# Tools for Assessing Status of European Aquatic Ecosystems

## Management implications of global change impacts on stream ecosystems

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ALTERRA GREEN WORLD RESEARCH

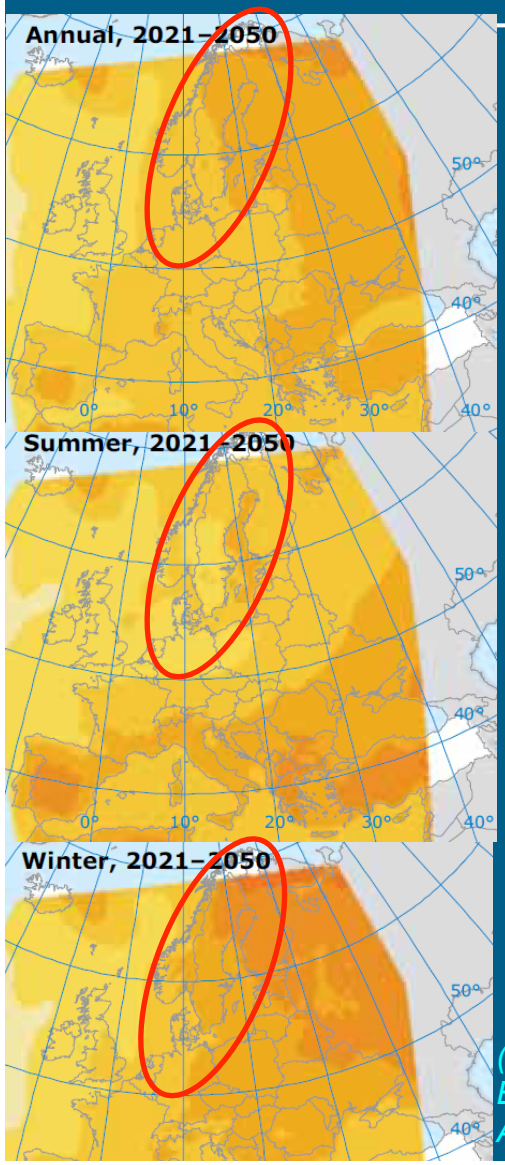
WAGENINGEN UR

# Global / Climate change

## Todays topics

1) How is climate changing (management horizon 2050)?
2) What direct climate change effects can be expected?
3) What to tackle: climate or global changes?
4) What does it mean for assessment and management?

# Temperature rise the next 35 years



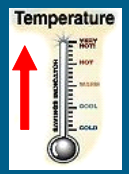

Temperature rise:

