

Bog restoration in the Peel

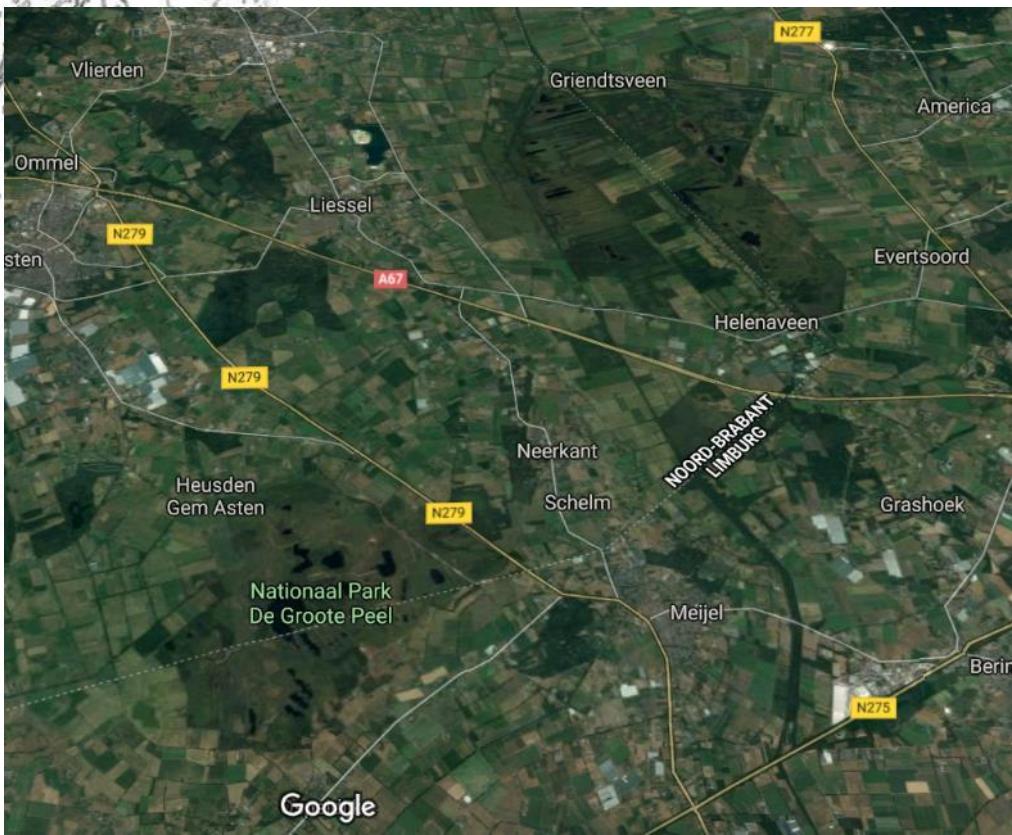
Dealing with water, mosses, trees, greenhouse gases,
species, landscape and people





Peatlands in the Netherlands

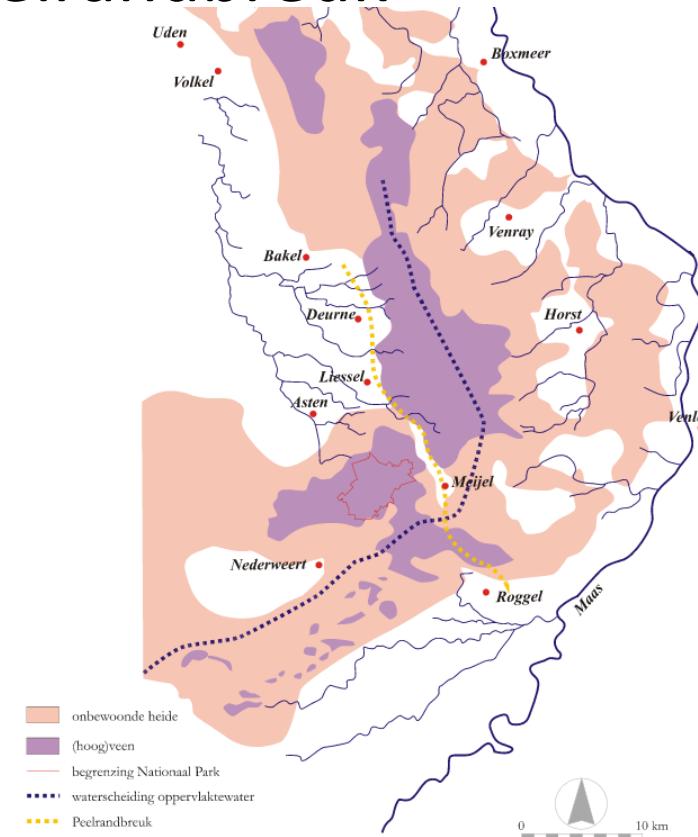
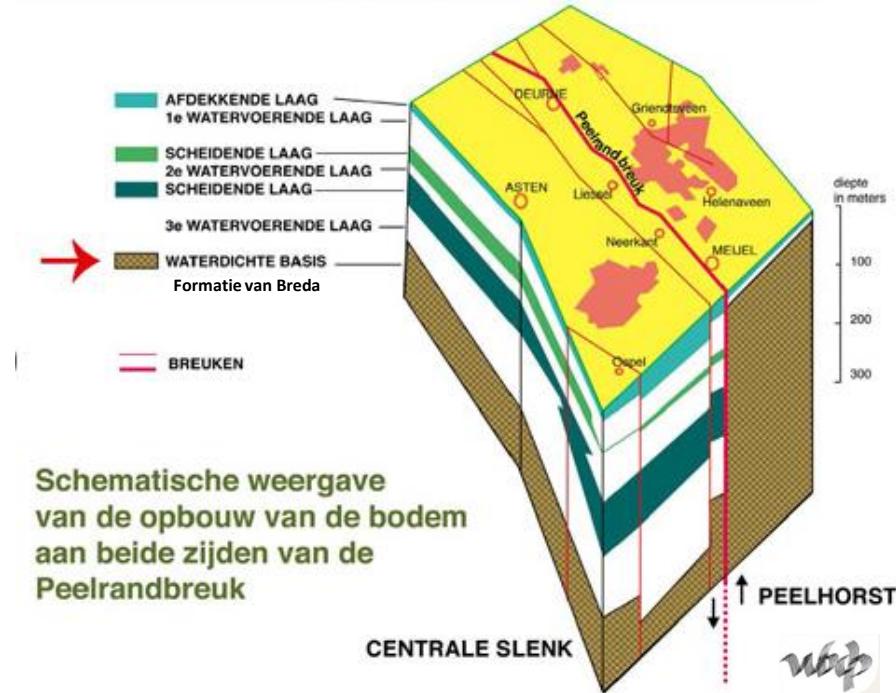
-Deurnsche Peel & Mariapeel
-Groote Peel



Ontstaan rondom de Peelrandbreuk

De Verheven Peel op de Peelhorst: hoog en nat

De Groote Peel in de Centrale slenk/Roerdalslenk

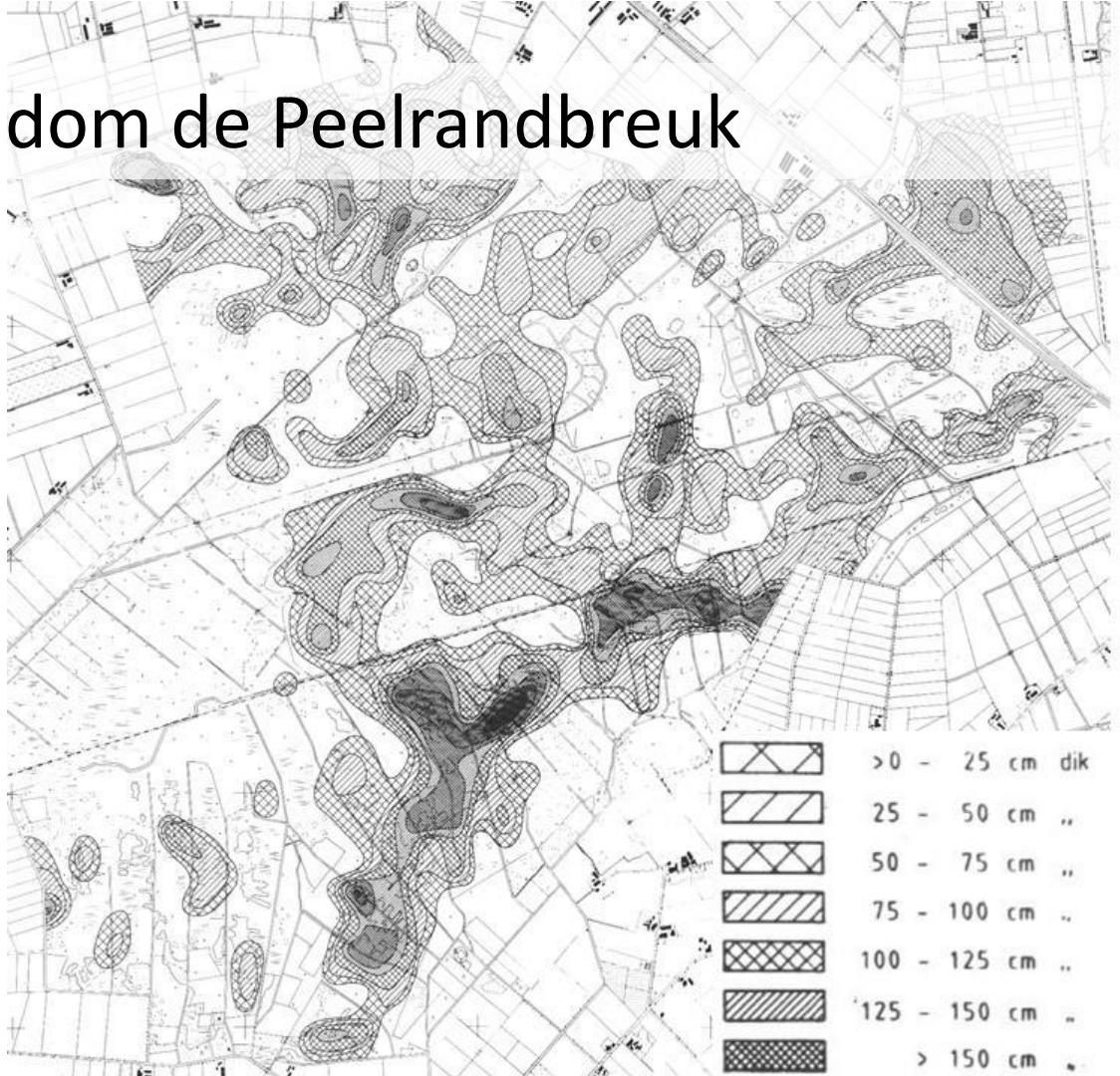
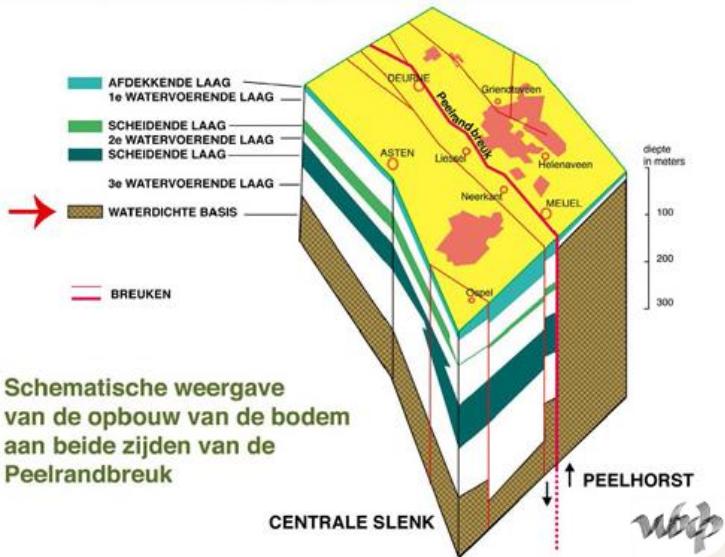


Historische kaart van De Peel

op basis van Tranchotkaart 1802-1804, de Topografische kaart van 1850 en Lorié, 1894
naar Van Engen en Joosten, 1994

Ontstaan rondom de Peelrandbreuk

Start: minerotroof veen in geulen
Daarna successie via
overgangsveen naar hoogveen

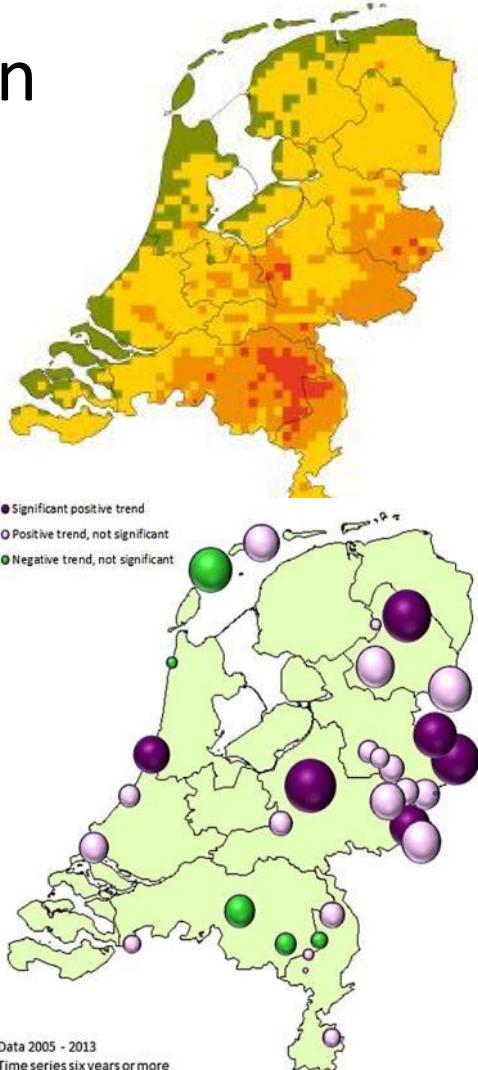






Werkgroep Behoud de Peel (<http://www.wbdp.nl/>)

Desiccation + High atmospheric N deposition



Investigation of key processes in effective restoration and conservation of Dutch raised bog remnants

Started in 1998

- University of Nijmegen: substrate quality, *Sphagnum*, N-deposition
- University of Wageningen: *Sphagnum*, N-deposition, birch and grass hydrology
- Stichting Bargerveen: invertebrate fauna
- NITG-TNO: monitoring

Reports, brochure, website natuurkennis.nl, hoogveenherstel.nl





Inundation? *Sphagnum* requires light and CO₂

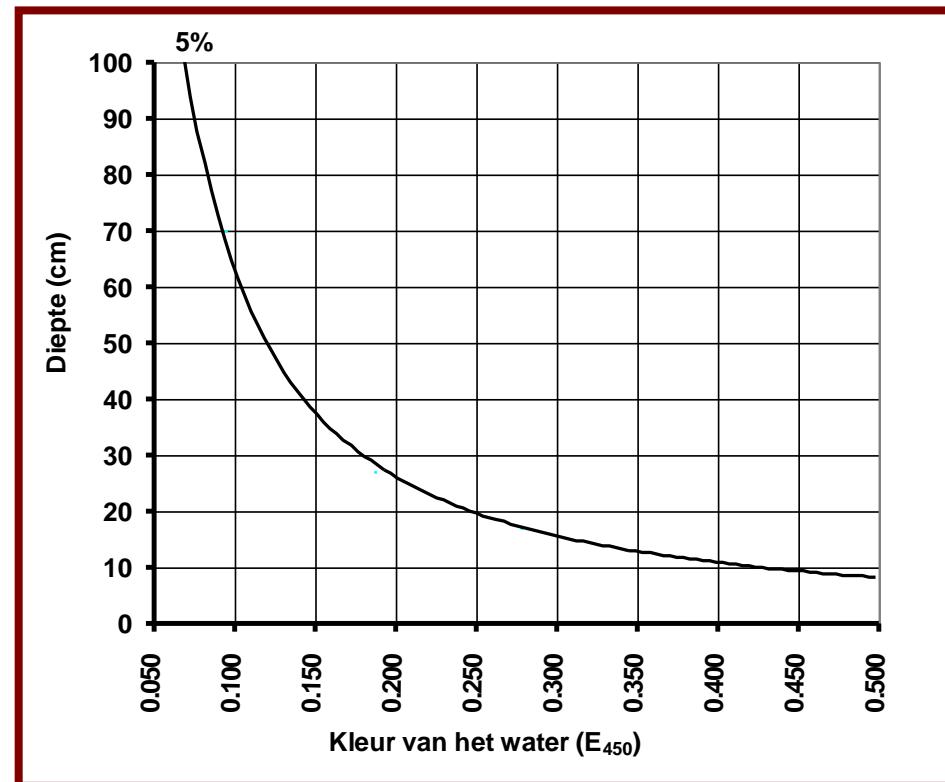
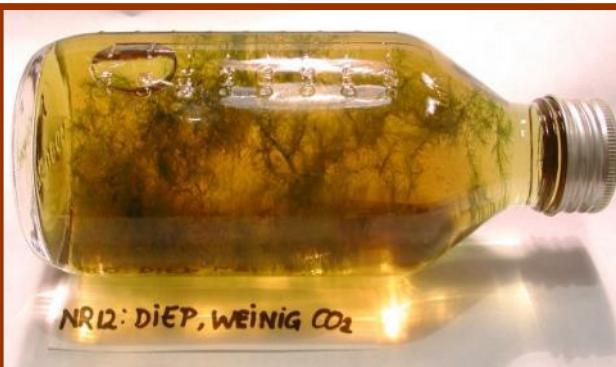
Shallow inundation & 2000 µmol l⁻¹

