Climate change

How predictable are water and vegetation?
A case study of the Netherlands

Flip Witte

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Climate change: temperature rise
Southern species appear, Northern species disappear
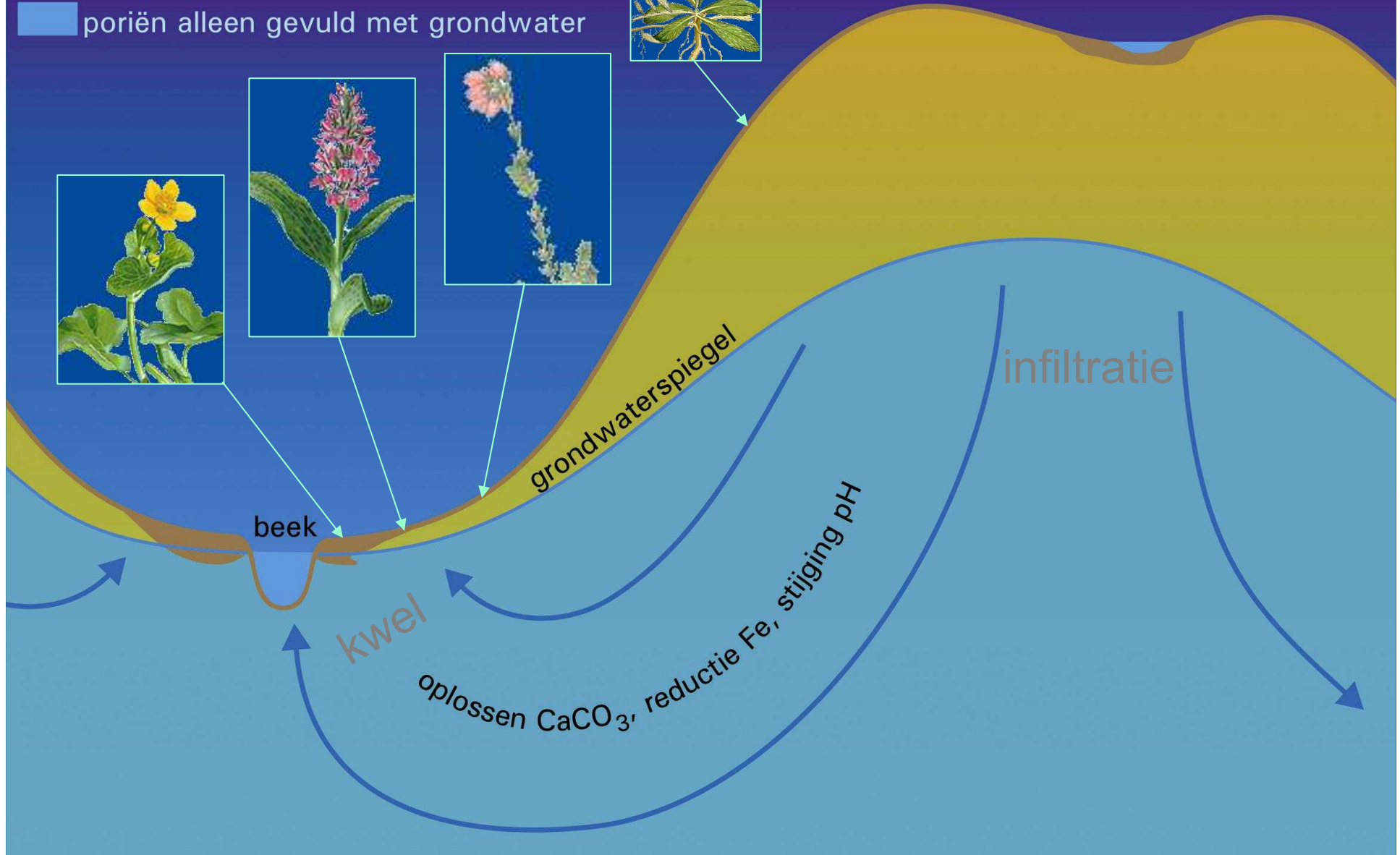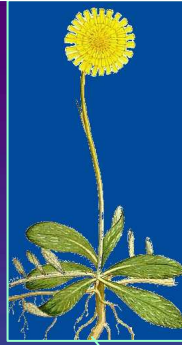
Eragrostis pilosa

Pedicularis palustris
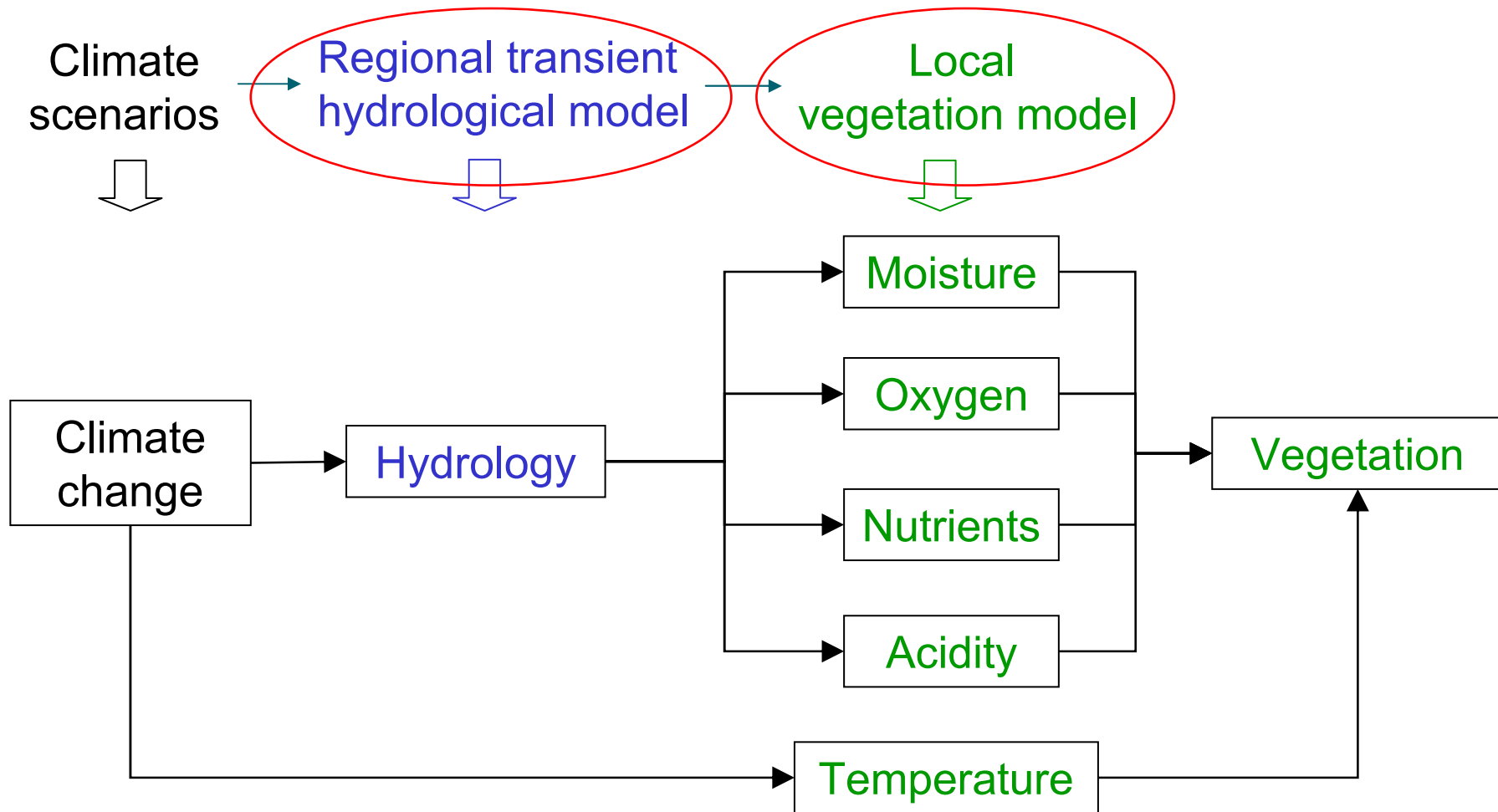
Crithmum maritimum

