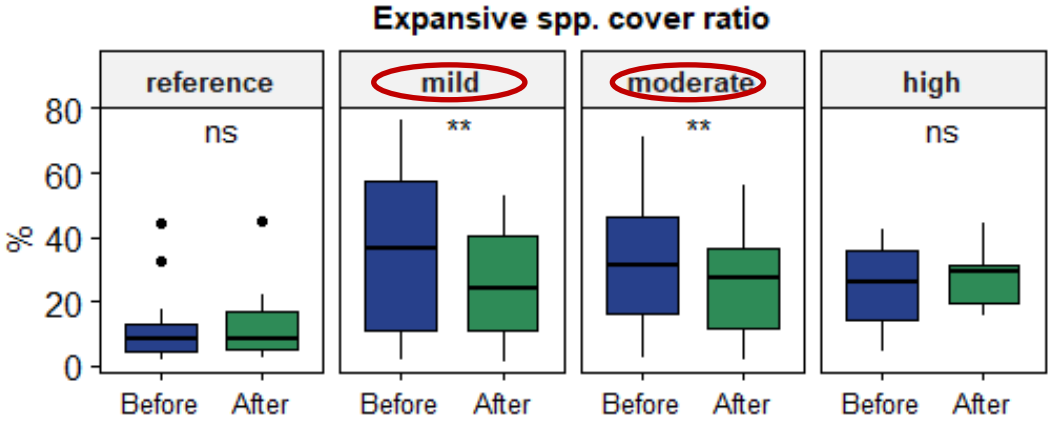
Higher biomass, higher species richness in 2021

Restoration period	Restoration intensity group	Shannon index	Gini-Simpson index	Pielou's evenness
Pre	reference	2.9±0.4	0.9±0.1	0.8±0.1
	mild	2.5±0.5*	0.8±0.1**	0.7±0.1*
	moderate	2.5±0.5*	0.8±0.1*	0.7±0.1
	high	2.7±0.2	0.9±0.0	0.8±0.1
Post	reference	3.0±0.3	0.9±0.1	0.8±0.1
	mild	2.7±0.4	0.9±0.1	0.8±0.1
	moderate	2.7±0.3	0.9±0.0	0.8±0.1
	high	2.8±0.4	0.9±0.0	0.8±0.0

between intensity groups

- Overall significant difference (no Simpson index)





between intensity groups

- Overall significant difference

Moderate intensity

2018

2021

2018

2021

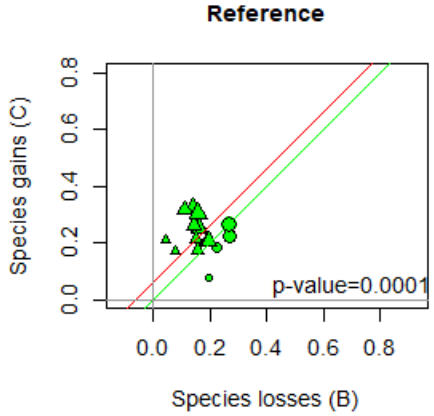
Dry grassland with *Poa angustifolia, Pimpinella saxifraga* and *Solidago virgaurea*.

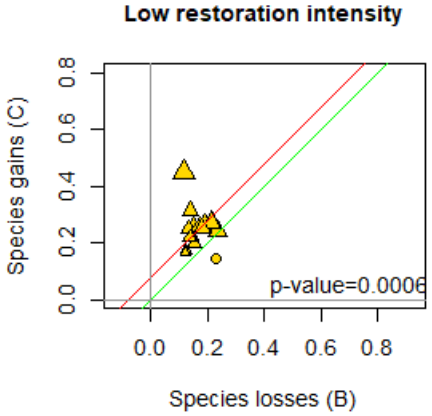
Intensively grazed

- litter layer density decreased
- expansive species cover decreased: *Equisetum arvense* and *Solidago virgaurea*.