CO₂

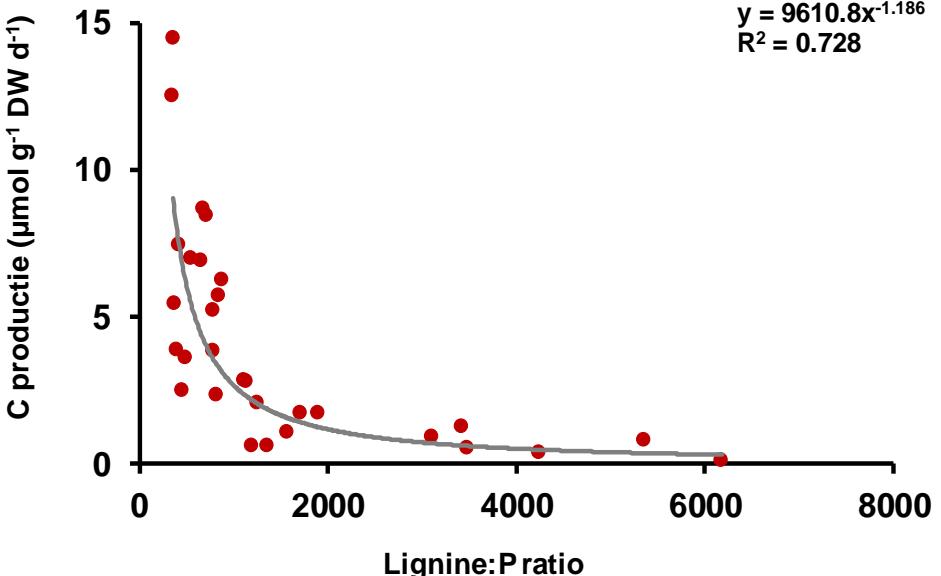
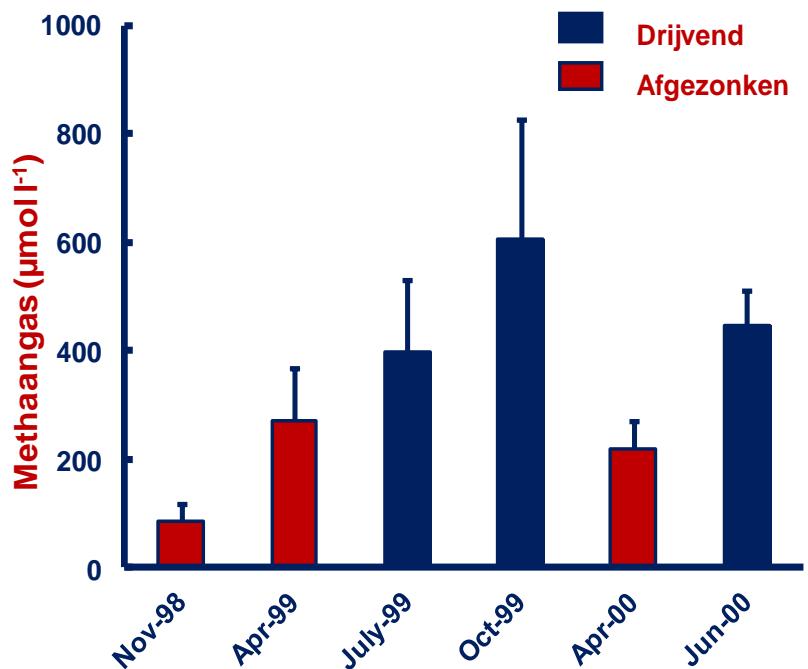


Deep inundation & 100 µmol l⁻¹ CO₂

CO₂



Inundation? Formation of floating raft



ontwikkeling + beheer natuurkwaliteit



Witveen of zwartveen

- Schematisch overzicht van meest kansrijke vernattingsstrategieën

Voor informatie zie de OBN-rapporten van Tomassen e.a., 2003 en Van Duinen e.a. (2011) of www.natuurkennis.nl.



Also studies and field excursions
in pristine raised bog landscapes !!!



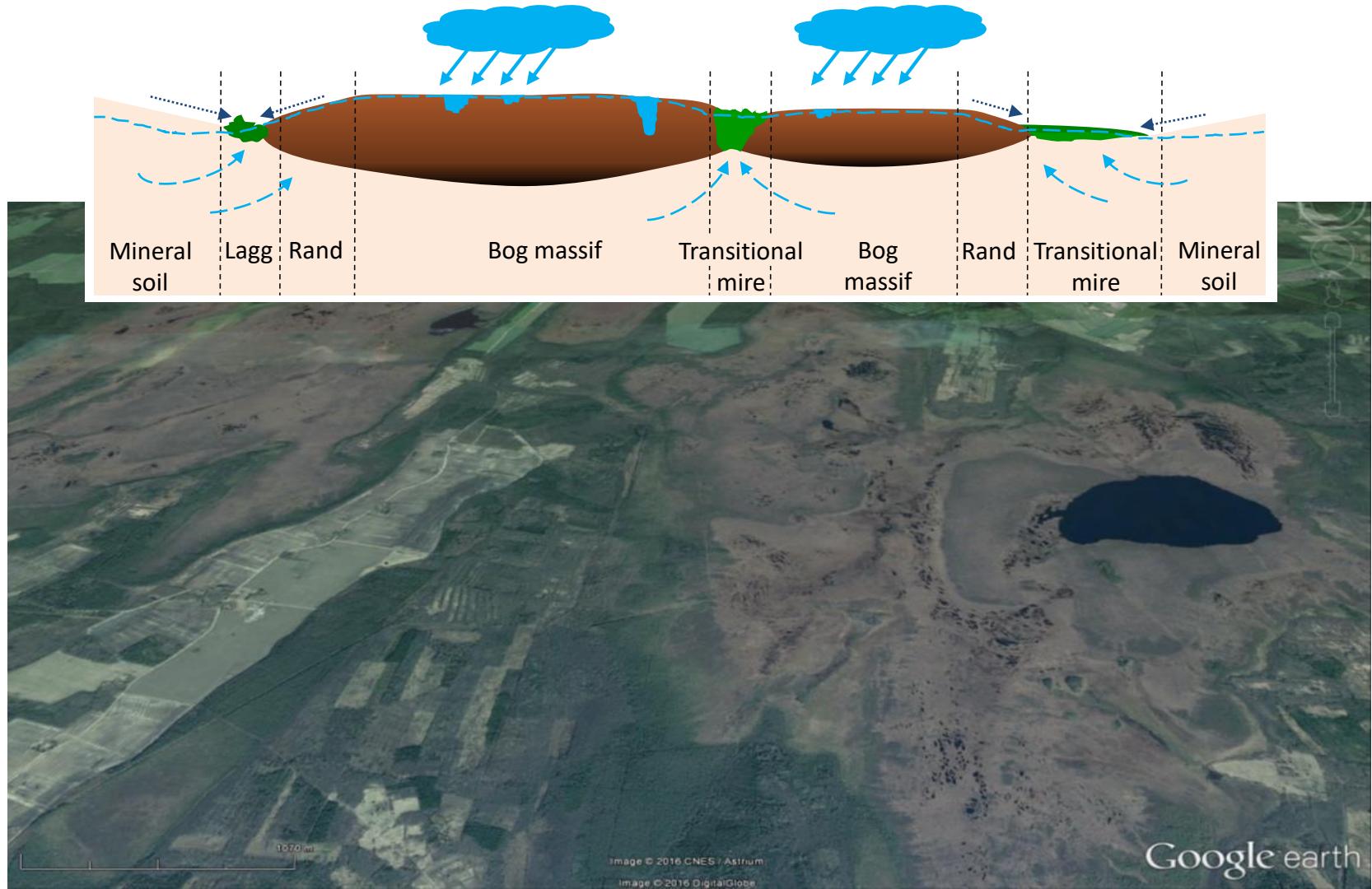


Image © 2016 CNES / Astrium

Image © 2016 DigitalGlobe

Google earth



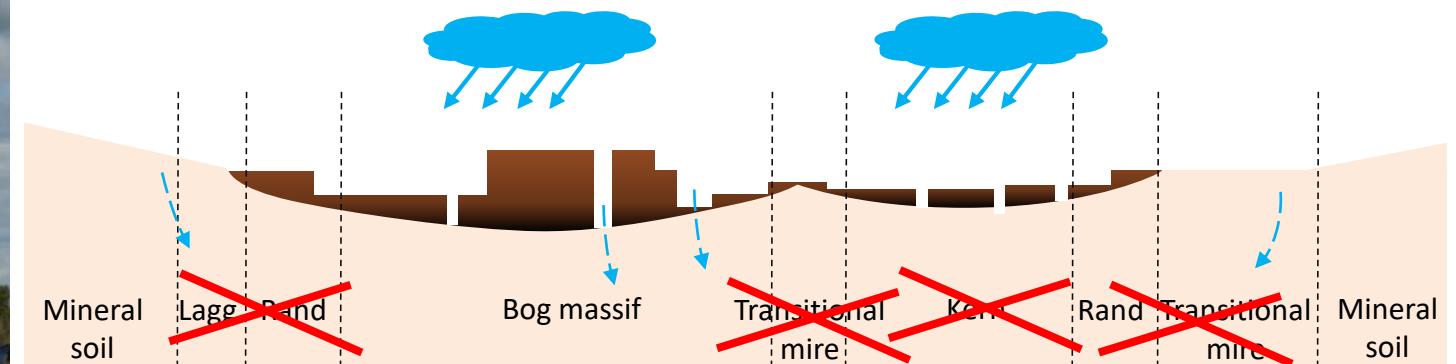
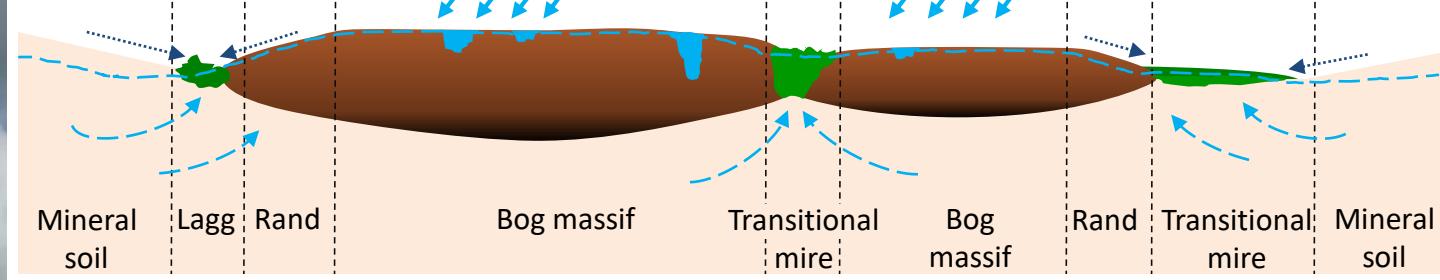
< Fen