Cornus suecica

oppervlaktewater
veenachtige bodem
grondporiën gevuld met water én lucht
poriën alleen gevuld met grondwater

beek

grondwaterspiegel

infiltratie

kwel

oplossen $CaCO_3$, reductie Fe, stijging pH

Effects of climate change on natural vegetation

How climate robust are these models?

Climate scenarios → Regional transient hydrological model → Local vegetation model

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Climate change → Hydrology → Moisture
                           → Oxygen      → Vegetation
                           → Nutrients
                           → Acidity
Climate change → Temperature → Vegetation
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Hydrological modelling

Climate Scenario W+ for 2050

mm/y

Precipitation P — 2000 2050

Evapot. ET ref (Makkink) — 2000 2050
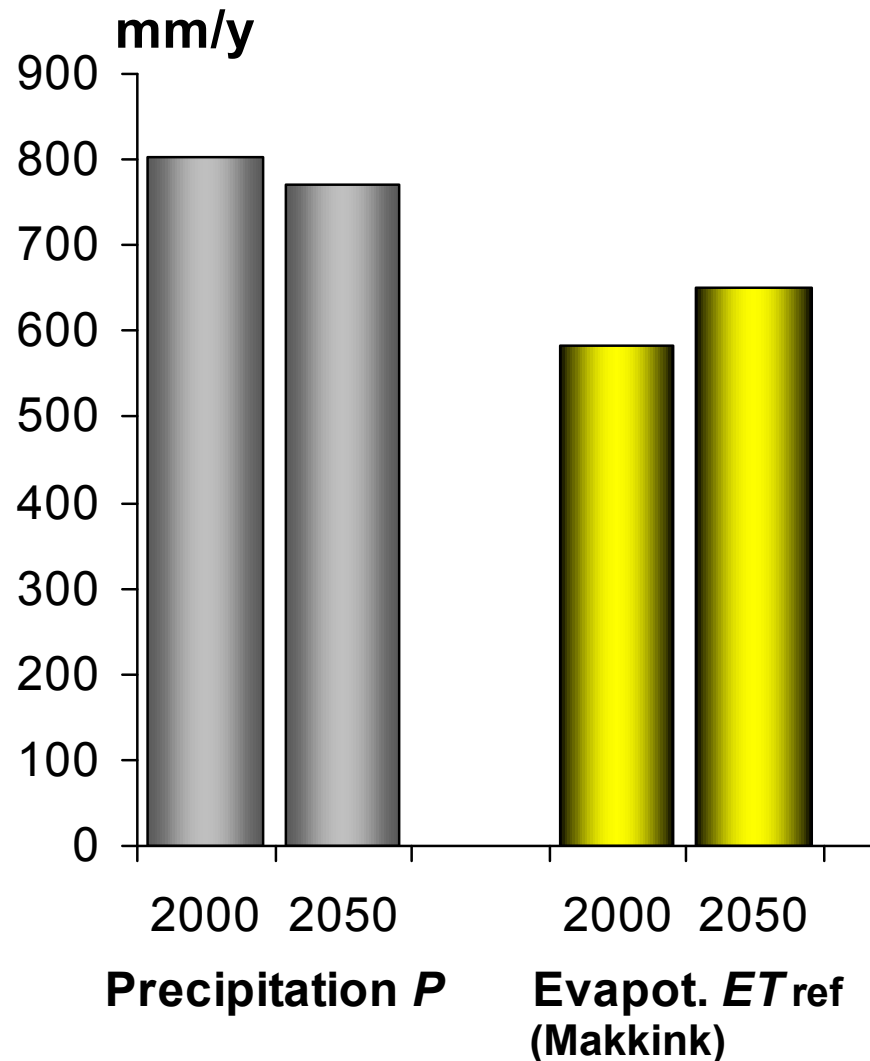
Scenario W+
- Based on IPCC GCMs
- Global temperature rise of 2 °K
- Changed air circulation patterns
- More rain in winter, drier summers

How vegetation saves water: $ET_{act} < ET_{pot}$

Three feedbacks of vegetation to climate change:

1. **Closing of stomata in response to drought**

2. **$CO_2\uparrow \rightarrow$ transpiration $T\downarrow$**

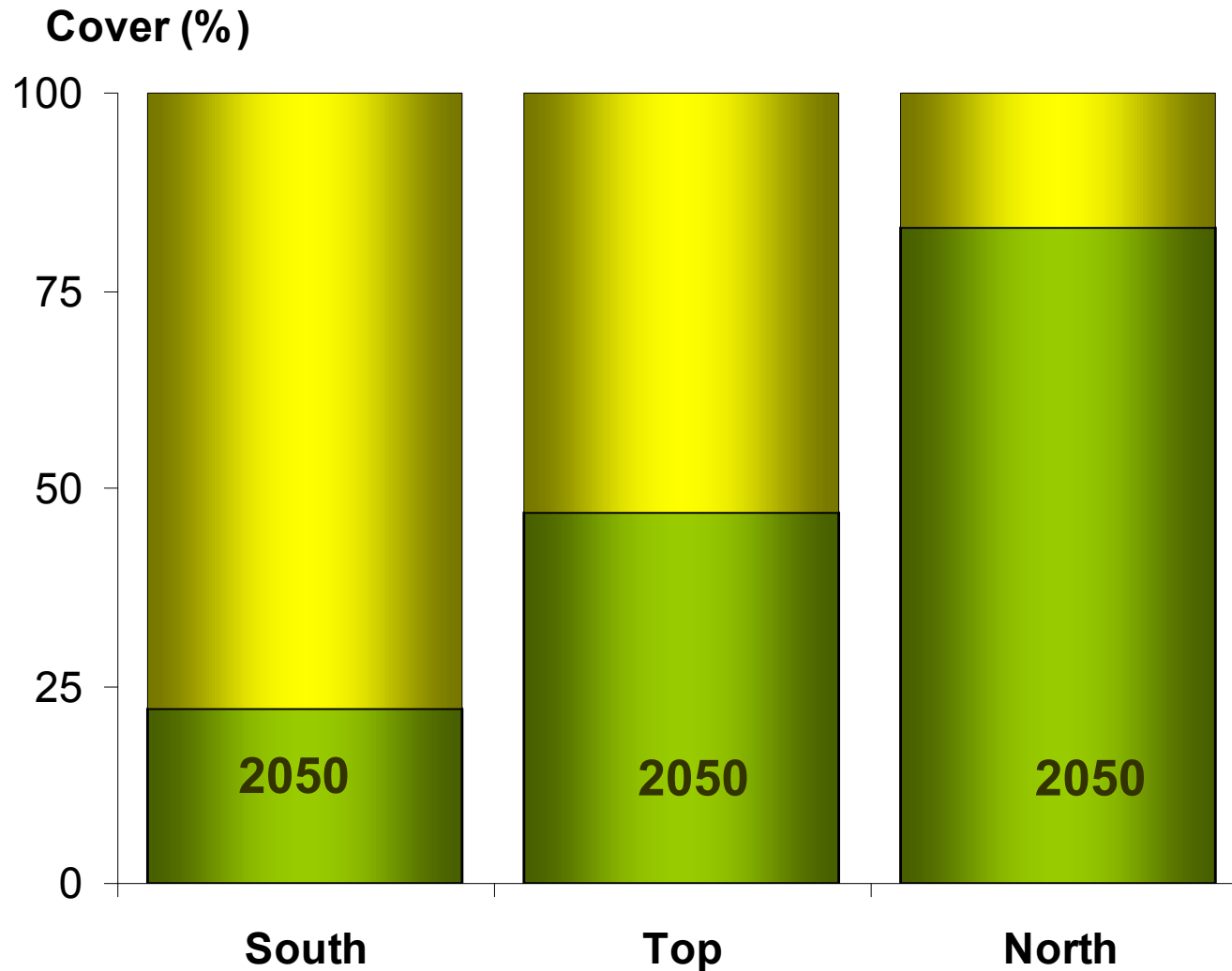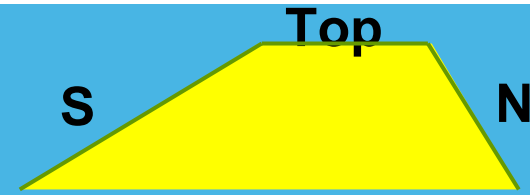3. **Reduction of vegetation cover in response to drought**

Feedbacks 1, 2 and 3 are changes of vegetation characteristics, not accounted for in current hydrological models

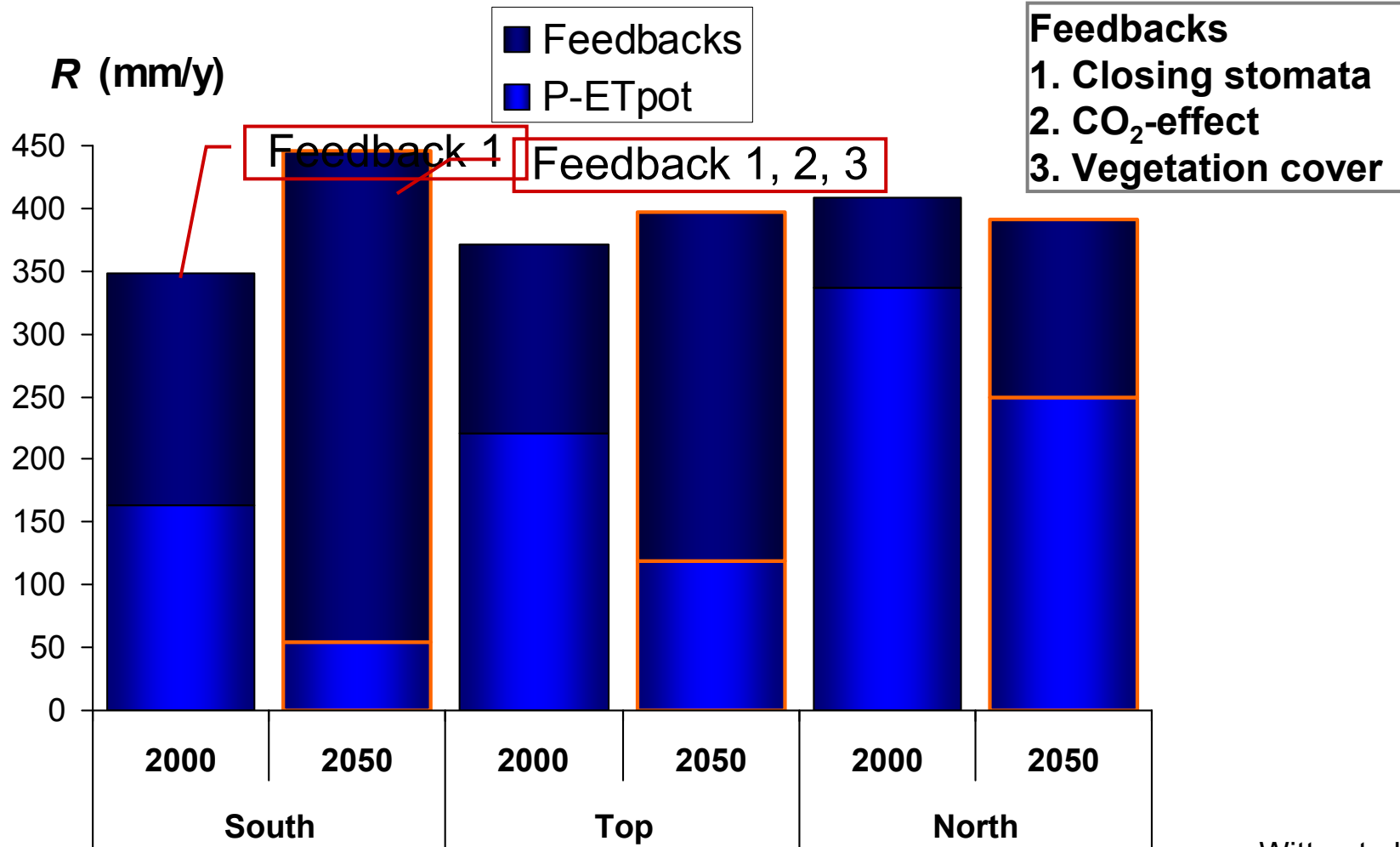# Feedback to drought: more bare soil and mosses