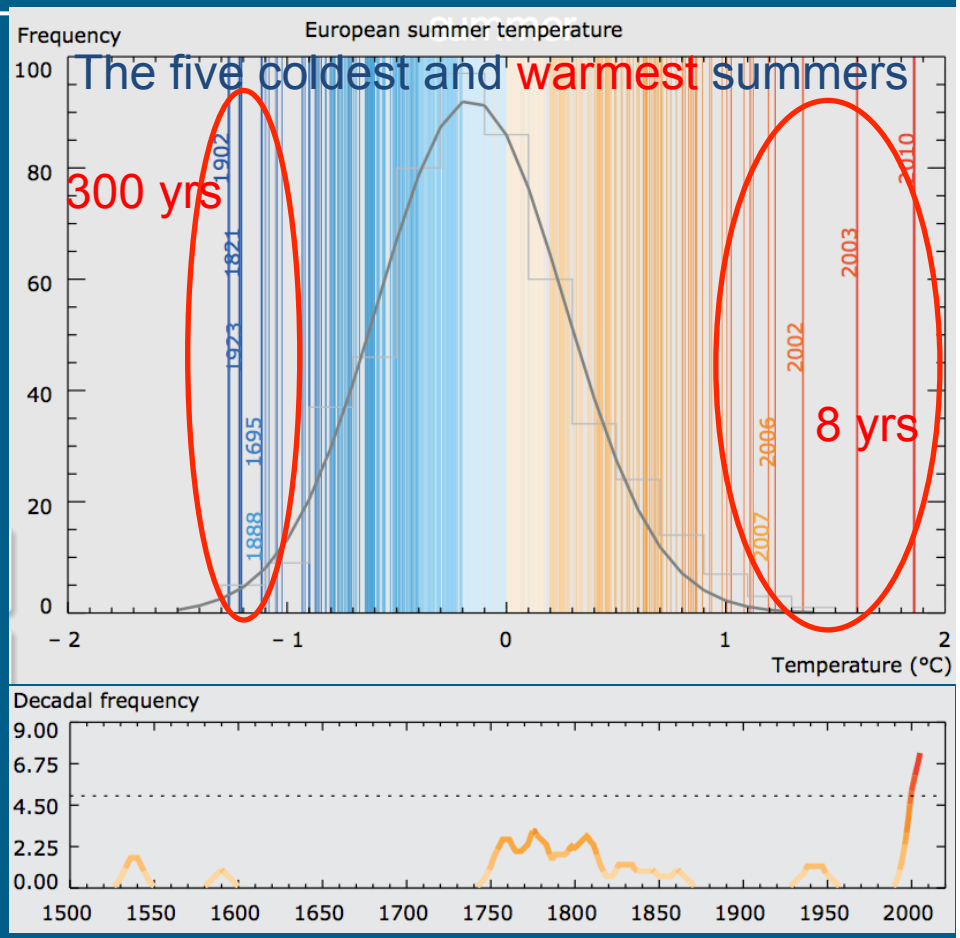
Annual 1.0-2.0°C

Summer 0.5-1.5°C

Winter 2.0-2.5°C

*(European Environment Agency 2012)*



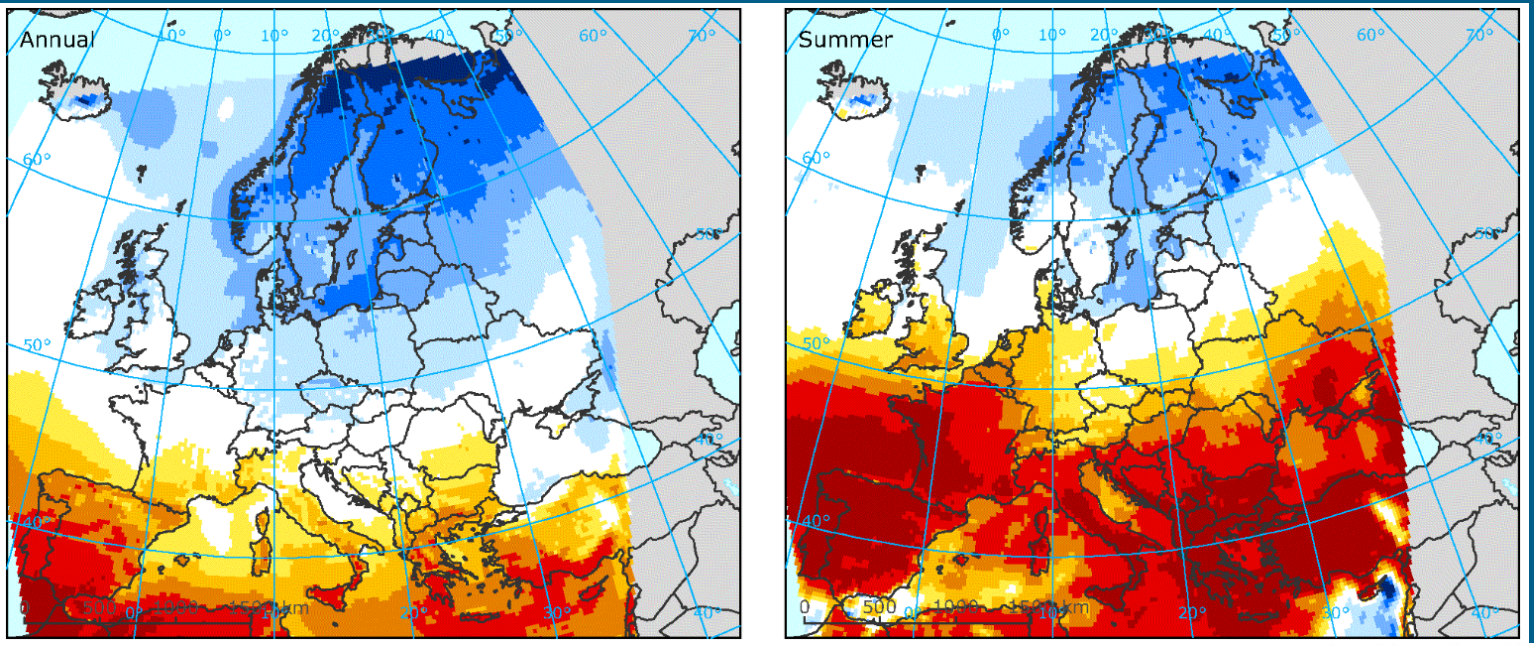




*Running decadal frequency of extreme summers*

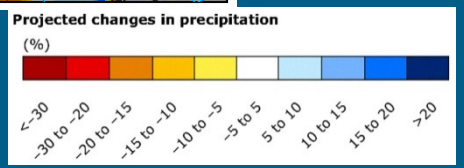
- Warming is speeding up
- Overall warming with more variability
- >Summer extremes (2-8 days >35°C)

# Precipitation the next 85 years

Projected changes in annual and summer precipitation (%) between 1961-1990 and 2071-2100 (ENSEMBLES Regional Climate Models for the IPCC SRES A1B emission scenario).