-

Transitional mire

-

Raised bog massif >



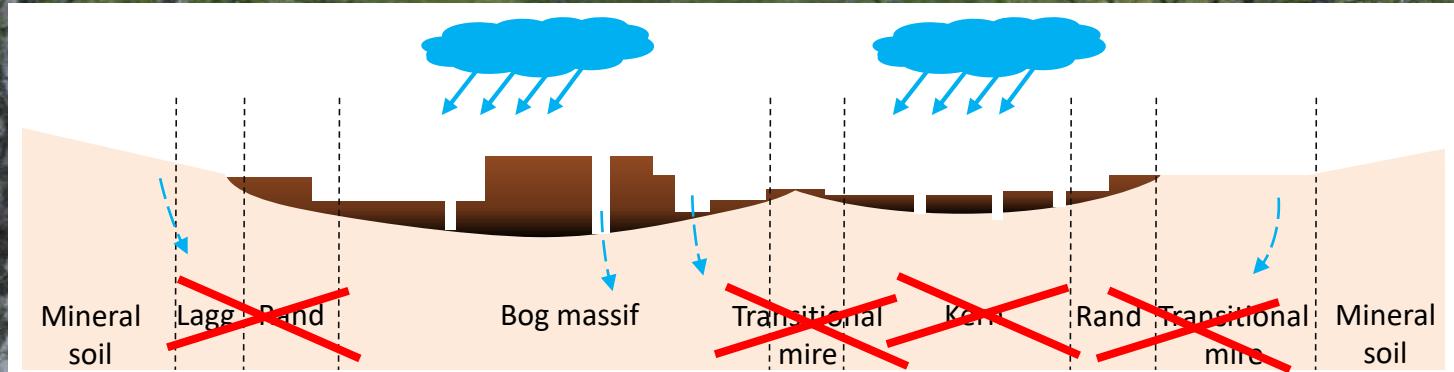
< Fen

-

Transitional mire

-

Raised bog massif >



Red-backed shrike



Cranberry fritillary



Somatochlora arctica

Conservation and restoration bog: rewetting required

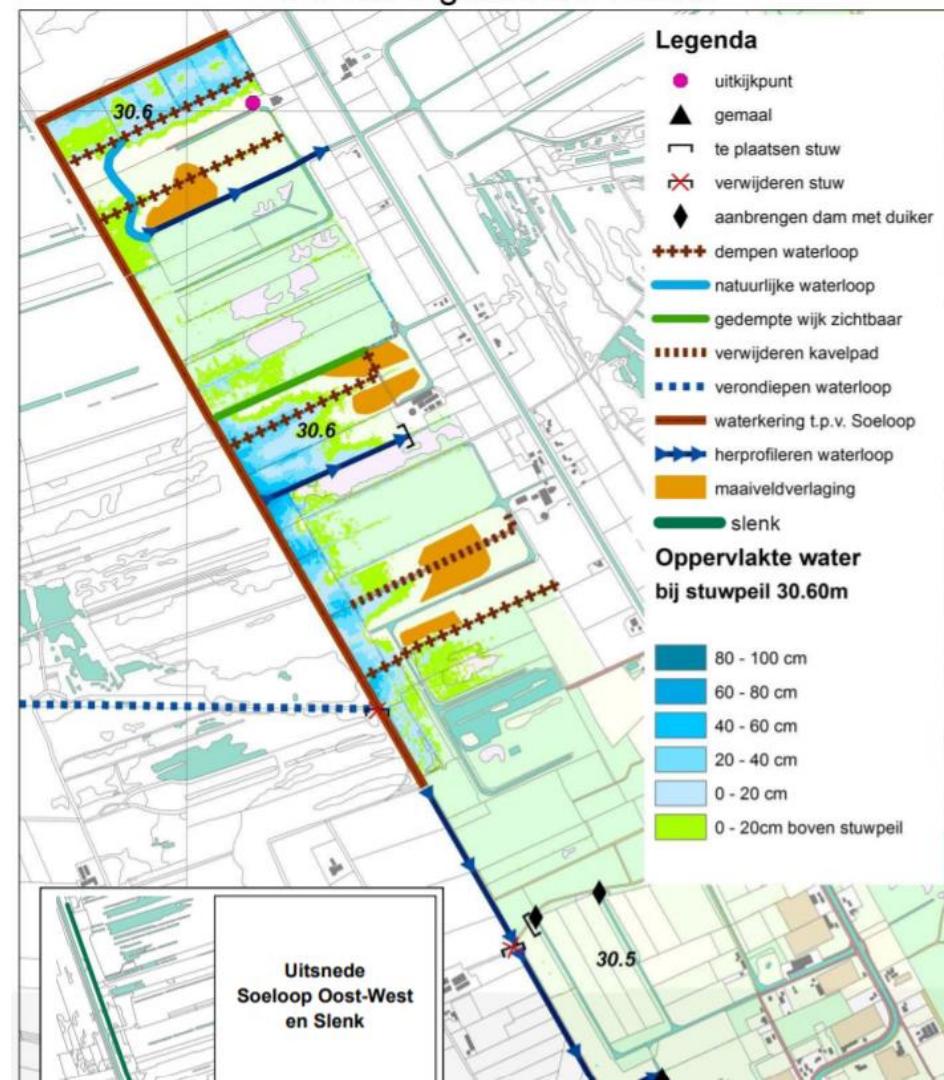


LIFE+ Mariapeel. Sealing of canal in 2016
Photo: Boena van Noorden

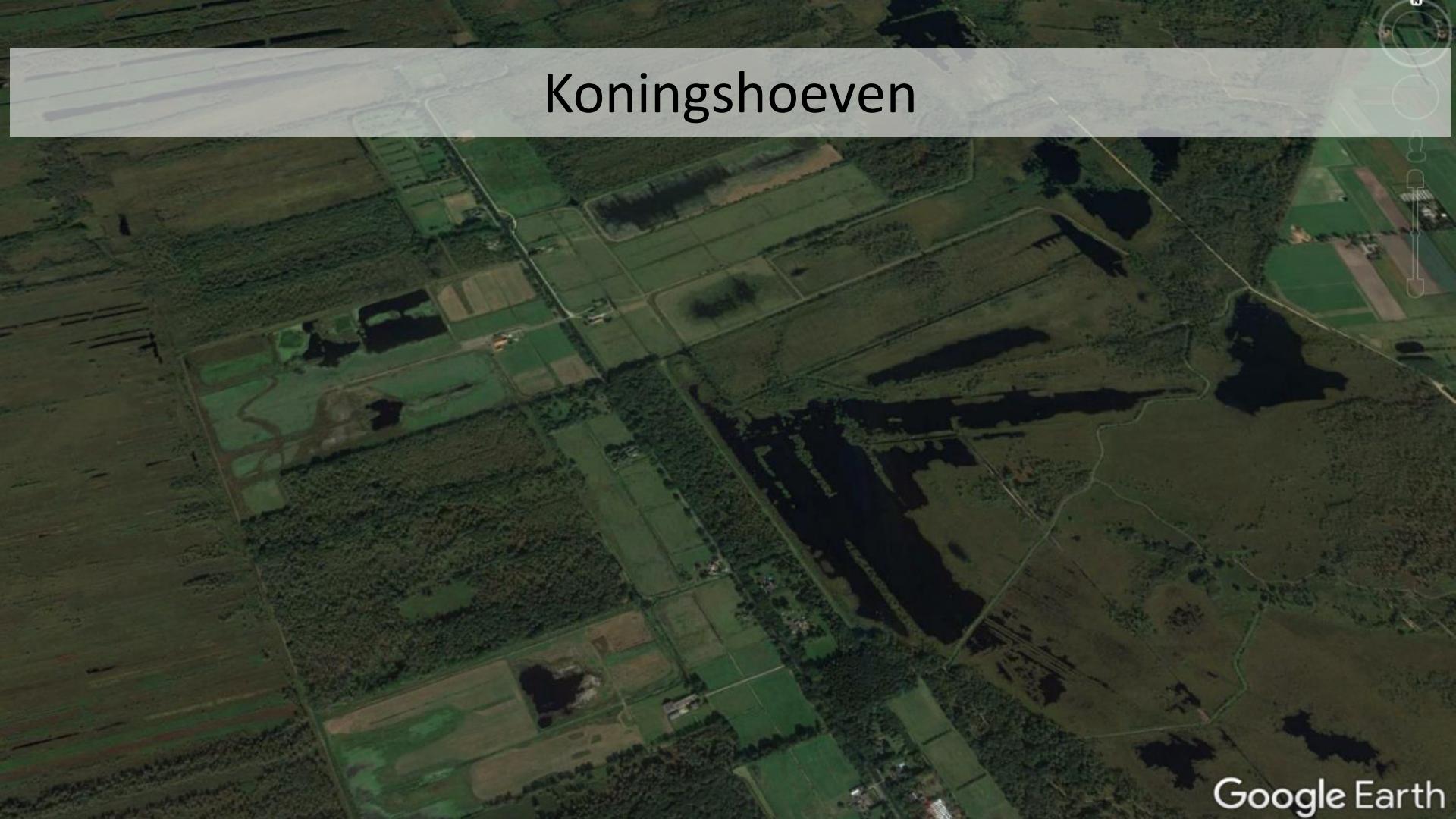




Koningshoeven

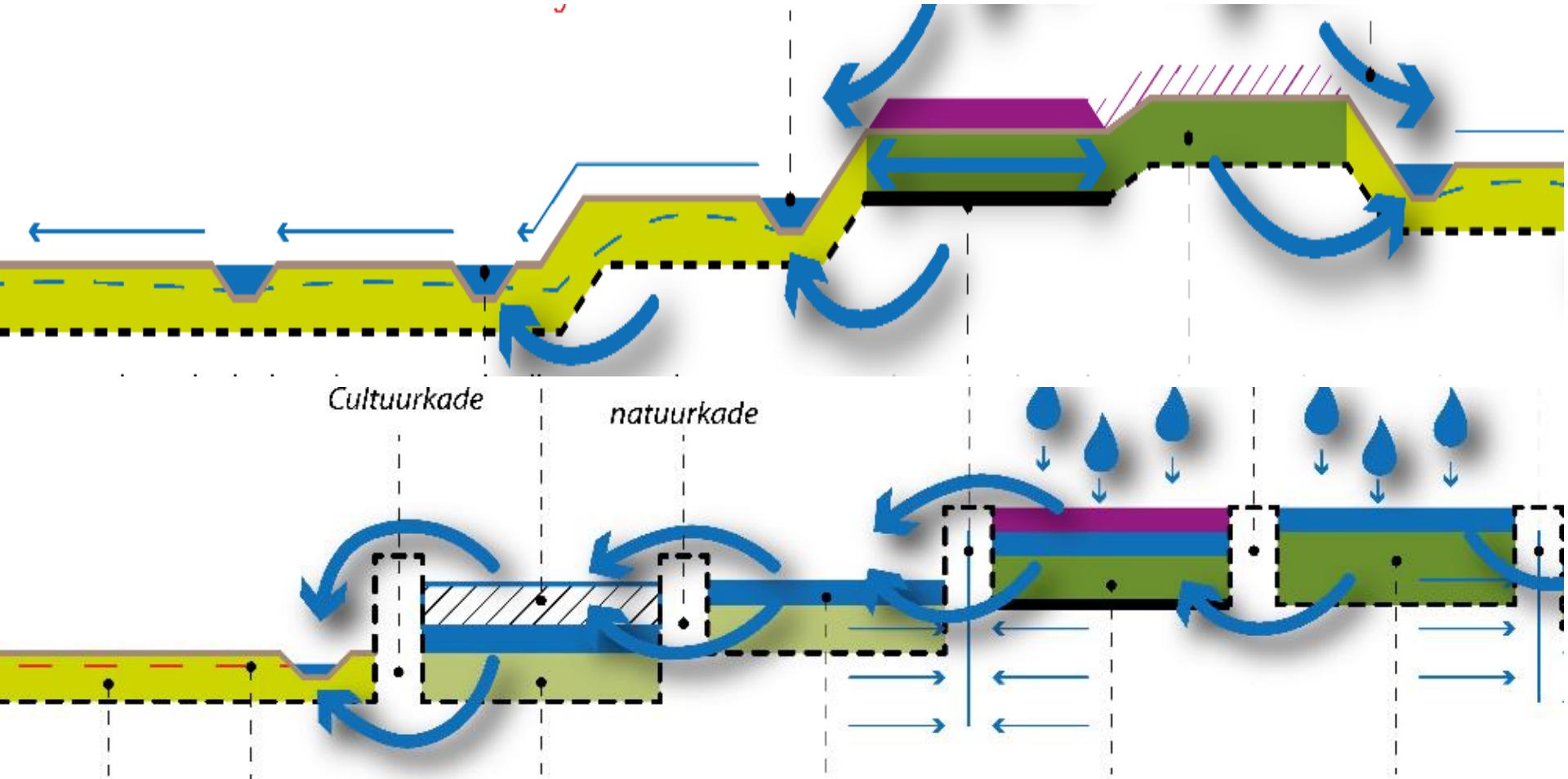


Koningshoeven

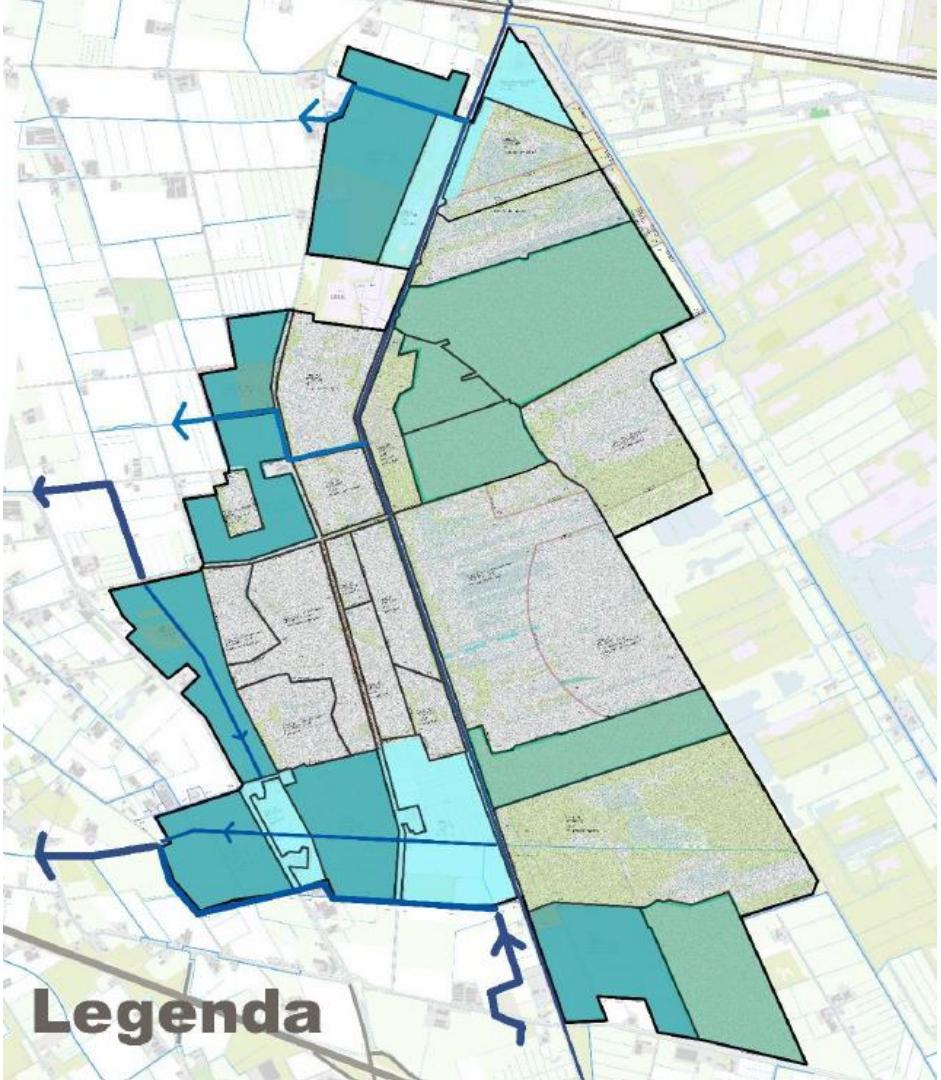


Google Earth

Current and future situation



Hydrological buffer zones Deurnsche Peel



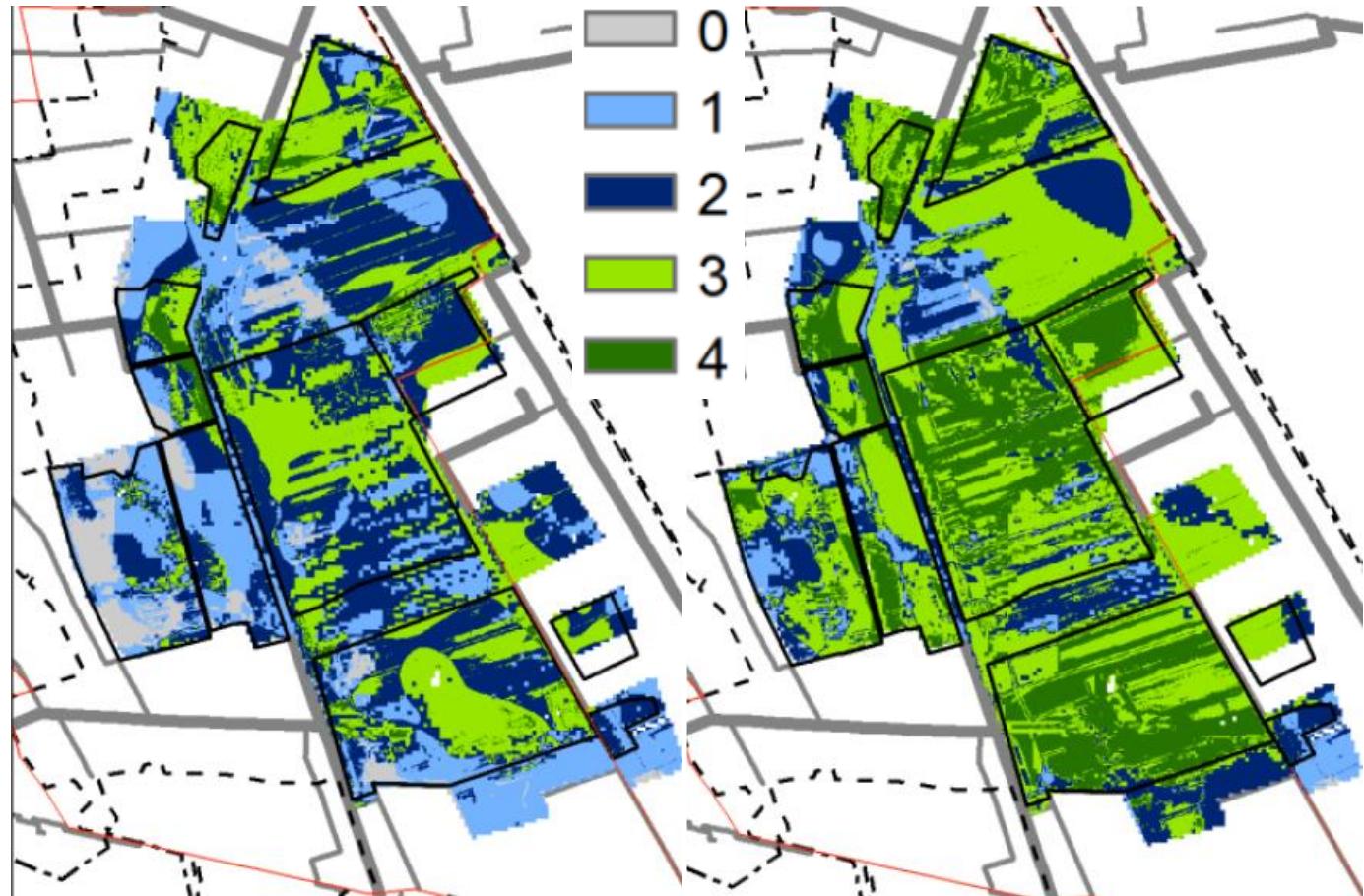
Legenda

Toets hoogveen criteria huidig en plan

Hoogveencriteria:

- GHG boven maaiveld
- Stijghoogte permanent in veenbasis (GLG)
- Wegzetting < 40 mm/jaar
- Peilfluctuatie gering

GHG-GLG < 30 cm



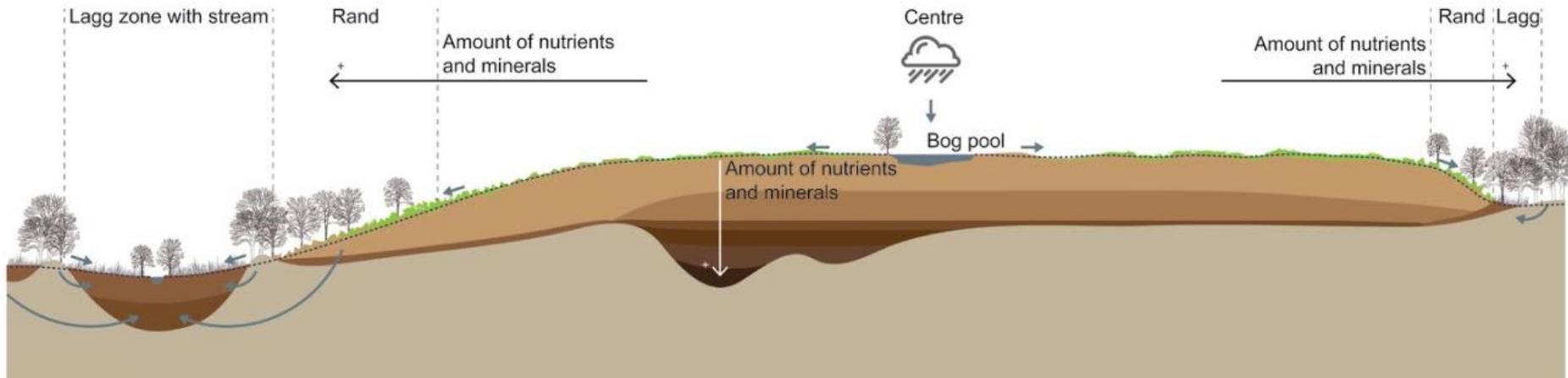


Figure 105: Schematic representation of an intact raised bog

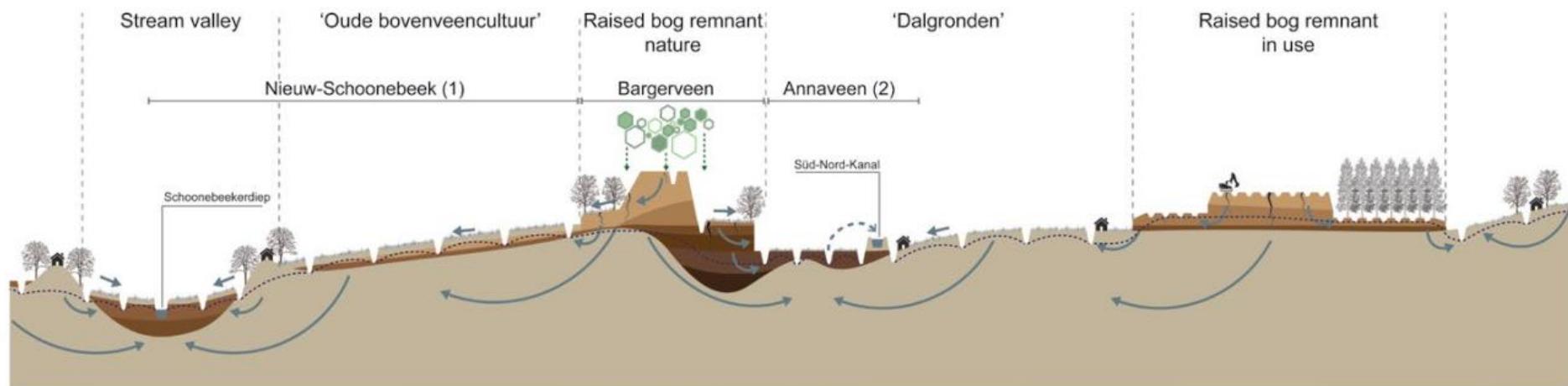


Figure 107: Schematic representation of the degraded raised bog landscape

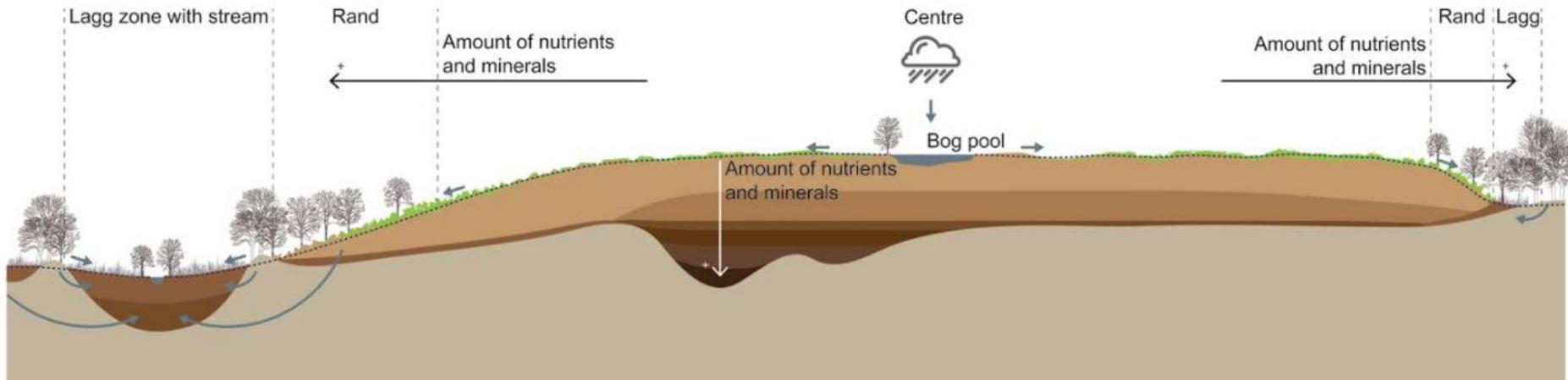


Figure 105: Schematic representation of an intact raised bog

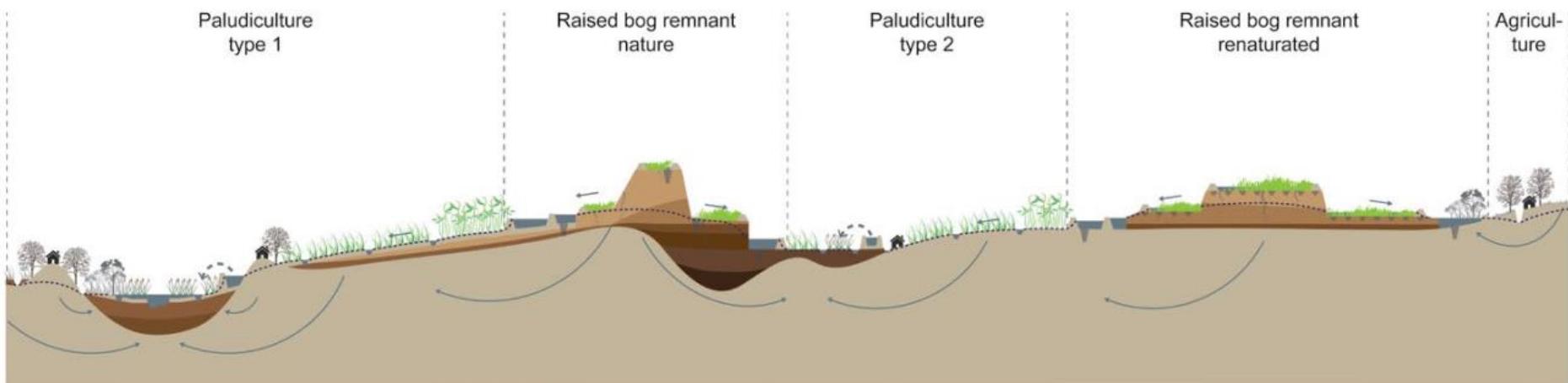


Figure 109: Schematic representation of a regenerated raised bog landscape

Peatlands: If you need to use them, use them wet!



