RESTORATION OPTIONS FOR ESTABLISHING

PHOSPHORUS-POOR SOIL CONDITIONS AFTER FERTILIZATION

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Mowing with hay removal is an effective and efficient restoration technique to remove nutrients.
Mowing with hay removal is an effective and efficient restoration technique to remove nutrients from a severely-fertilized site to restore species-rich grasslands.
Species-rich *Nardus* grassland

**Intensification**

- NPK
- Up to annual tillage of > 30 cm
- > 4 LU/ha
- Up to 5 x hay making annually

**DISTANCE TO TARGET?**

**ABIOTIC** bottlenecks: hydrology?, nutrients too high, pH modified, ...

**BIOTIC** bottlenecks: target flora are absent, soil biota are different...
Species-rich *Nardus* grassland

**BIOTIC BOTTLENECK**
No resemblance with the target community despite mowing for a long time

Landscape context…
Very isolated remnants

34 reference *Nardus* grasslands in Flanders (BE)

vs

29 quadrats in seven grasslands with 15-25 year mowing management + autumn grazing

Schelfhout et al. (2017 in Restoration Ecology)
Species-rich *Nardus* grassland

ABIOTIC BOTTLENECK

Large difference from reference grasslands in bioavailable P concentrations &

Large variation between the seven grasslands

34 reference *Nardus* grasslands

vs

7 grasslands with 15-25 year mowing management + autumn grazing

Target P concentration = 12 mg P$_{Olsen}$/kg

Schelfhout et al. (2017 in Restoration Ecology)
Level of intensification is different between European regions but also within regions:
P-load dependent on fertilization history (& texture, Fe-content...)

=> Measure soil-P to know about the historical landuse intensity
P = a complex nutrient:
Total P analyse not ecologically relevant
A lot of chemical extraction techniques

Unpublished results ForNaLab
1. ABBIOTIC RESTORATION

- Is abiotic restoration necessary?
  - Look up biogeochemical and hydrological requirements of target habitat type
  - Analyze relevant soil parameters in field
  - Determine the distance to target

2. Biotic Restoration (if target species are missing)

3. REINTRODUCE traditional grassland MANAGEMENT by mowing and grazing

Fertilization

- Never fertilized
- -> potentially species-rich

Dispersal limitation?

- Soil $P_{olsen}$ mg P/kg

Schelfhout et al. (2017) in Restoration Ecology

Ceulemans et al. 2015 in GCB
EFFECTIVELY AND EFFICIENTLY REMOVING PHOSPHORUS?
4 fields x 4 replications per field
2-3 times mowing and removing P with biomass
2011-2017
**EFFECTIVELY AND EFFICIENTLY REMOVING PHOSPHORUS**

**MOWING?**

Field experiment: 2011-2017

Low biomass production due to N and K limitation:
3 ton/ha/y independent of soil-P concentration
Effective but not efficient at P-removal from soil

Schelfhout et al. (submitted at Plant and Soil)
1. ABIOTIC RESTORATION

Determine the distance to target:
- Look up biogeochemical and hydrological requirements of target habitat type
- Analyse relevant soil parameters in the field

Is P-depletion needed?

NO

YES

Is P-removal feasible in an acceptable time-span by mowing?

NO

YES

Mowing

2. BIOTIC RESTORATION
(if target species are

Schelfhout et al. (2017 in Restoration Ecology)
P-mining: Using agriculture for ecological restoration

Keeping biomass production at a high level by selective fertilization with N and K to maximize P removal

Schelfhout et al. (submitted at Plant and Soil)
EFFECTIVELY AND EFFICIENTLY REMOVING PHOSPHORUS

MOWING
P-MINING?