Temporal Beta Diversity

abundances-per-species

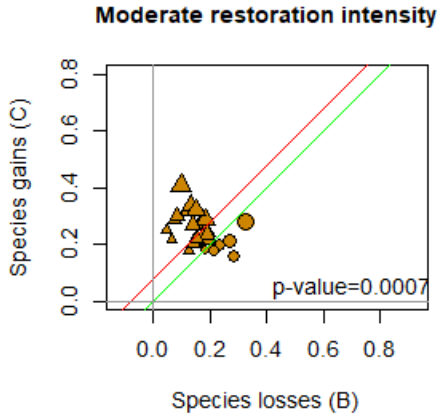


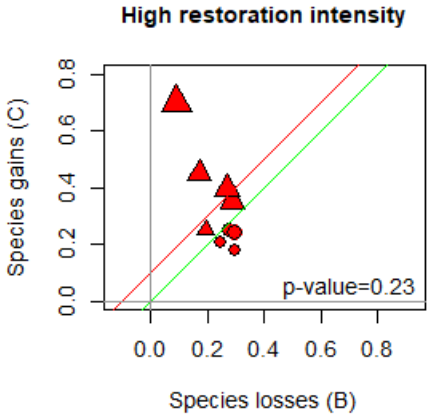


Veronica chamaedrys

Cerastium holosteoides

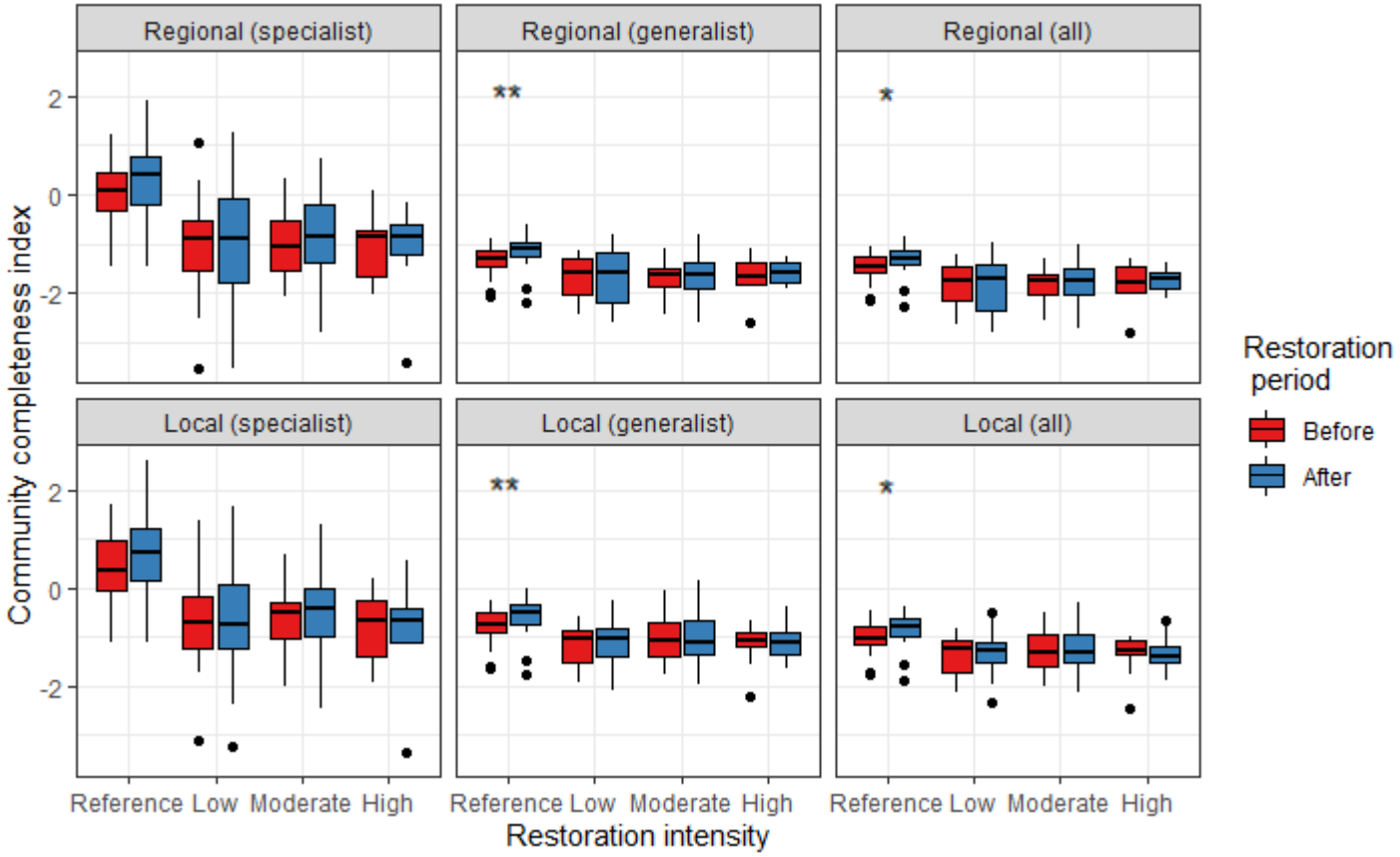
Stellaria graminea





RESULTS

changes in community completeness



- Lack of recruitment of **specialist species** from both local and regional species pools
- No changes in restored sites

Preface

Introduction

Methods

Results

Discussion

Conclusions

DISCUSSION

Remarkable differences in **richness** and **evenness** components of species diversity

1. Weather influence

2. Lack of recruitment of indicator sp:

- **Regional** scale

  - dispersal limitation
  - transient soil seed bank

- **Local** scale

  - environmental filtering
  - mutualist plant-pollinator or plant-mychorriza assemblages

- Colonization credit

driven by

- generalist spp. abundance increase
- expansive spp. decrease

Preface

Introduction

Methods

Results

Discussion

Conclusions

CONCLUSIONS

- **No clear pattern** in relation to restoration intensity
- **Positive changes** in mild and moderate groups

- Keep an eye to **reference sites**!
- Characterize the **species identity** → specialist and generalist

- Species richness alone might lead to wrong conclusion → take into account **evenness**!
- Community completeness analysis helps to assist ecological recovery in the **long-term**

multiple indicators

Thank you!