Tobias Dahms. lensescape.org

Wendelin Wichtmann, Christian Schröder & Hans Joosten (Hrsg.)

Paludikultur – Bewirtschaftung nasser Moore

Klimaschutz – Biodiversität – regionale Wertschöpfung



Schweizerbart



Wendelin Wichtmann, Christian Schröder & Hans Joosten (eds.)

Paludiculture – productive use of wet peatlands

Climate protection – biodiversity – regional economic benefits



Schweizerbart
Science Publishers



Paludiculture as a solution

Growing crops on wet peat soil (water level within 20 cm from surface)

→ Sustainable biomass production + Restoring ecosystem services

- Farmers can continue business (not business as usual!)
 - Crops → low-high value product chains
 - 1128 species in Database of Potential Paludiculture Plants (DPPI; Abel et al., 2014)
 - Carbon credits
 - Blue credits: Water retention, purification
 - Biodiversity
- Rewetting of drained peat soils
 - Reduction GHG emission (CO₂-neutral)
 - Water retention
 - No subsidence (peat preservation)
 - Biodiversity

Paludiculture: how to do it?

- Technically many crops ready to be implemented on the farm scale

Cranberry, Cattail (*Typha*), Reed (*Phragmites*), Willow (*Salix*), Miscanthus, Bog mosses (*Sphagnum*), Rice (*Oryza*)

Potential ones/new ones: Azolla, Sagittaria (duck potato), Zizania (wild rice), Reed canary grass (*Phalaris*) etc. etc.

Also: Water buffalo, Wild horses (eating *Typha* fields)

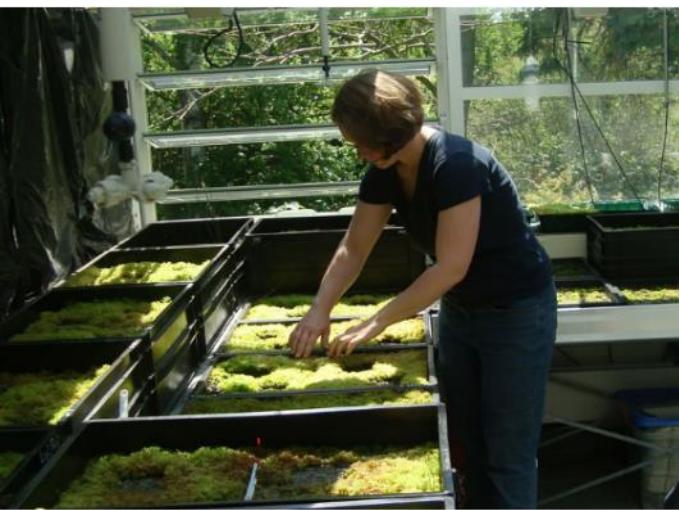


Paludiculture: how to do it?

- A lot of products based on biomass from paludiculture/wet agriculture
- Development (innovations) of products, machinery and markets
- Rewetting difficult in drained landscape (→ pilots in nature reserves)
- Legislation, subsidies, long-term schemes, planning security for farmers (Wichtmann 2018)



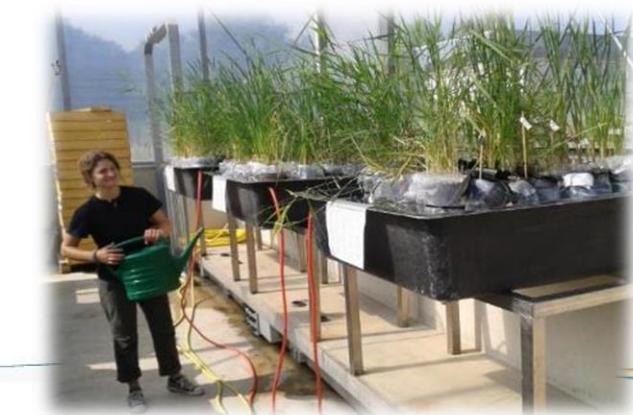
Greenhouse experiments → field experiments → pilots on ha scale



Start Peatlands Paludiculture Infotheque Publications Contact

The website header includes links for Start, Peatlands, Paludiculture, Infotheque, Publications, and Contact. Below the header are two logos: 'GREIFSWALD MIRE CENTRE MOORWISSEN' with a stylized blue and red circular logo, and 'PALUDI CULTURE GREIFSWALD' with a stylized green, blue, and orange logo. A large aerial photograph of agricultural fields is displayed in the background.

MoorWissen ▾ | Paludiculture | Paludiculture in detail ▾ | Sphagnum farming ▾



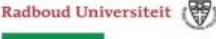
Paludiculture pilots in the Netherlands



Veen Voer en Verder



provincie frysln
provincie frysln





Zuiderveen (Noord-Holland)

12 ha



Range in yield of crops



Reed
(*Phragmites*)

5-22 t ha⁻¹ y⁻¹

Wichtmann et al. 2016



Bog mosses
(*Sphagnum*)

3-8 t ha⁻¹ y⁻¹

Temmink et al. 2017
Gaudig et al. 2017



Cattail
(*Typha*)

8-30 t ha⁻¹ y⁻¹

Fritz et al. 2017,
Geurts et al. 2018 a,b

Typha: Yield depends on harvesting period

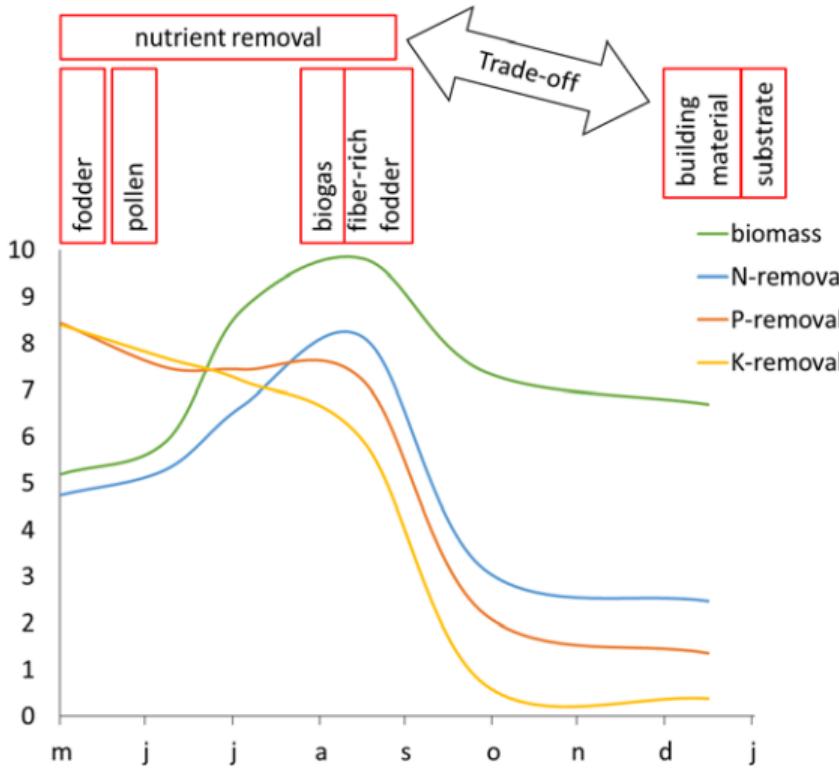
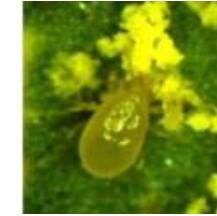


Figure 35. Trade-off between harvesting period, biomass yield, biomass application and sustainable nutrient removal of *Typha* (adapted from Geurts et al. 2017a).



Paludiculture pilots and experiments with focus on cattail and reed in the Netherlands Technical report - 2018

(Eds. J. Geurts & C. Fritz)

Ecological success: measuring GHG-fluxes



Water level is key factor

- GHG-reduction and water level
 - avoid summer flooding (max. 2 weeks; confirmed by Peatwise project)
 - stop carbon input by inlet of surface water for irrigation
 - promote methane oxidizing paludicrops (*Sphagnum*, other crops?)
 - belowground carbon storage important CO₂ sink (Reed, Alder and Peatmoss)

>> Large CO₂-reduction potential + reduction of nitrous oxide (when rewetting drained and fertilized peatlands)

[Geurts & Fritz, 2018: Paludiculture pilots and experiments with focus on cattail and reed in the Netherlands.pdf](#)



Water level is key factor

- Water level and production
 - drought stress most damaging, young-plant stage most vulnerable
 - many crops produce more when flooded, conflicts with GHG-reduction (rice, azolla, cattail)
 - some wet crops don't like water-logged soils (Willow, *Miscanthus*, cranberry on nutrient rich soils)

Geurts & Fritz, 2018



Main determinants for ecological success



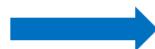
- Water level management + crop choice determine productivity, GHG-reduction, costs of implementation, provision of ecosystem services
- Preliminary results suggest: peat forming crops and water levels 10 cm below surface optimal compromise between biomass production and GHG-reduction. (Peat moss, Reed and Alder)
- Biodiversity: grazing herbivores / typical species ...

Crop choice funnel

Potential crops

Water level regime

- current situation + climate change
- water retention/buffer



Soil type, nutrients

- current situation
- impoverishment for aimed habitat type



Economically (locally) interesting

- products (yield, biomass, quality, market, processing, transport, harvesting options, residues)
- carbon emission/-sequestration (C-credits)
- water purification
- tourism



Support ecology of the area

- habitat type (mire, gradient)
- species

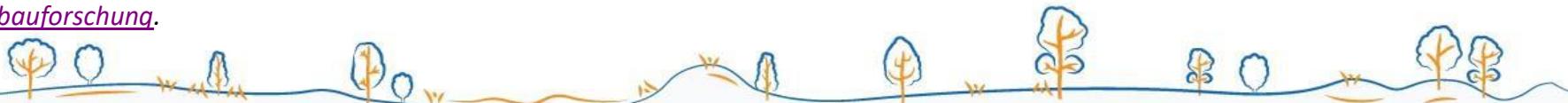


[van Duinen, Fritz & de Hullu \(2018\) Perspektiven für landwirtschaftlichen Nassanbau im Internationalen Naturpark Moor-Veenland.](#)

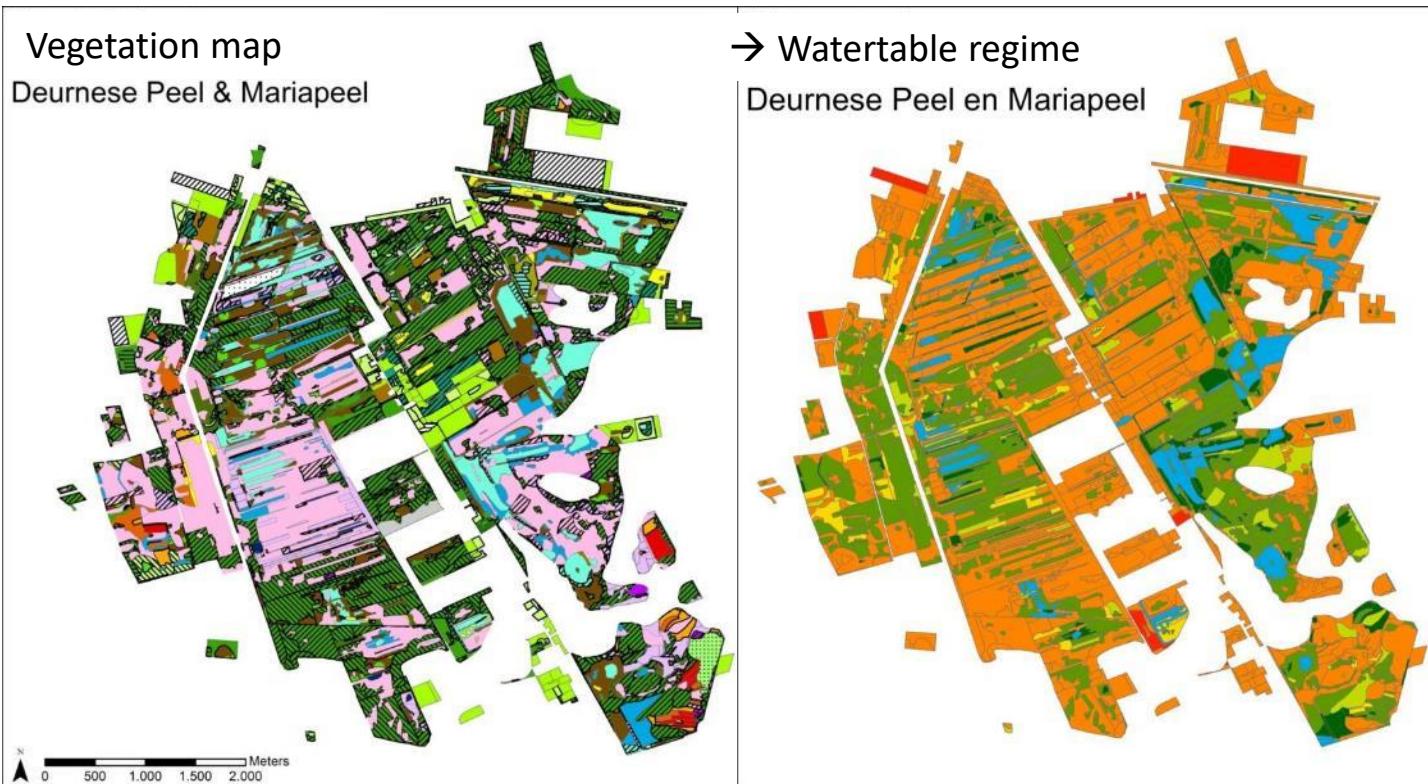
Lessons (to be) learned from paludiculture pilots

- Large interest from different companies and organizations for pilots and biomass from these pilots
- Technically a lot of crops adapted to wet soils work; ready to be implemented on farm/catchment scale
- Lot of products based on biomass from paludiculture/wet agriculture
- Wet peatlands produce a lot of biomass and will stimulate technology and market development when societies invest in CO₂-neutral productive peatlands
- Innovations in products, machinery and markets
- Income security for farmers: subsidies, long-term schemes
- Rewetting difficult + expensive on small scale in drained landscape and in nature reserves → *upscaling to polder – landscape scale !!!*

Geurts, van Duinen e.a. 2019. Recognize the high potential of paludiculture on rewetted peat soils to mitigate climate change.
Landbauforschung.



Estimate GHG emission: GEST-approach (Couwenberg et al. 2011)

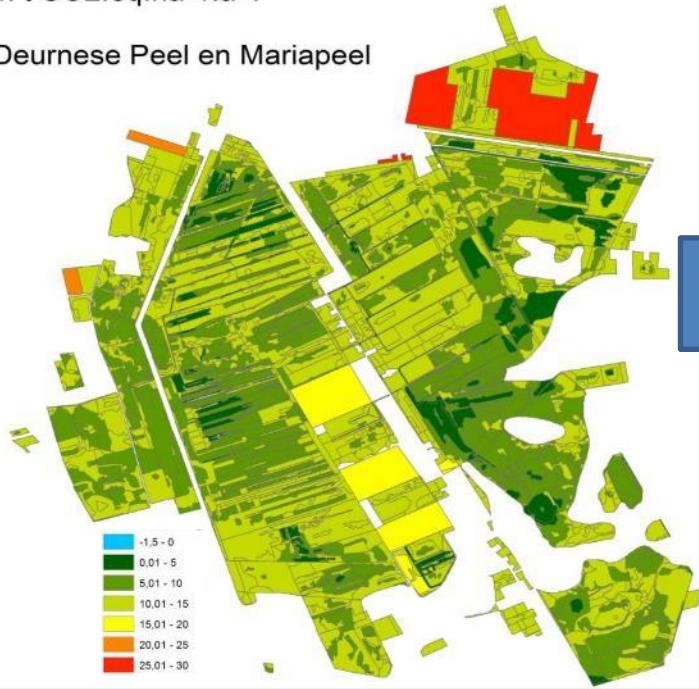


* **Greenhousegas Emission Site Types:** Couwenberg et al. 2011. Assessing greenhouse gas emissions from peatlands using vegetation as a proxy. *Hydrobiologia* 674: 67–89.