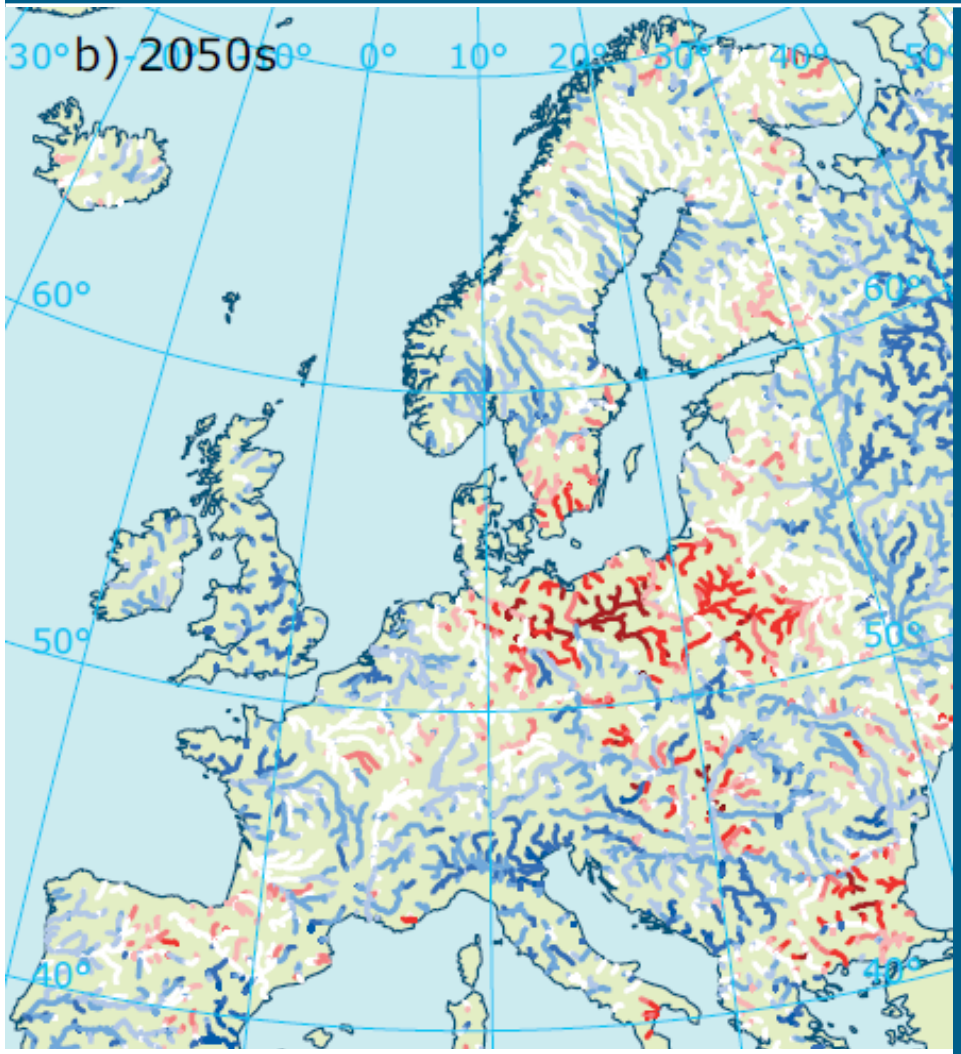

*(http://www.eea.europa.eu/)*



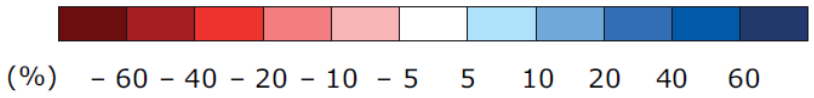

More rainfall with:

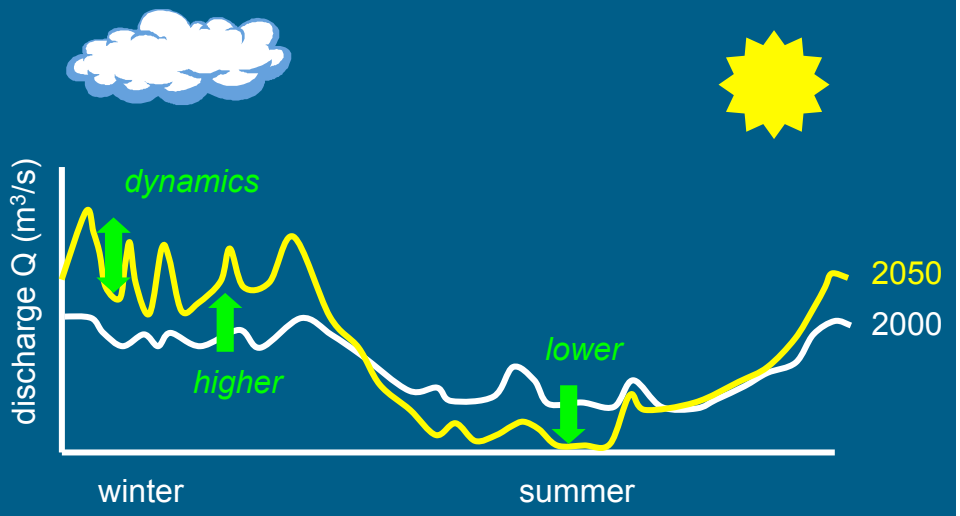
- Less low rainfall days
- More high rainfall days
- Intense precipitation events from 20 to 2–4 years in Scandinavia

# Floods in the next 35 years




**Relative change in river floods with a return period of 100 years**




- wetter in the North
- winter downpours
- summer spates (more extremes)
- more severe summer droughts

*(European Environment Agency 2012)*

# Climate Change impacts: Northern Europe

*(European Environment Agency 2012)*

- Temperature rise much larger than global average
- Decrease in snow, lake and river ice cover
- Increase winter/spring river flows
- Increasing damage risk from winter storms
- More frequent and intense weather events
- Northward movement of species
- Increase in crop yields
- Decrease in energy demand for heating
- Increase in hydropower potential
- Increase in summer tourism

Not only direct, but also indirect effects of climate change!