Vegetation cover (W+)
S, Top and E slope of a dune

Cover (%)

South   Top   North

Witte et al., 2008

Groundwater recharge 2050 — W+ scenario. Witte et al., 2008
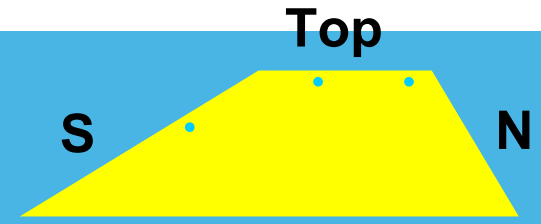
Vegetation modelling

Predictive vegetation models
Distribution of vegetation types in the current climate

Occurence probability
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00

10   0   10   20   Kilometers

Moerasvaren-Elzenbroekbos
Thelypterido-Alnetum
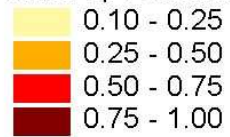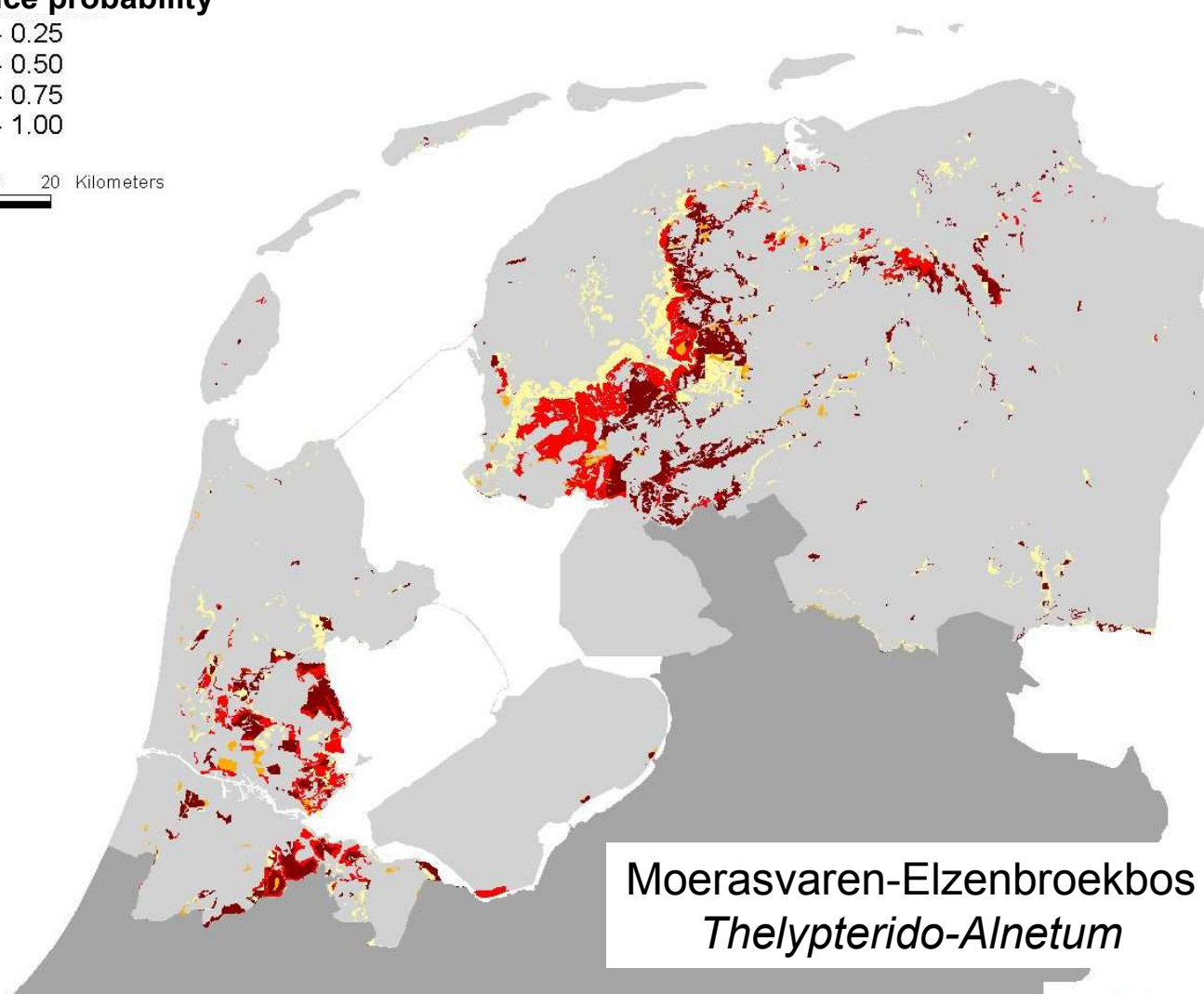
Observed climate change: more precipitation in the NL
What is the cause?