Global warming potential

Global Warming Potential in 2005
in t CO₂.eq.ha-1.a-1

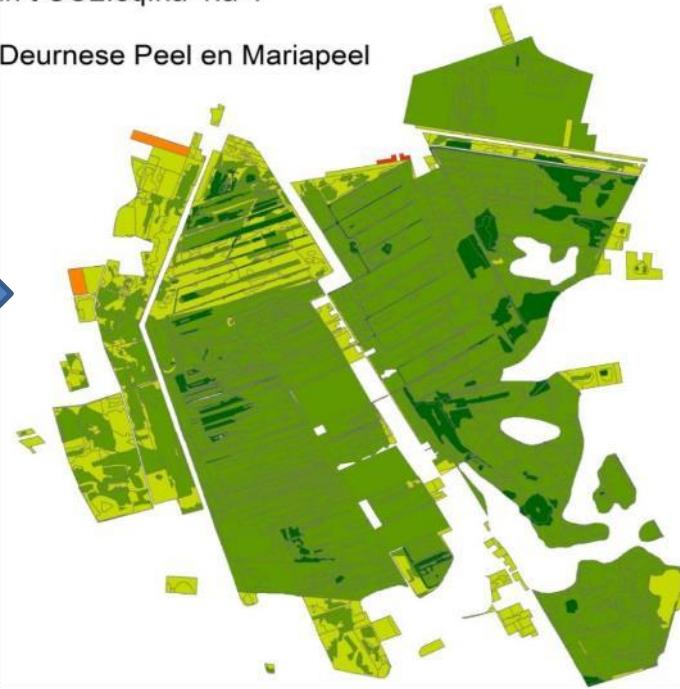
Deurnese Peel en Mariapeel



After
restoration

Global Warming Potential in 2040
in t CO₂.eq.ha-1.a-1

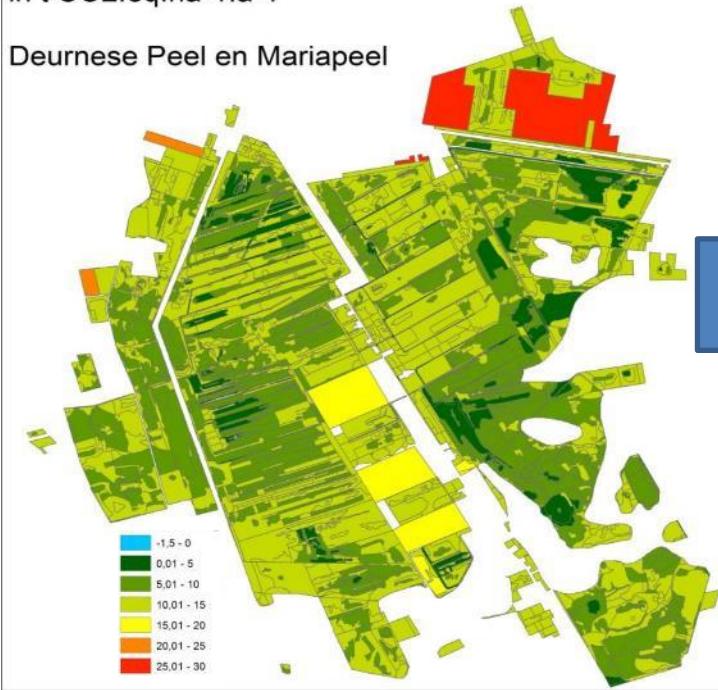
Deurnese Peel en Mariapeel



Global warming potential

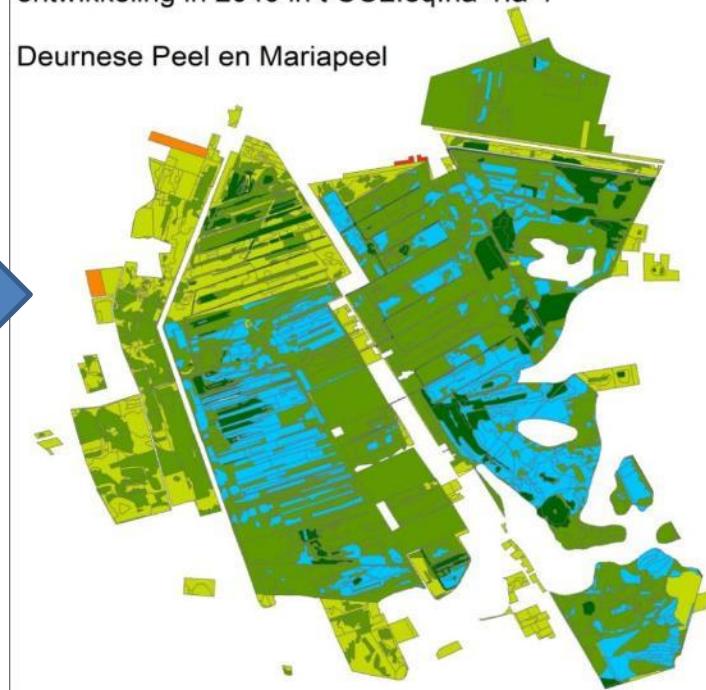
Global Warming Potential in 2005
in t CO₂.eq.ha-1.a-1

Deurnese Peel en Mariapeel



Global Warming Potential bij een optimale veenmos-ontwikkeling in 2040 in t CO₂.eq.ha-1.a-1

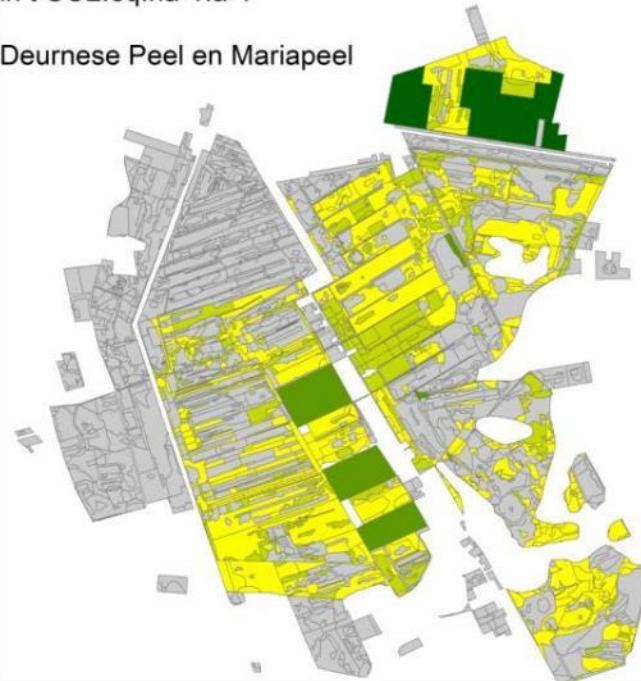
Deurnese Peel en Mariapeel



Reduction GHG emisison: 5-10 kton CO₂-eq/year (20-40%)

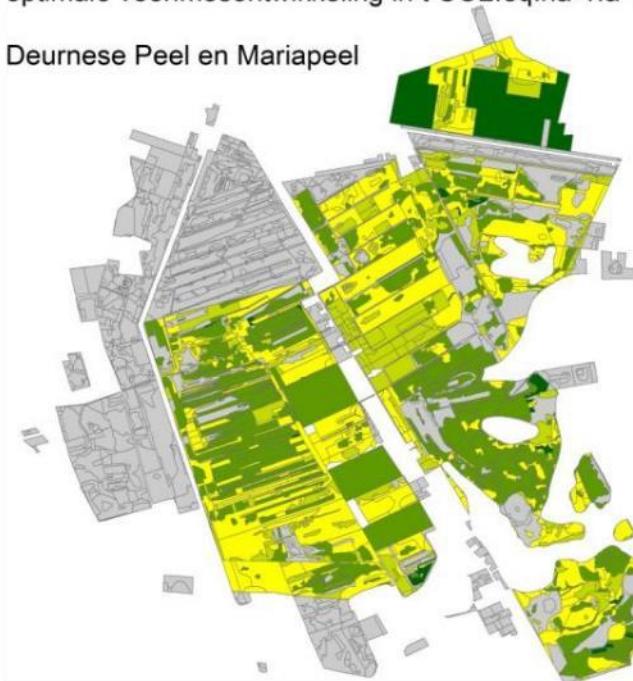
Change in Global Warming Potential in 2040
in t CO₂.eq.ha-1.a-1

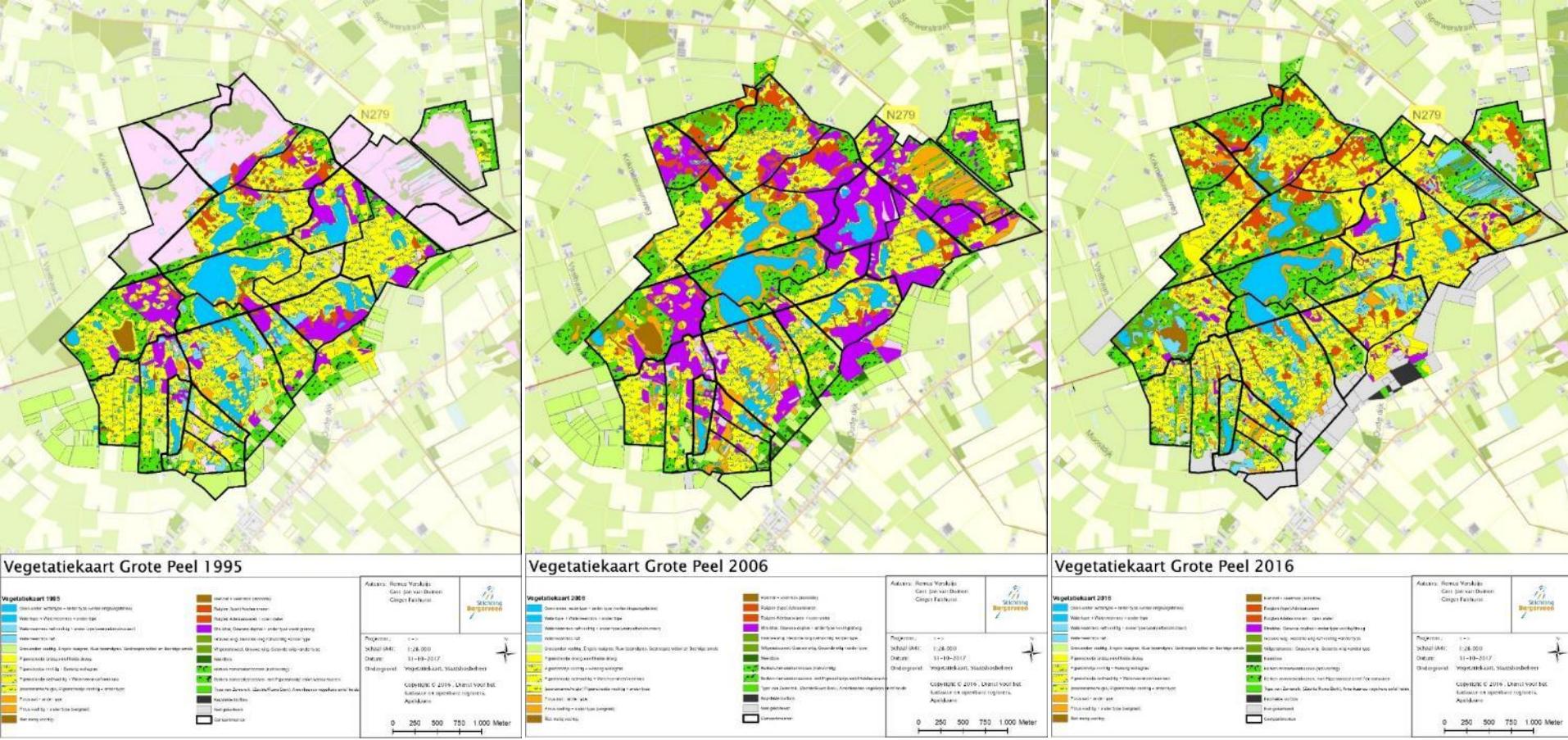
Deurnese Peel en Mariapeel

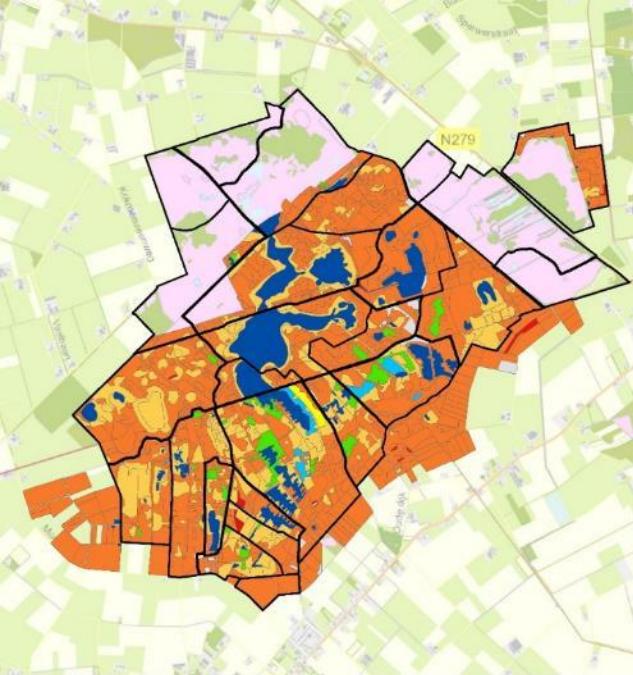


Change in Global Warming Potential in 2040 bij een
optimale veenmosontwikkeling in t CO₂.eq.ha-1.a-1

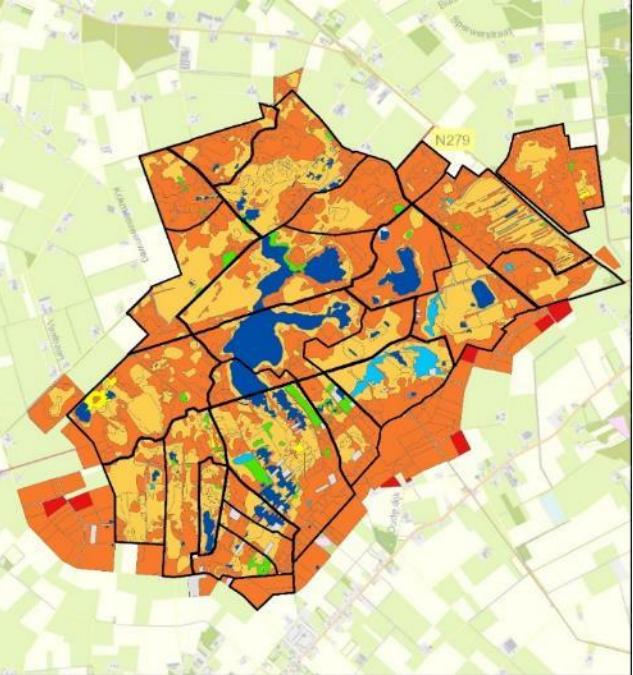
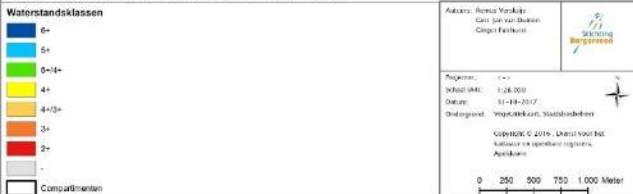
Deurnese Peel en Mariapeel



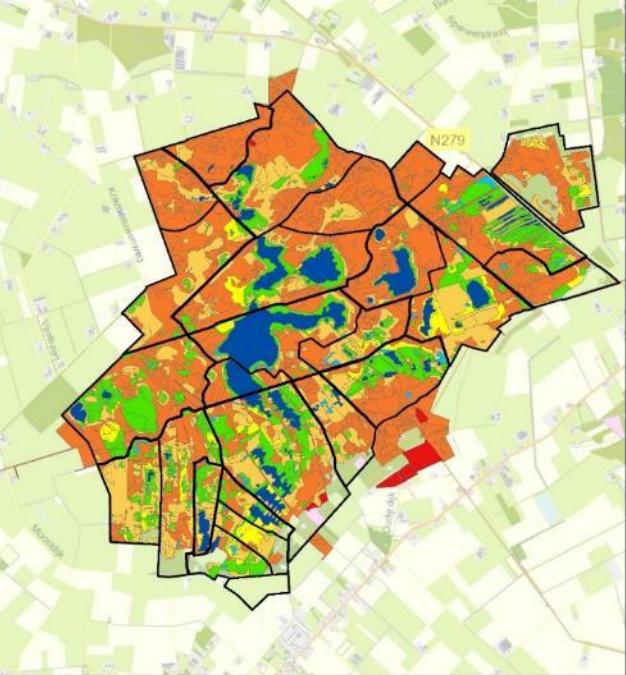
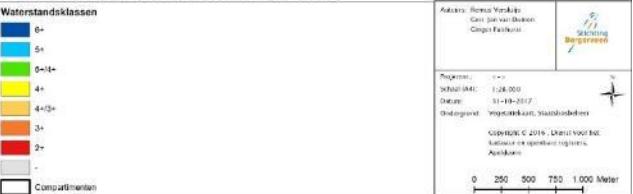