Higher biomass production due to N and K fertilization: 9 ton/ha/y independent of soil-P concentration
Three times more P-removal than mowing, but dependent of soil-P-concentration

Restoration technique
- Mowing
- P-mining

Field
- Liereman-1
- Liereman-2
- Liereman-3
- Vloethemveld

Schelfhout et al. (submitted at Plant and Soil)
WHAT HAPPENED TO SOIL-P-CONCENTRATIONS?

⇒ Bioavailable and slowly cycling P decreased more with higher P removal (P-mining) & are tightly linked to each other
⇒ important to measure both

15-30 cm soil depth: no difference

0-15 cm soil depth:
- Bioavailable P-concentrations decreased
- Slowly cycling P-concentrations unchanged

Schelfhout et al. (submitted at Plant and Soil)
EFFECTIVELY AND EFFICIENTLY REMOVING PHOSPHORUS

P-MINING: faster by using other crop species?

Schelfhout et al. (2018 at IJP)
ESTIMATION OF P-REMOVAL TIME UNTIL TARGET

Include slowing down of P-removal with decreasing soil-P concentration

Depth to deplete?
Fields of the experiment (Olsen-P 29-112 mg/kg):
  0-10 cm: 15-85 years of mowing vs 9-21 years of P-mining
  0-30 cm: 44-255 years of mowing vs 30-64 years of P-mining
1. ABIOTIC RESTORATION
   - Determine the distance to target:
     - Look up biogeochemical and hydrological requirements of target habitat type
     - Analyse relevant soil parameters in the field
   - Is P-depletion needed?
     - NO
     - YES
       - Is P-removal feasible in an acceptable time-span by mowing?
         - YES
         - Mowing
         - NO
         - P-mining
   - Is P-removal possible in an acceptable time-span by P-mining or is the cost of topsoil removal feasible within the boundaries of the project?
     - YES
   2. BIOTIC RESTORATION (if target species are missing)
     - Mowing
     - P-mining
EFFECTIVELY AND EFFICIENTLY REMOVING PHOSPHORUS

MOWING
P-MINING
TOPSOIL REMOVAL

Efficient & effective removal of soil P (but measure depth of P in advance)
Very expensive (~75 000 EUR ha$^{-1}$)
-> depending on depth, …
Soil buffering components removed too
-> acidification & aluminum toxicity; lack of organic material
Soil biota removed too
-> crucial for germination of some plant species??

Unpublished results ForNaLab
Life project *Blues in the marshes* in NL
Target = Restoring 300 ha 6410 - *Molinion*

1. **ABIOTIC RESTORATION**
   - Determine the distance to target:
     - Look up biogeochemical and hydrological requirements of target habitat type
     - Analyse relevant soil parameters in the field
   - Is P-depletion needed?
     - NO
     - YES

   - **Is P-removal possible in an acceptable time-span by P-mining**?
     - YES
     - NO
     - **OR**

   - **Topsoil removal**

2. **BIOTIC RESTORATION** (if target species are missing)
   - Mowing
     - **YES**
     - **NO**
   - **P-mining**

Photo: Kars Veling
1. ABIOTIC RESTORATION

Determine the distance to target:
• Look up biogeochemical and hydrological requirements of target habitat type
• Analyse relevant soil parameters in the field

Is P-depletion needed?

2. BIOTIC RESTORATION (if target species are missing)

Is P-removal feasible in an acceptable time-span by mowing?

3. REINTRODUCE traditional grassland MANAGEMENT by mowing and/or grazing

Is P-removal possible in an acceptable time-span by P-mining or is the cost of topsoil removal feasible within the boundaries of the project?

No abiotic restoration at this location
Select another field or another habitat type with realistic abiotic requirements
Thank you!

**UGent- ForNaLab team:** Luc Willems, Greet de Bruyn, Kris Ceunen, Filip Ceunen, Robbe De Beelde, Andreas Demey, Predrag, Tomo, Simon Oosterlynck, Danny Vereecke, Jelle Soleme, Jolien Venneman, Geert Baert, Filip Debersaques...

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Soil biota communities are also very different after intensification