30 year backward moving avareage (mm/yr)

30 year backward moving avareage (mm/yr)

$y = 4.8393x^2 - 41.538x + 824.58$

$R^2 = 0.88$

2007

1970

1990   2000

1980

1960

1940

1950

women in the Netherlands (million)
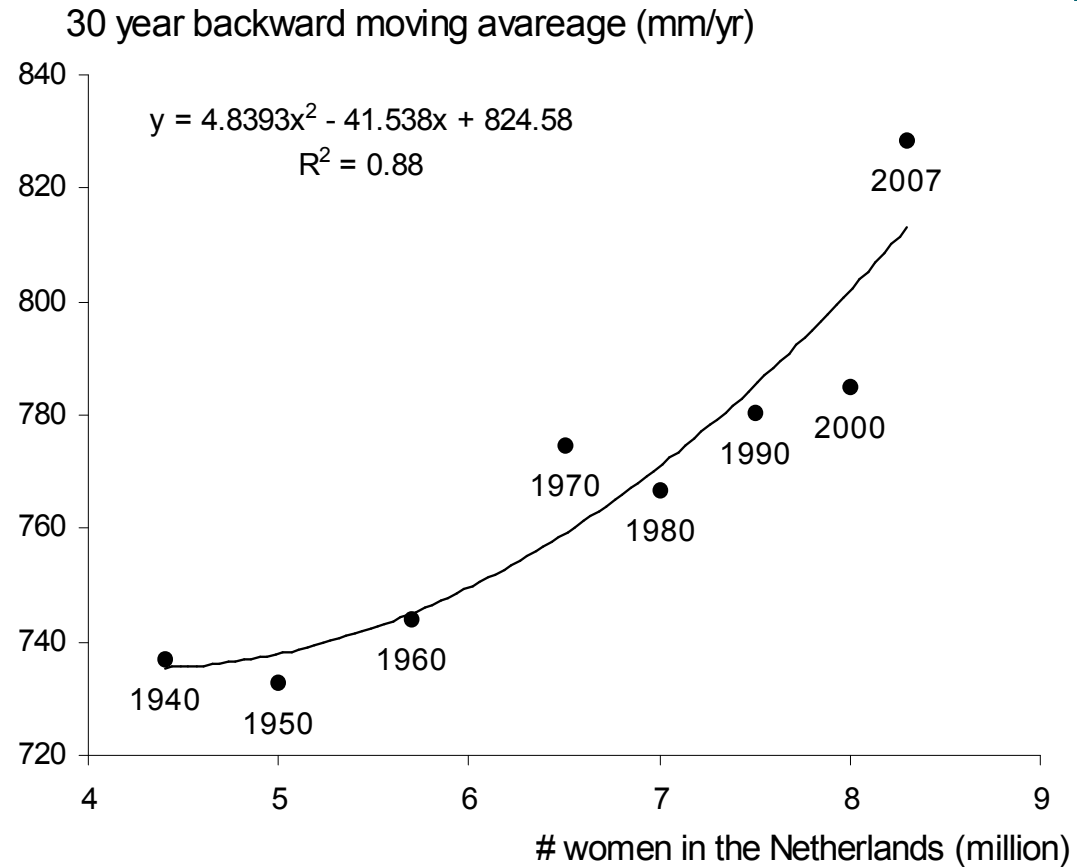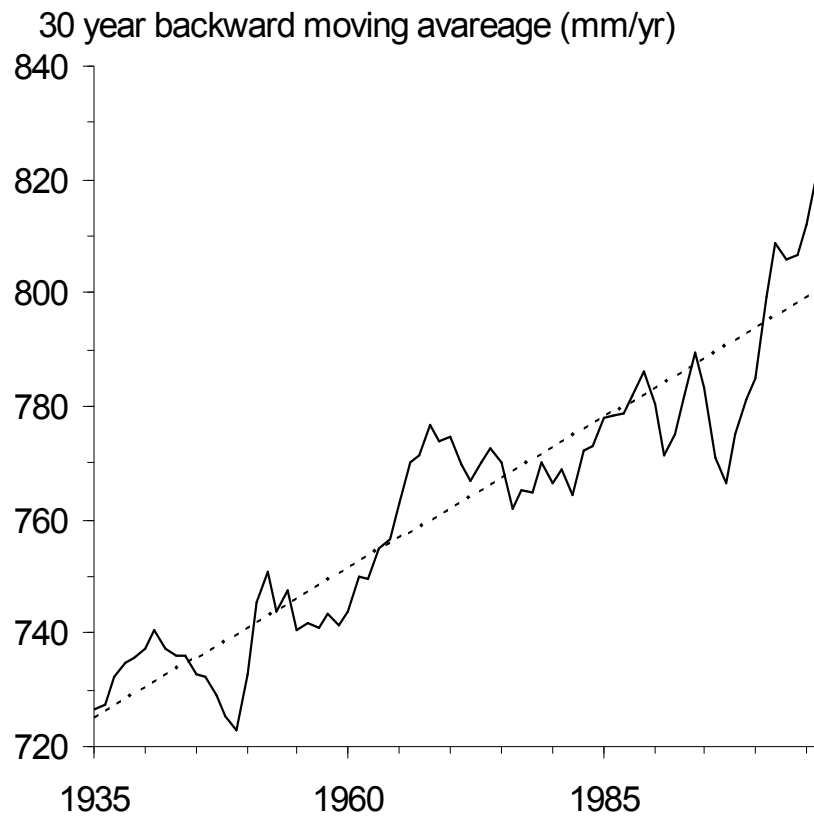
Correlative relationships
Beware with extrapolations

Average indicator value Fm

Leontodon autumnalis

Lysimachia thyrsiflora

F=3.2

F=1.7

Mean Spring groundwater level *MSL* (cm – surface)