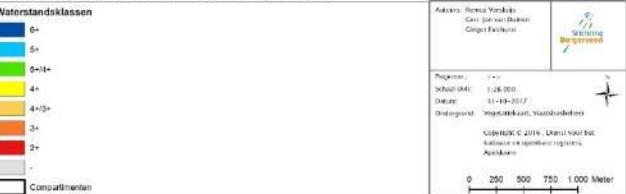
Waterstandsklassen Grote Peel 1995

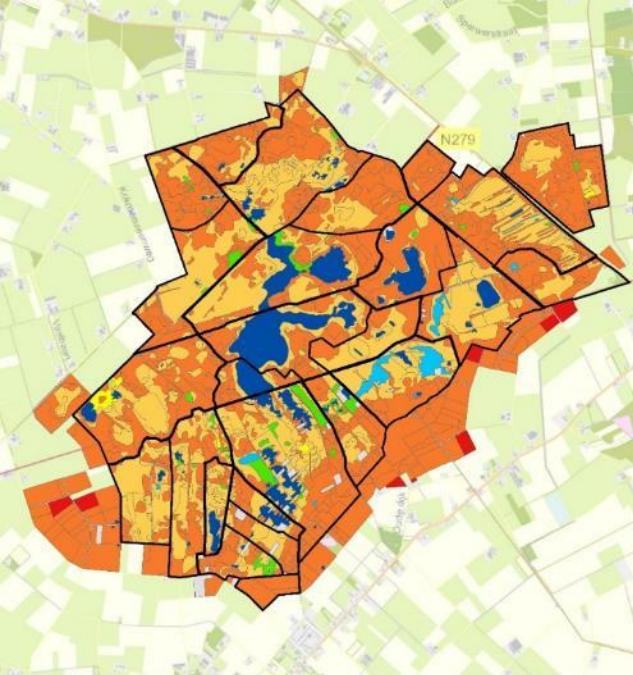


Waterstandsklassen Grote Peel 2006

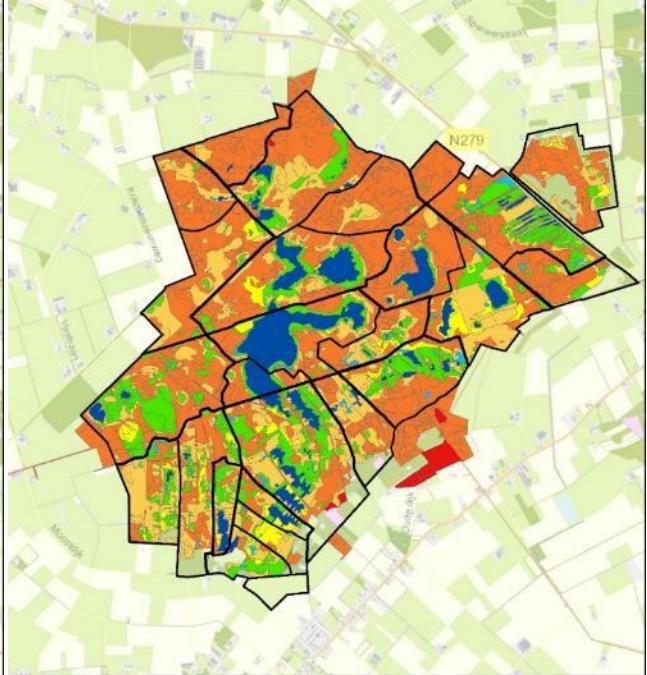
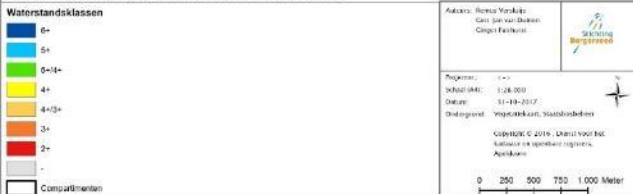


Waterstandsklassen Grote Peel 2016

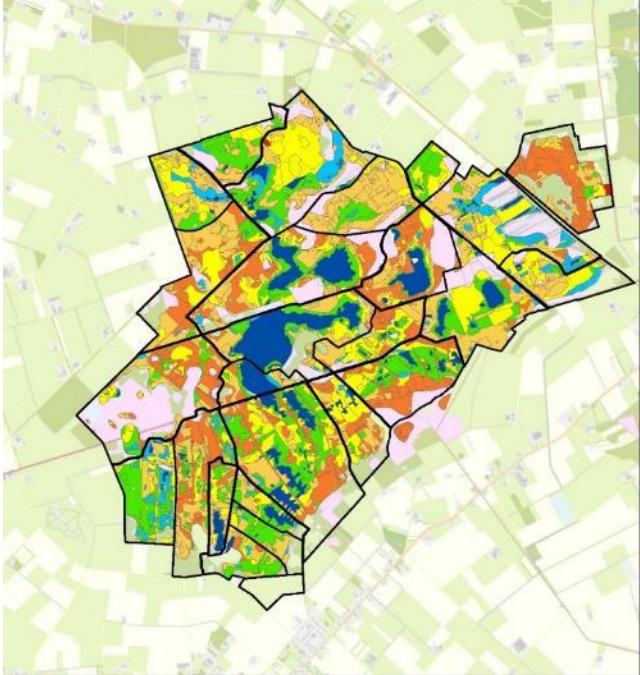
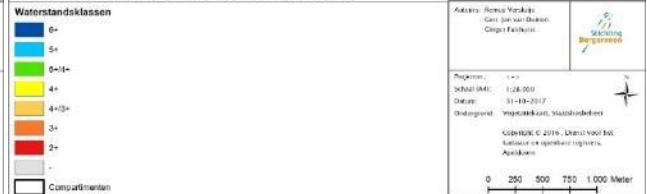




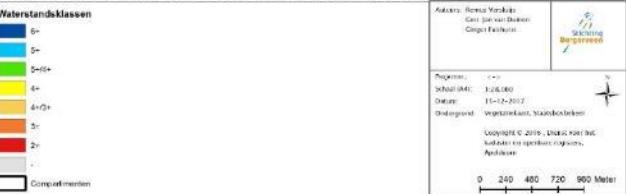
Waterstandsklassen Grote Peel 2006

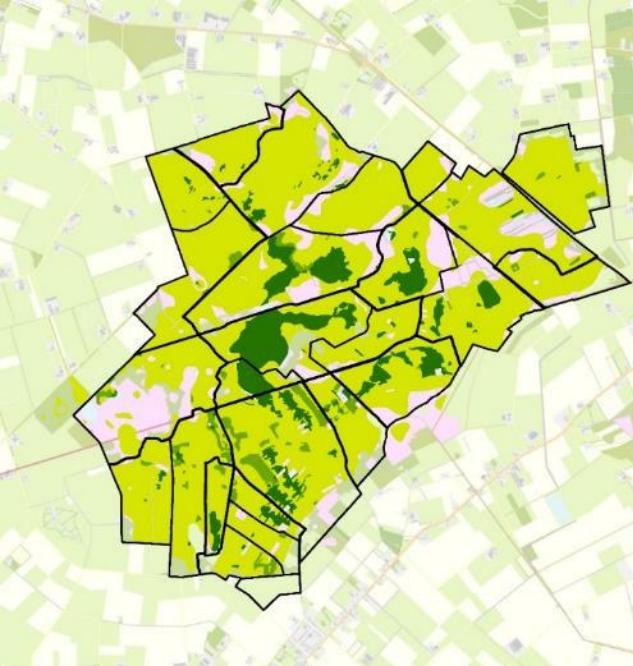


Waterstandsklassen Grote Peel 2016

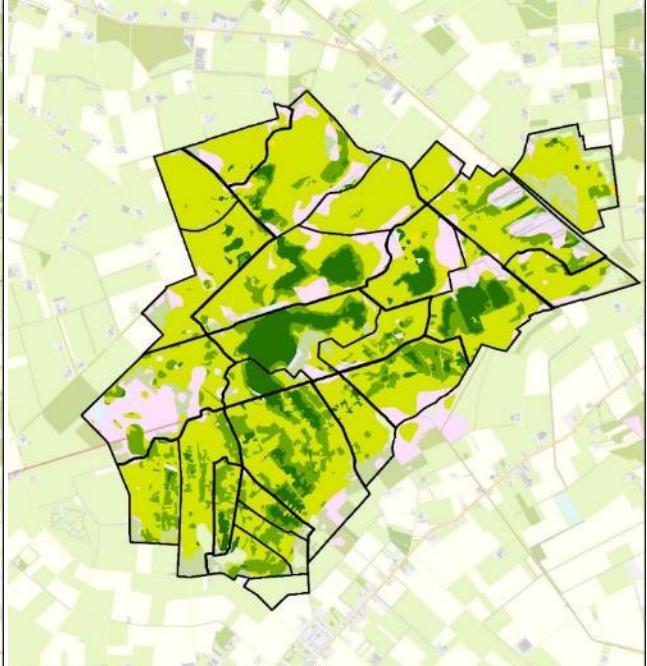
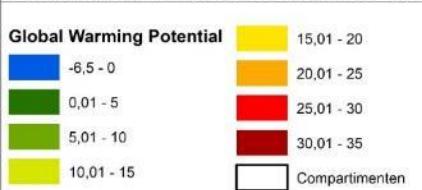


Waterstandsklassen in de Grote Peel, doelscenario 2050

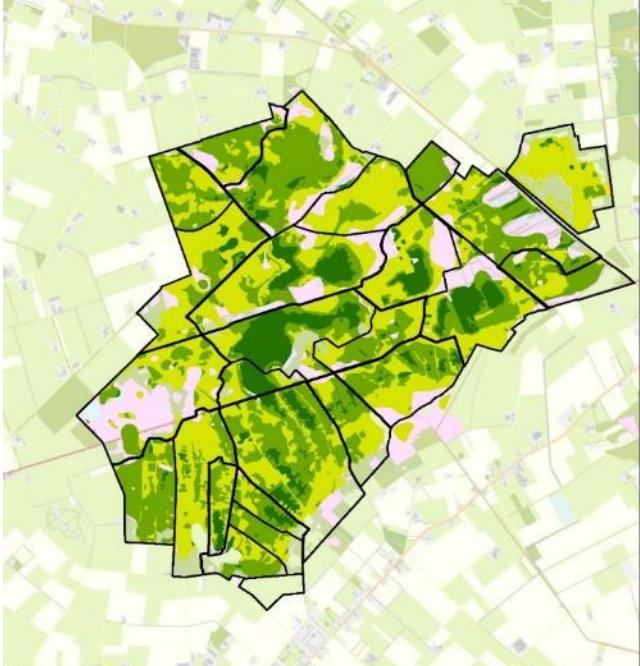
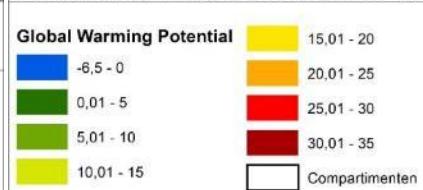




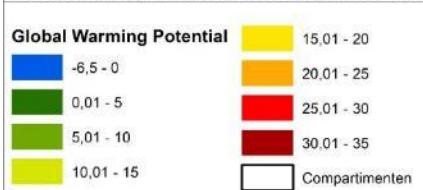
Global Warming Potential in t CO₂.eq.ha-1.a-1, Grote Peel 2006

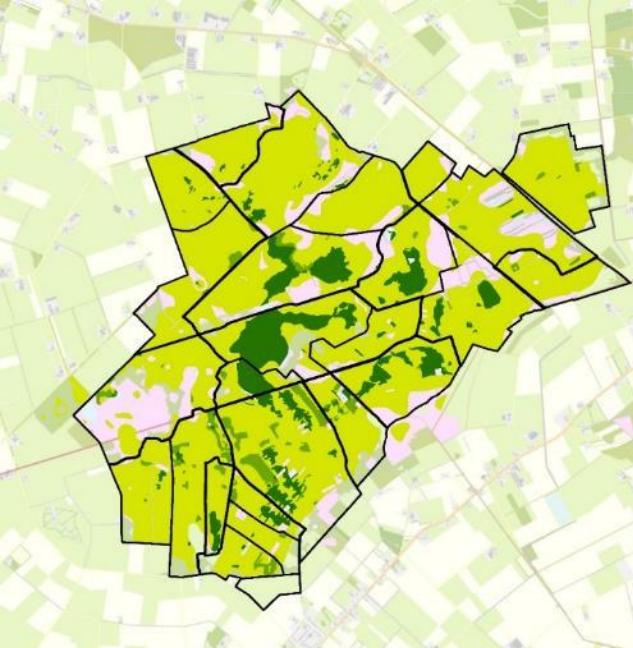


Global Warming Potential in t CO₂.eq.ha-1.a-1, Grote Peel 2016

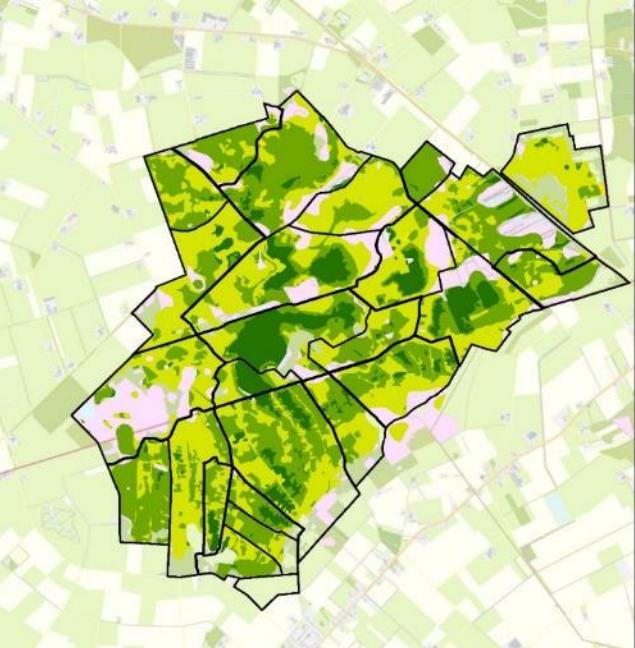
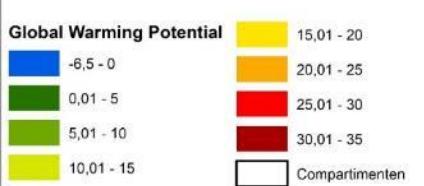


Global Warming Potential in t CO₂.eq.ha-1.a-1, Grote Peel 2050

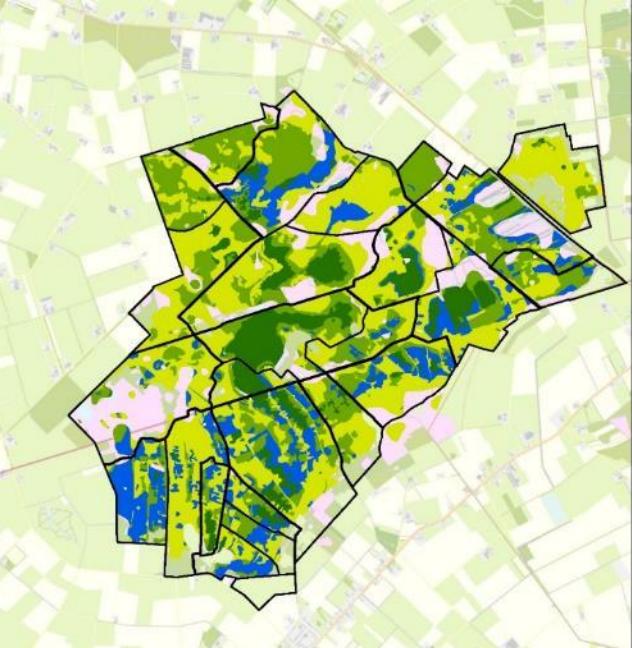
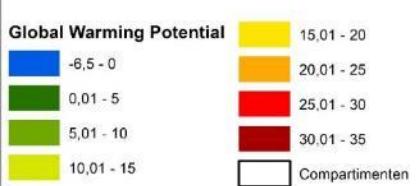




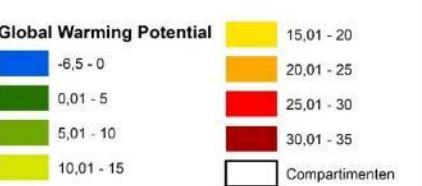
Global Warming Potential in t CO₂.eq.ha⁻¹.a⁻¹, Grote Peel 2006



Global Warming Potential in t CO₂.eq.ha⁻¹.a⁻¹, Grote Peel 2050



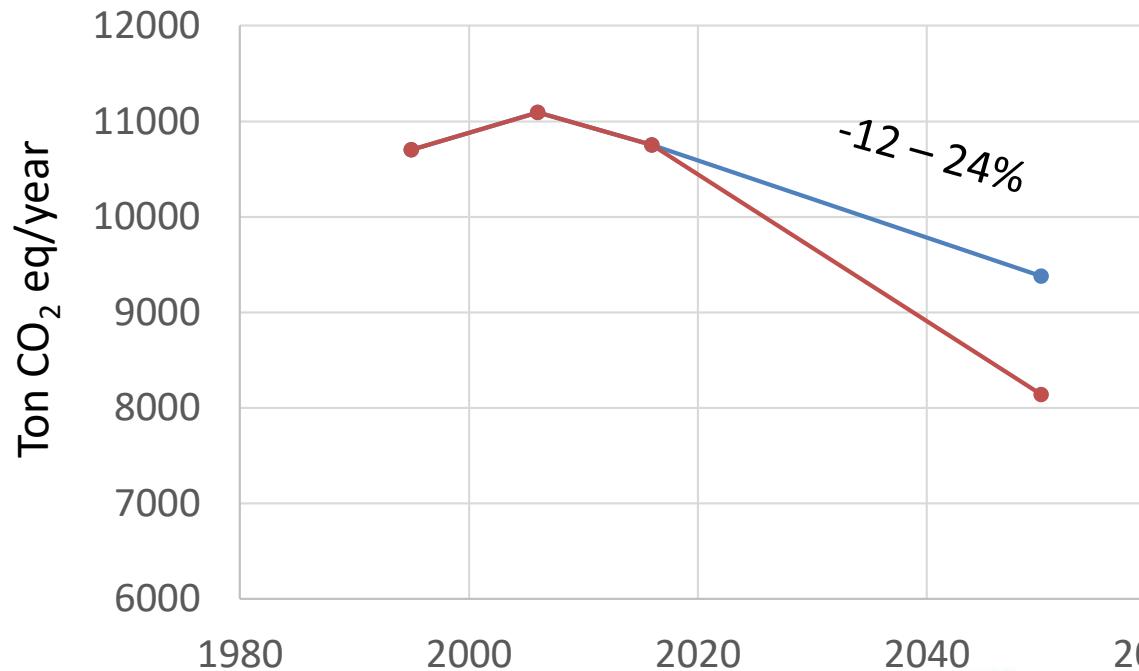
Global Warming Potential in t CO₂.eq.ha⁻¹.a⁻¹, Grote Peel 2050 Veenmos



Estimate GHG emission: GEST-approach (Couwenberg et al. 2011)

GHG emission (Global Warming Potential)

GWP Groote Peel



Rewetting: What's happening with the species?