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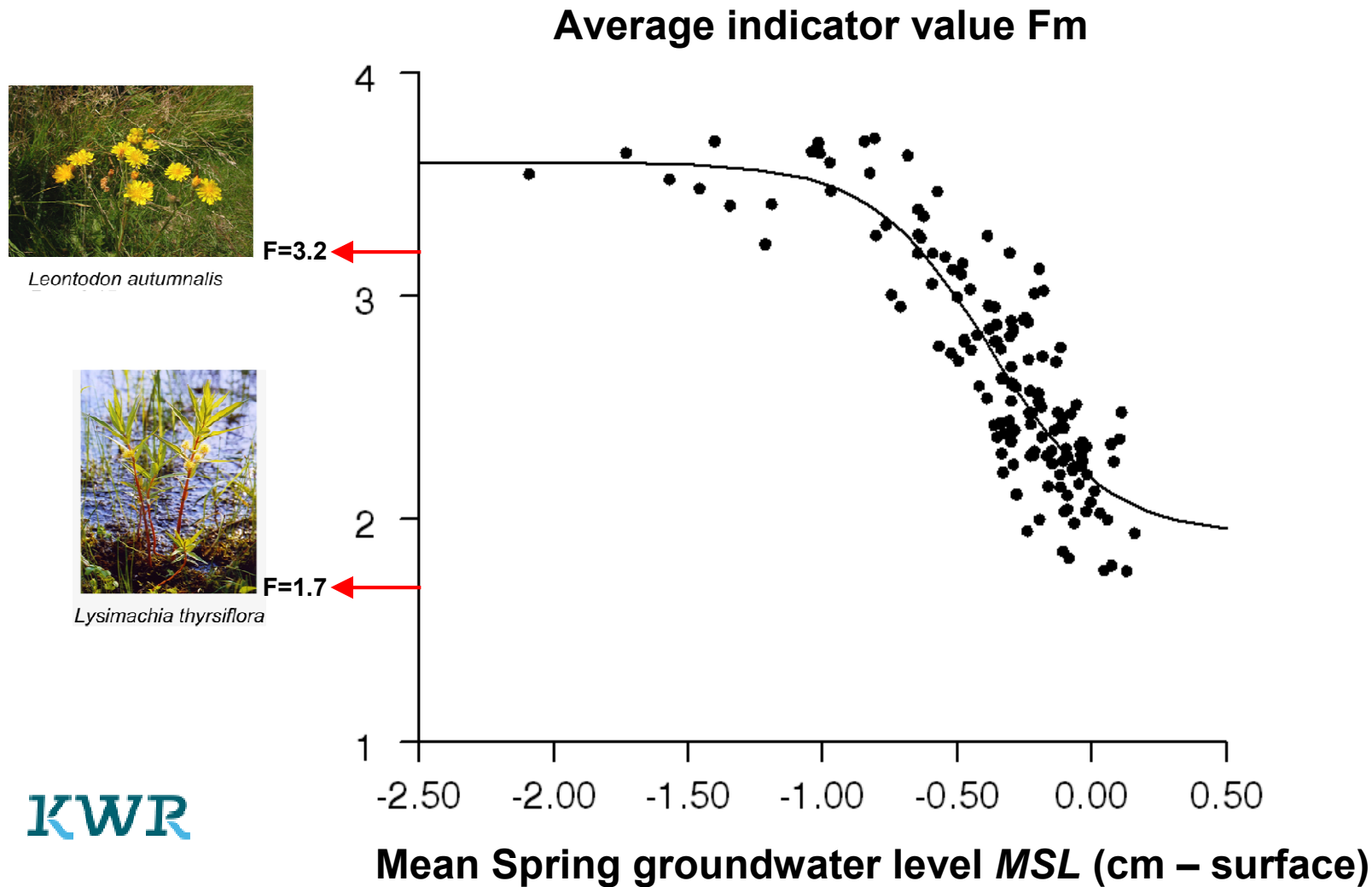
Relationships between water and vegetation
Groundwater level is not a climate proof site factor

Plants need
- **Enough water to transpire (avoid water stress)**
- **Enough oxygen to respire (avoid oxygen stress)**

These direct habitat factors depend on
- **Soil (texture, organic matter)**
- **Temperature**
- **P and ET_{ref}**
- **Plant physiology**
- **Groundwater level**

Effect of oxygen stress on root development

without O_2-stress   with O_2-stress

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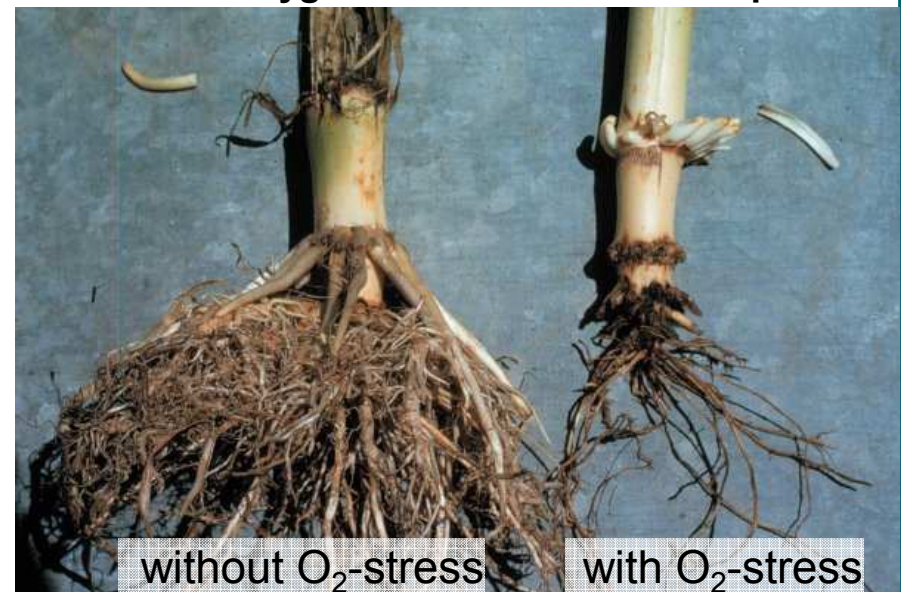
Site factor: oxygen stress
Simulations: daily respiration reduction

Bartholomeus et al., 2008

macro scale

micro scale

O$_2$ diffusion

[O$_2$] in gas phase of soil

depth

root respiration
microbial resp.
soil diffusivity

gas phase

water film

respiring root

O$_2$ diffusion

SINK: microbial respiration

16
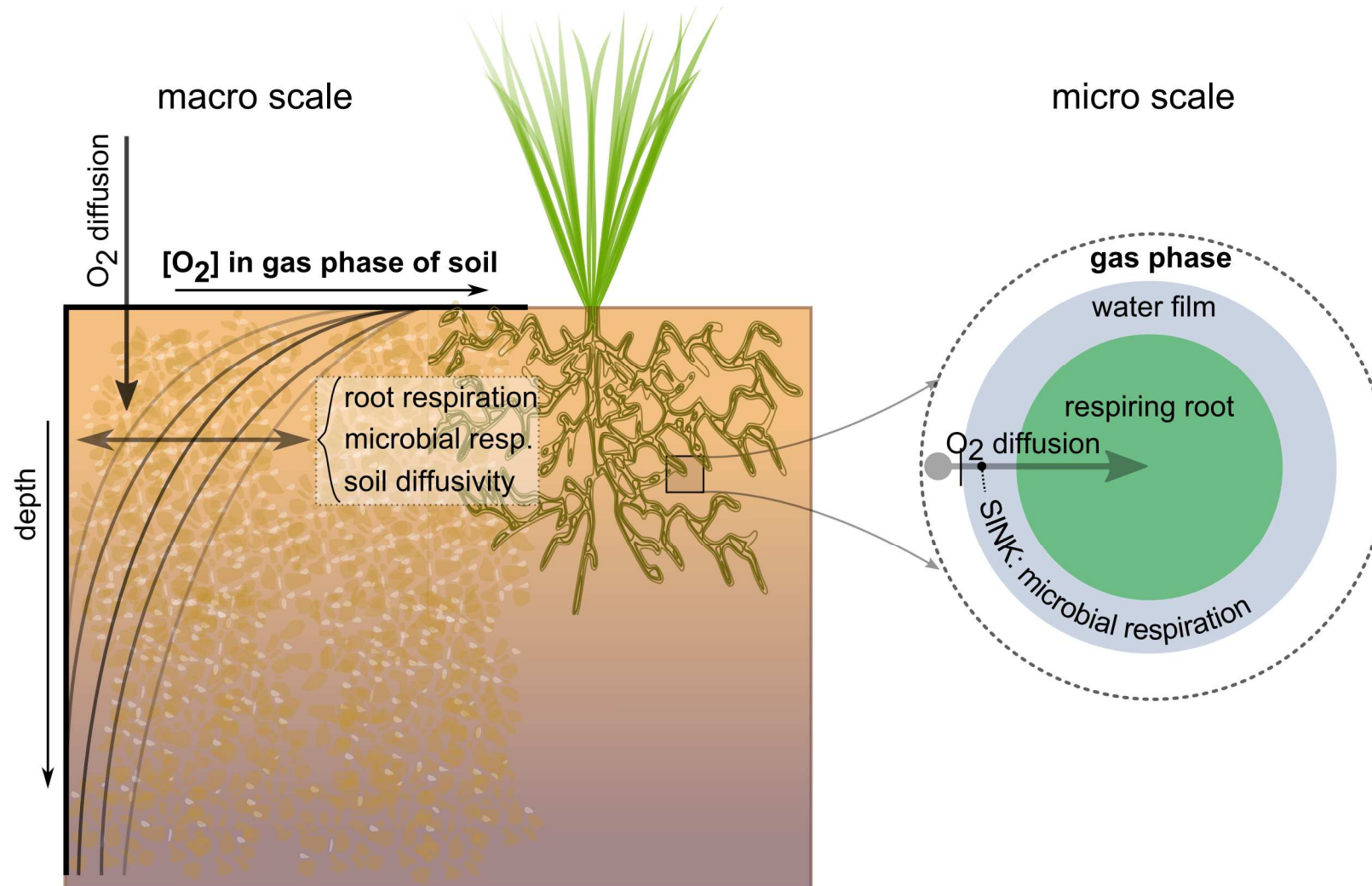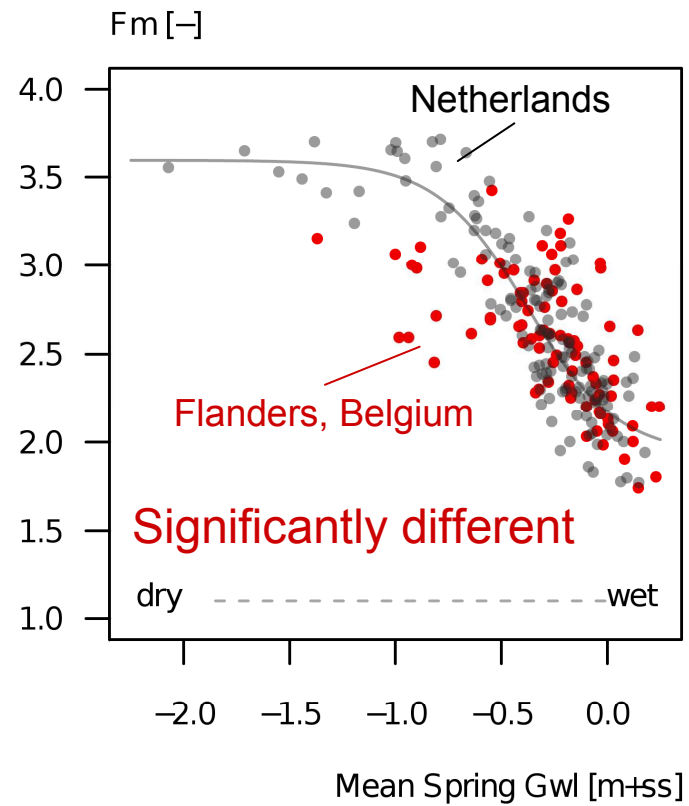
Two measures of oxygen stress
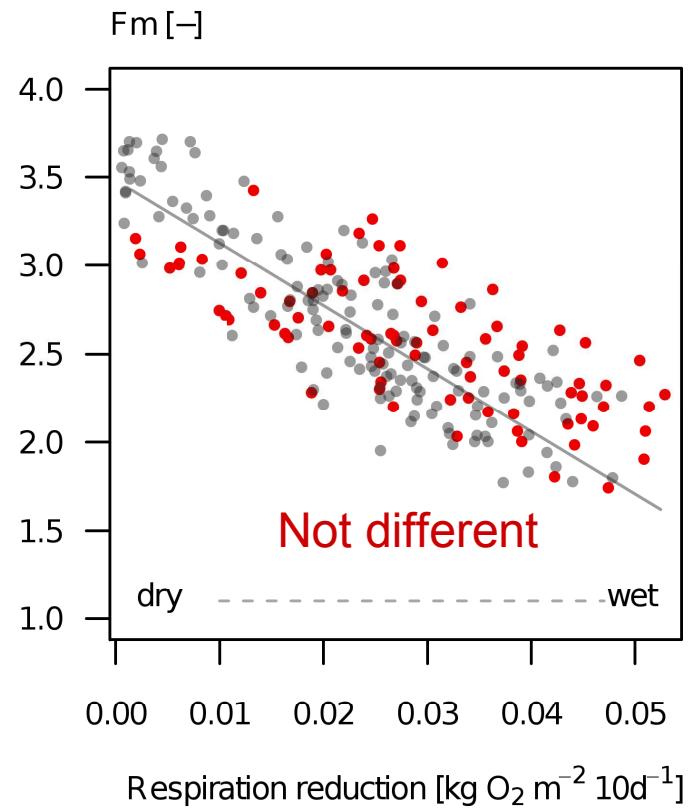
Propositions