Red-backed shrike



Cranberry fritillary

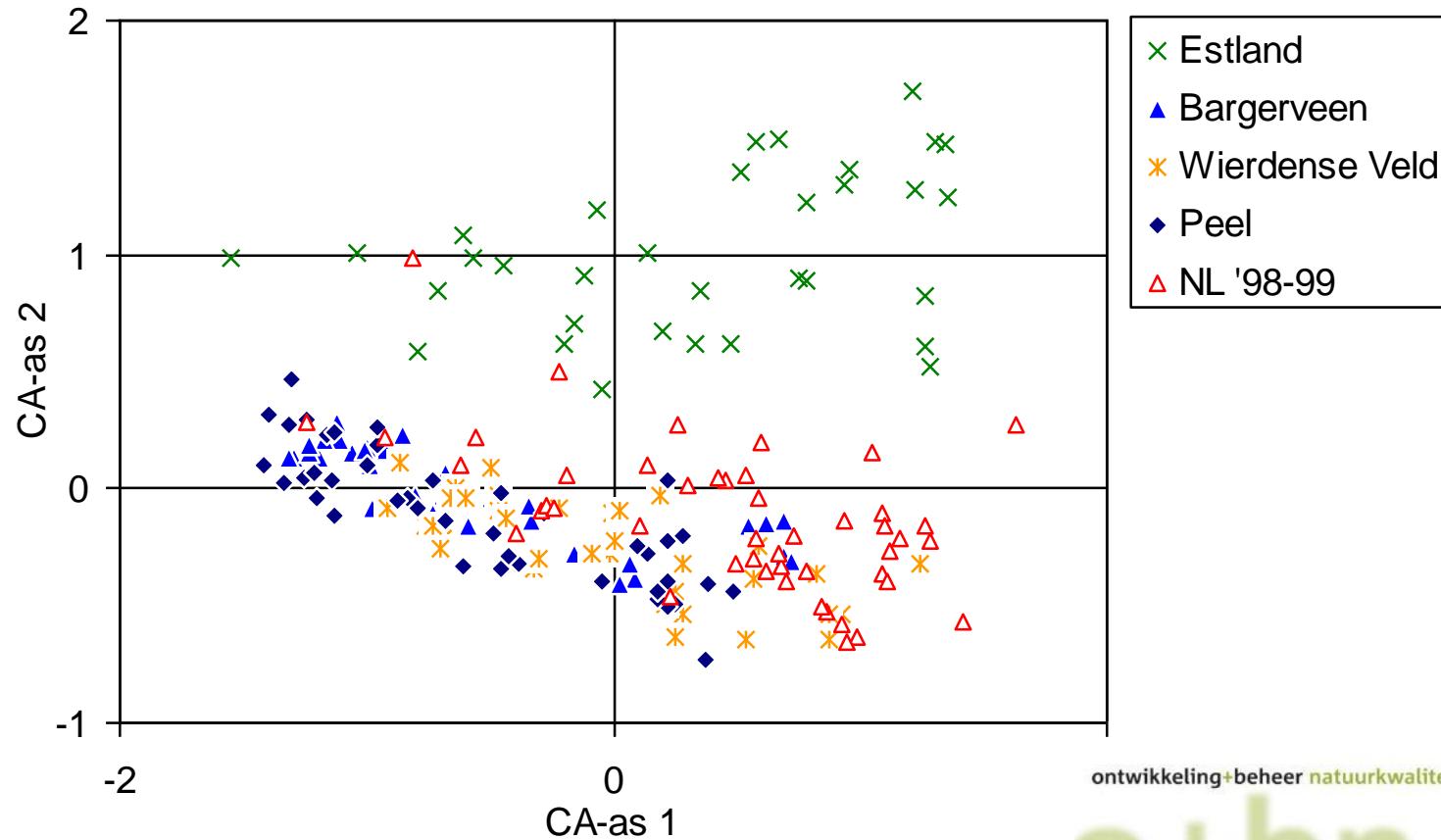


Somatochlora arctica





Species assemblage aquatic macro invertebrates





17 november 2016



7 november 2017



Mariapeel

(Land van Van Bommel)

→**Intense rewetting**
in winter 2017-2018

(Photos: P. van den Munckhof)

30 january 2018



12 february 2018

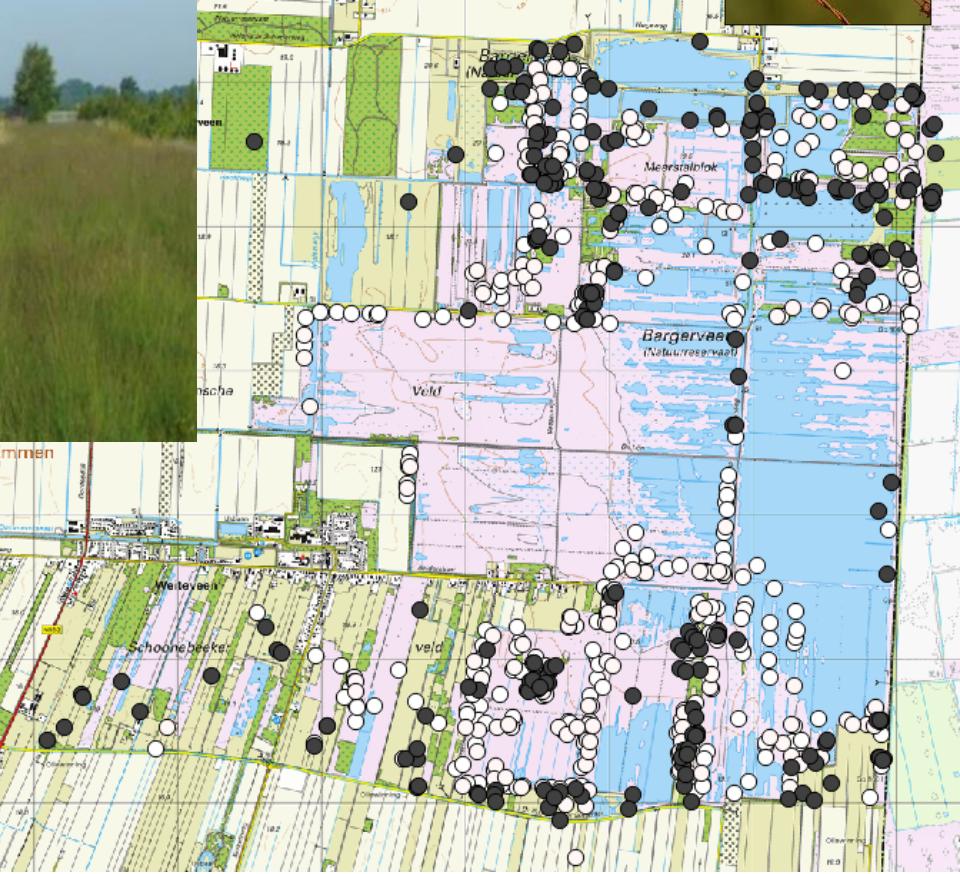




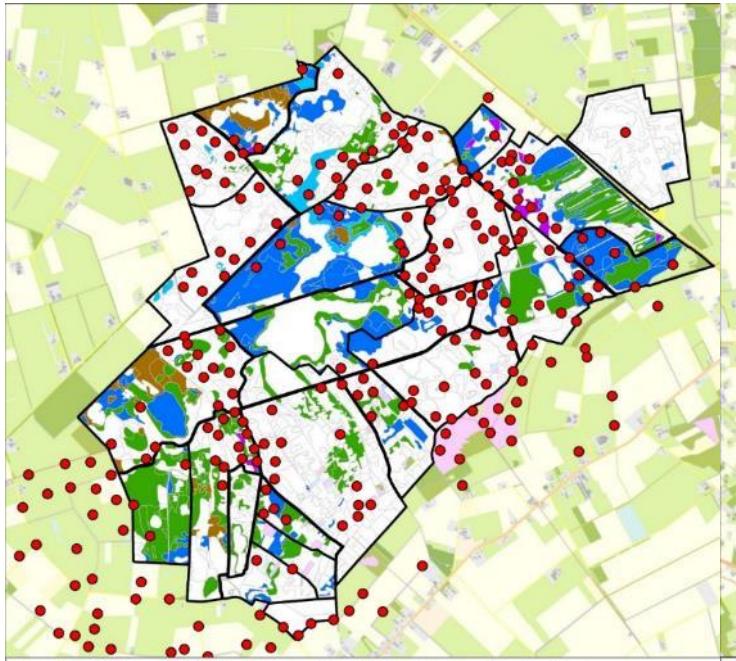
‘Disturbances’ inside reserves



Development Red-backed shrike: landscape scale!



Stonechat: increasing, profits from new nature development around bog. Might decrease inside bog remnant.



Roodborsttapuit 2016. Vegetatie-Waterstand, Grote Peel

Vegetatie

Idem

Voedselarme veenmosvegetatie

natter bos

vochtiger heide

natter

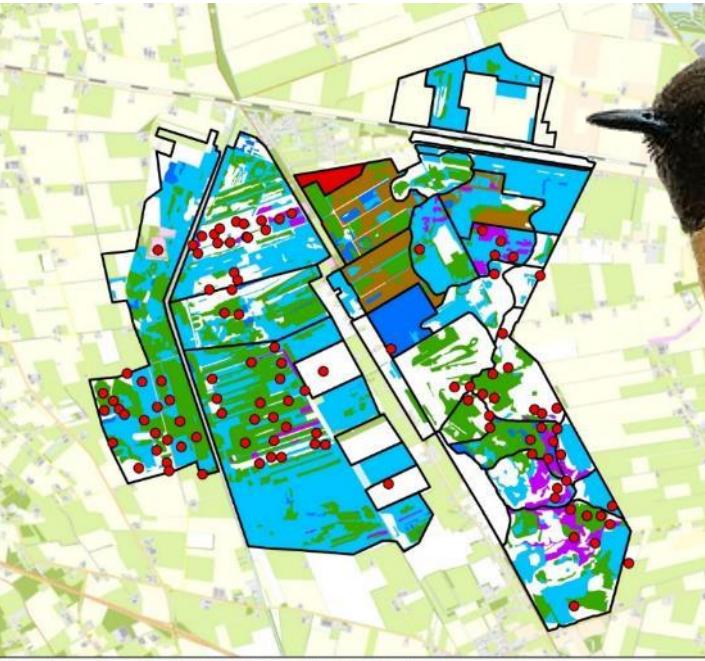
stabiel

● Roodborsttapuit, Territoria 2016

Auteurs: Remco Verduijz
Gert-Jan van Duinen
Rob Heijls (Natuurmonitoren)
Stichting Bergerven

Projectnr.: <-->
Schaal (1:10.000)
Datum: 15-2-2017
Ondergrond: Vegetatiekaart Staatsbosbeheer
NOF-Taunusdata

Copyright © 2016, Dienst voor het
kadaster en openbare registers,
Afdeling Kadaster



Roodborsttapuit 1998. Vegetatie-Waterstand

Mariapeel en Deurnse Peel

● Territoria 1998 (n=107)

Auteurs: Remco Verduijz
Gert-Jan van Duinen
Rob Heijls (Natuurmonitoren)
Stichting Bergerven

Projectnr.: <-->
Schaal (1:10.000)
Datum: 17-2-2017
Ondergrond: Vegetatiekaart Staatsbosbeheer
NOF-Taunusdata

Copyright © 2016, Dienst voor het
kadaster en openbare registers,
Afdeling Kadaster



Saxicola rubicola

[Van Duinen et al. 2018](#)

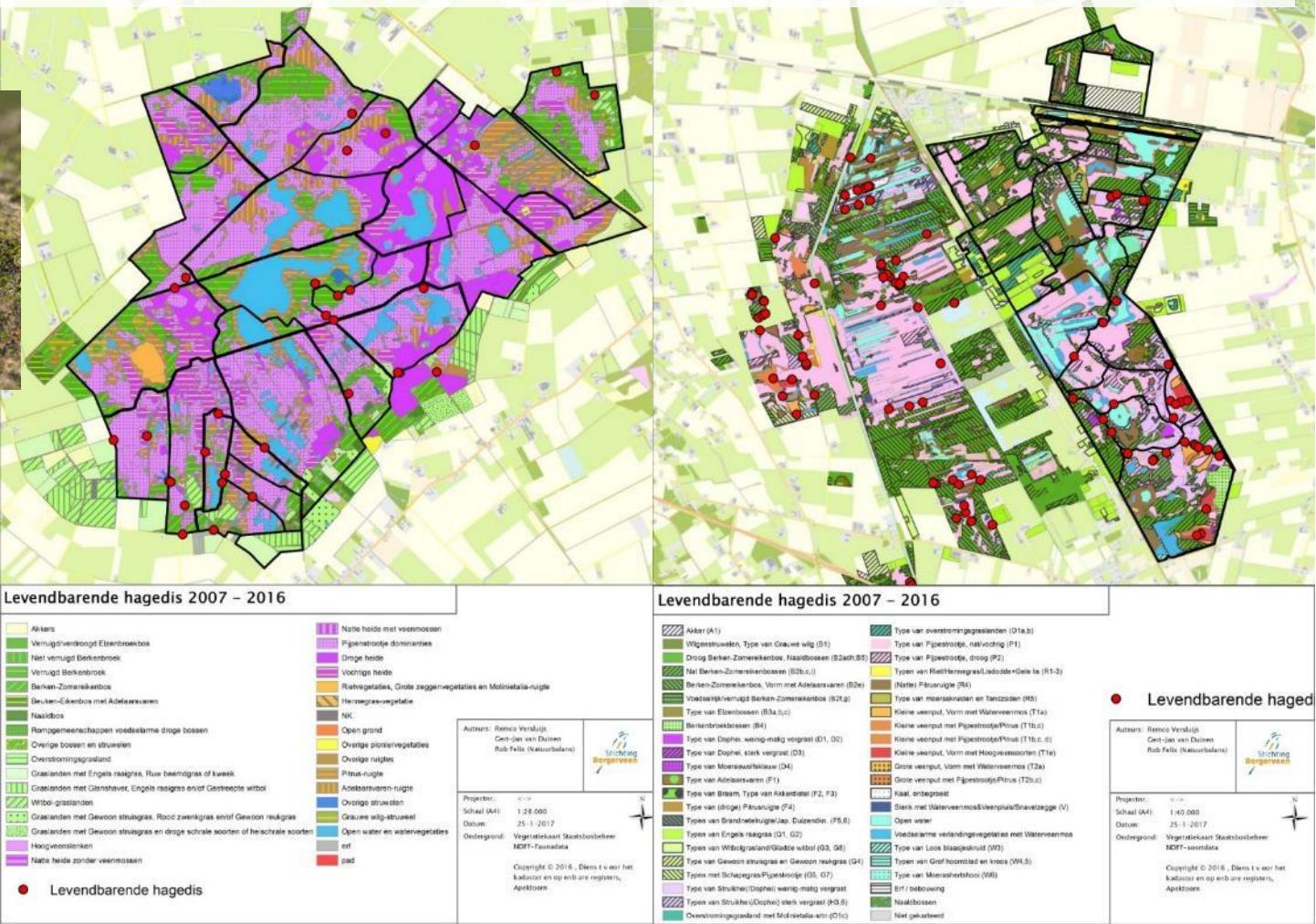


viviparous lizard: Small scaled heterogeneity, observed mainly near forest/bushes, but not in large open area



Zootoca vivipara

[Van Duinen et al. 2018](#)

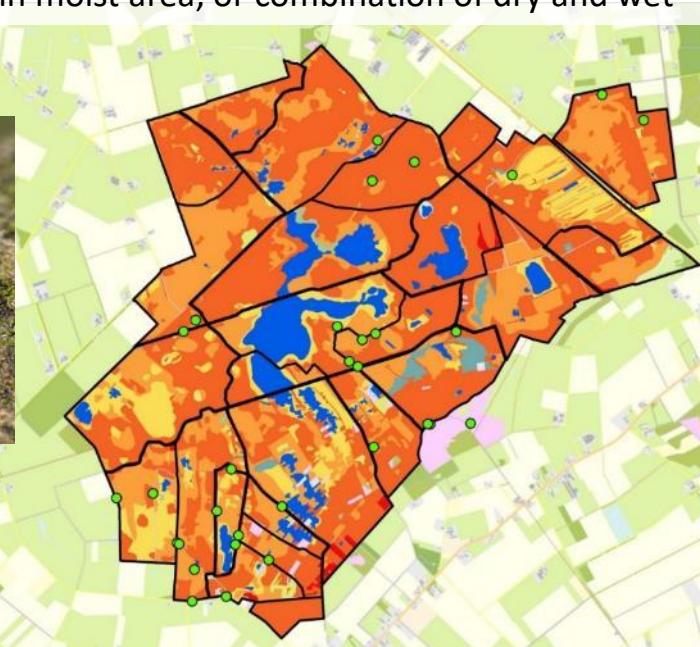


viviparous lizard: Mainly in moist area, or combination of dry and wet



Zootoca vivipara

[Van Duinen et al. 2018](#)



Levendbarende hagedis 2007–2016. Waterstanden 2006, Grote Peel

Waterstand in cm -mv

- >0 cm Boven maaiveld
- 0,01 - 10
- 10,01 - 20
- 20,01 - 30
- 30,01 - 40
- 40,01 - 50
- 50,01 - 60
- > 60 cm Onder maaiveld

● Levendbarende hagedis



Levendbarende hagedis 2007–2016. Waterstand 2005

Waterstand in cm-mv

- >0 cm Boven maaiveld
- 0,01 - 10
- 10,01 - 20
- 20,01 - 30
- 30,01 - 40
- 40,01 - 50
- 50,01 - 60
- > 60 cm Onder maaiveld