1. **Both transient hydrological and vegetation models are not yet suited to simulate the effects of climate change on vegetation biodiversity**
    (work in progress)

2. **For the time being, a combination of models and good reasoning should be preferred above relying on models alone**

The ecohydrological sketchmap
A combination of models and good reasoning should be preferred above relying on model output alone

Witte et al. 2009, in prep.

acidity, and the availability of moisture, oxygen and nutrients. This map shows the possible eco-hydrological effects in 2050 under two climate change scenarios: W and W+. Both scenarios include a global temperature rise of 2°C, increased winter rainfall, dryer summers (especially W+) and more intensive rainfall events. The map was drawn up on the basis of an extensive literature survey, hydrological model results and consultations with numerous experts.
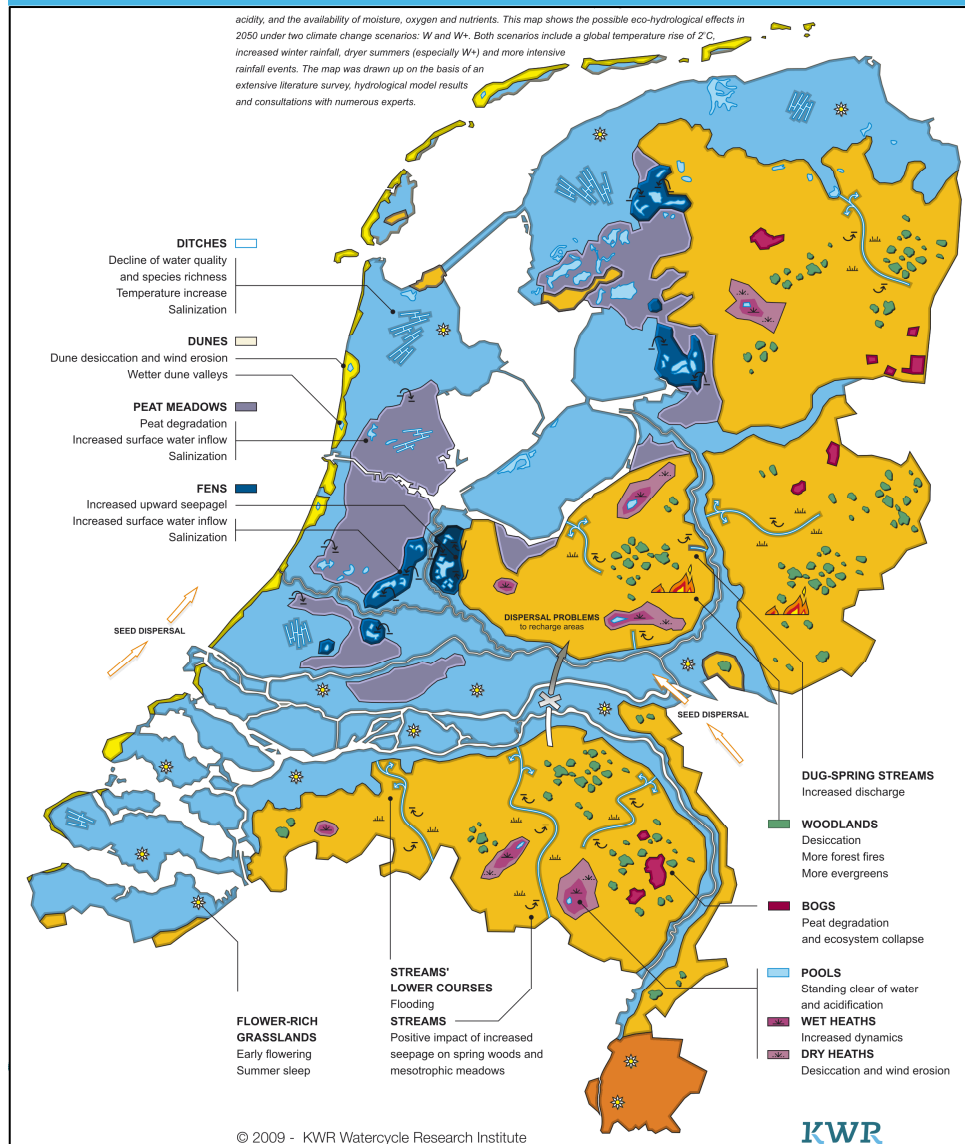
DITCHES
Decline of water quality
and species richness
Temperature increase
Salinization

DUNES
Dune desiccation and wind erosion
Wetter dune valleys

PEAT MEADOWS
Peat degradation
Increased surface water inflow
Salinization

FENS
Increased upward seepagel
Increased surface water inflow
Salinization

SEED DISPERSAL

DISPERSAL PROBLEMS
to recharge areas

SEED DISPERSAL

DUG-SPRING STREAMS
Increased discharge

WOODLANDS
Desiccation
More forest fires
More evergreens

BOGS
Peat degradation
and ecosystem collapse

POOLS
Standing clear of water
and acidification

WET HEATHS
Increased dynamics

DRY HEATHS
Desiccation and wind erosion

**STREAMS'
LOWER COURSES**
Flooding

STREAMS
Positive impact of increased
seepage on spring woods and
mesotrophic meadows

**FLOWER-RICH
GRASSLANDS**
Early flowering
Summer sleep

19

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