● Levendbarende hagedis

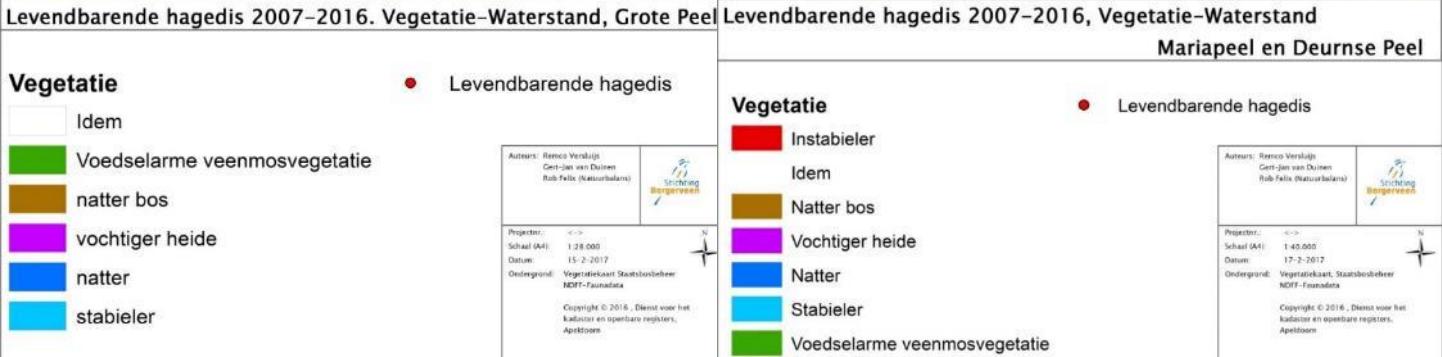
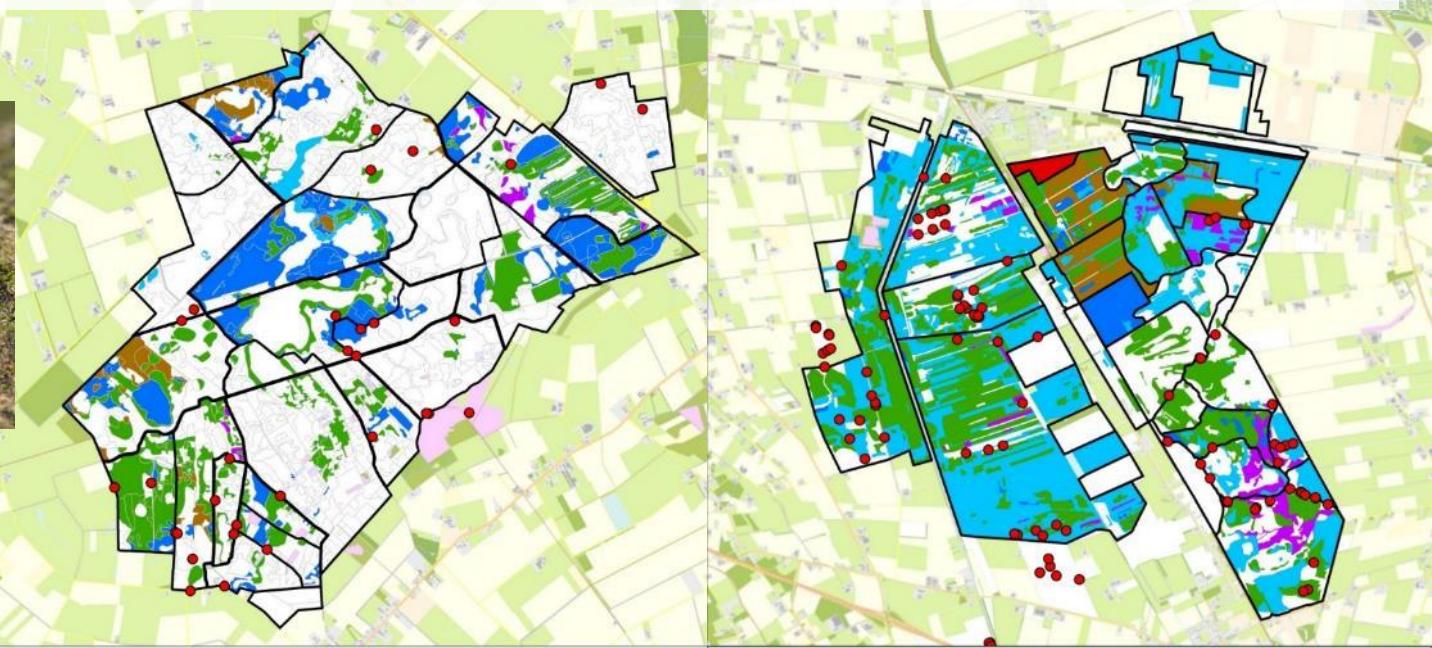


viviparous lizard: neutral or positive effects of measures. New nature valuable if reachable



Zootoca vivipara

[Van Duinen et al. 2018](#)



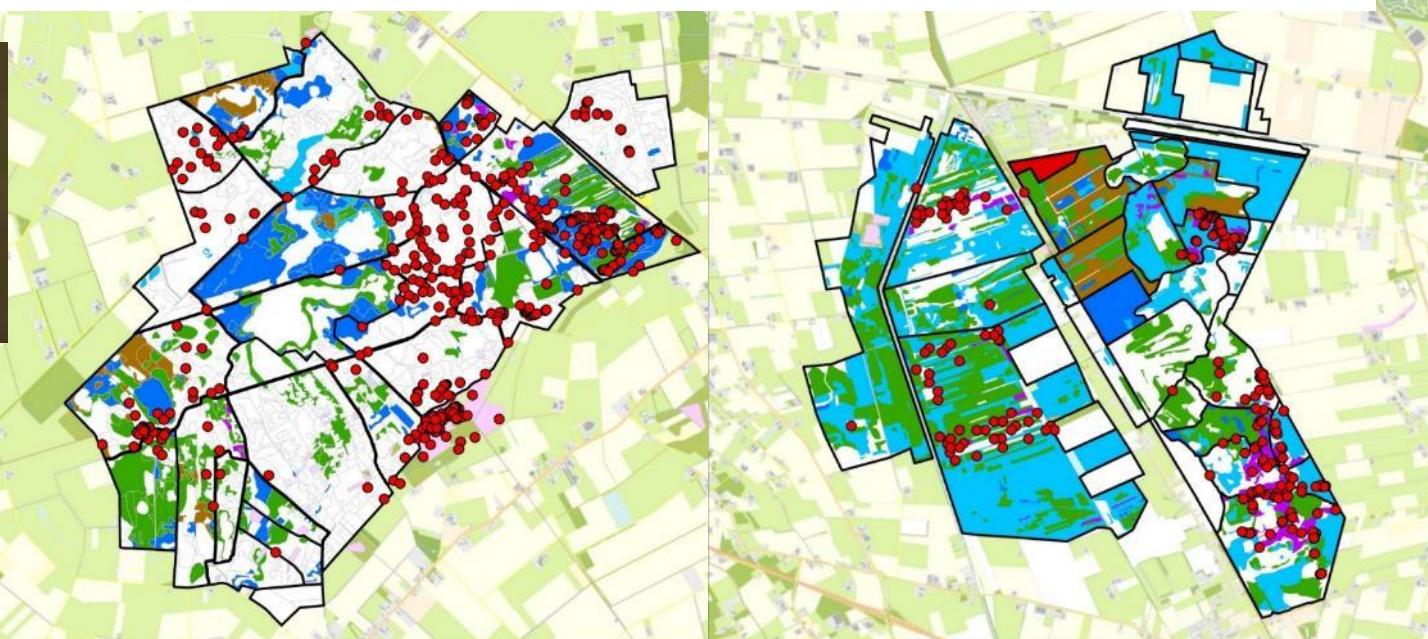
silver-studded blue: Development, improvement + conservation moist heath required



Plebejus argus

Photo: NEV - sectieThijssen

[Van Duinen et al. 2018](#)



Heideblauwtje 2007–2016. Vegetatie–Waterstand, Grote Peel

Vegetatie

- Idem
- Voedselarme veenmosvegetatie
- natter bos
- vochtiger heide
- natter
- stabiel

● Heideblauwtje

Autors:	Renco Versluij
Gert-Jan van Duinen	
Rob Felix (Natuurmonitoren)	
	Stichting Bergerveen
Projectnr.:	11-18
Schaal (1:4):	1:28.000
Datum:	15-2-2017
Ondergrond:	Vegetatiekaart Staatsbosbeheer NFI-T-faunadata
Copyright © 2016, Dienst voor het kadastrale en openbare registers, Apeldoorn	

Heideblauwtje 2007–2016, Vegetatie–Waterstand

Mariapeel en Deurnse Peel

Vegetatie

- Instabiel
- Idem
- Natter bos
- Vochtiger heide
- Natter
- Stabiel
- Voedselarme veenmosvegetatie

● Heideblauwtje

Autors:	Renco Versluij
Gert-Jan van Duinen	
Rob Felix (Natuurmonitoren)	
	Stichting Bergerveen
Projectnr.:	11-18
Schaal (1:4):	1:40.000
Datum:	17-2-2017
Ondergrond:	Vegetatiekaart Staatsbosbeheer NFI-faunadata
Copyright © 2016, Dienst voor het kadastrale en openbare registers, Apeldoorn	

Copyright © 2016, Dienst voor het kadastrale en openbare registers, Apeldoorn





Zoekgebieden ontwikkeling en behoud/herstel kwaliteit van heide



Beheer t.b.v. Kraanvogel

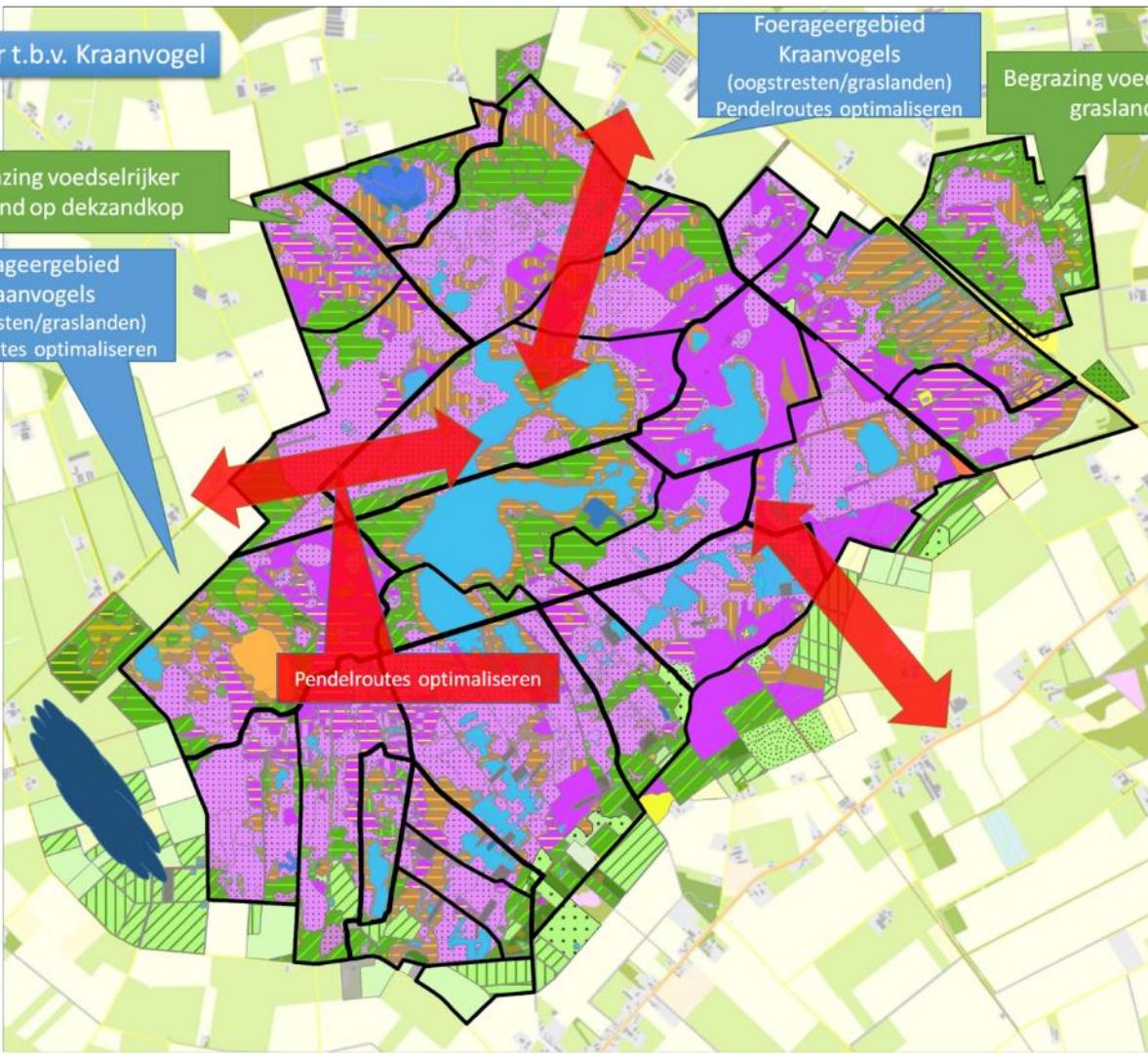
Foageergebied
Kraanvogels
(oogstresten/graslanden)
Pendelroutes optimaliseren

Begrazing voedselrijkere
graslandjes

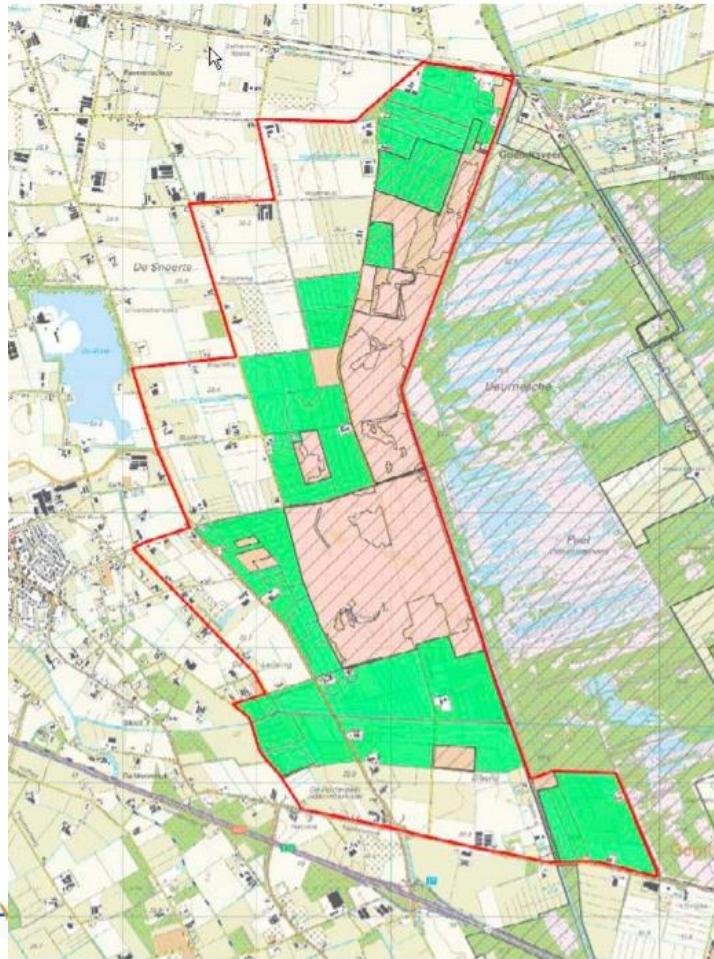
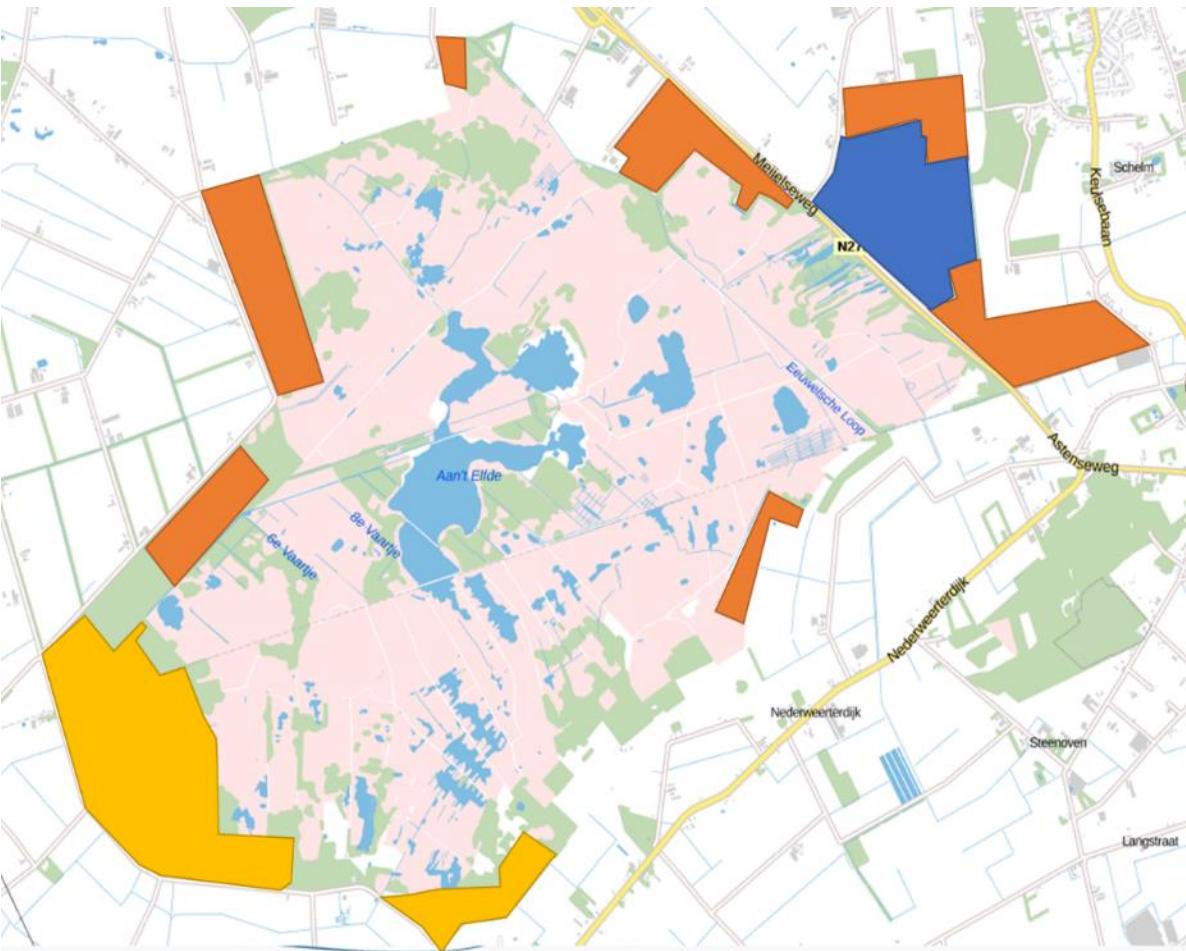
Begrazing voedselrijker
grasland op dekzandkop

Foageergebied
Kraanvogels
(oogstresten/graslanden)
Pendelroutes optimaliseren

Pendelroutes optimaliseren



Buffer zones: further improvement hydrological situation



... also potential for species richer edges.





... paludiculture (short/long term)







... paludiculture (short/long term)



Thank you ...



... for your attention !