# So, much is about future extremes!

http://purpology.com/2015/02/02/when-will-spring-come-and-climate-change/

# Direct Climate Change effects

Euro-limpacs
Contract No. GOCE-CT-2003-505540

REFRESH
GA 244121

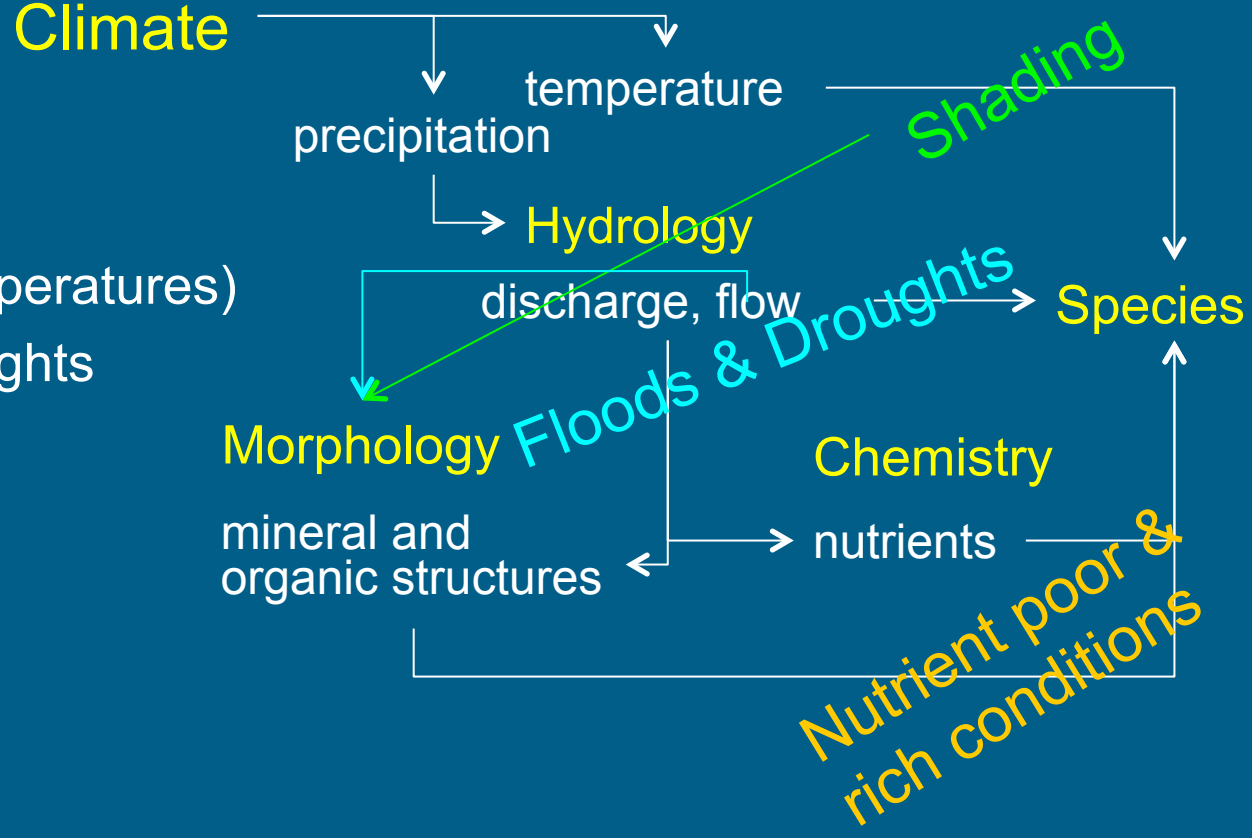
EUROLIMPACS

- High temperatures
- High flows

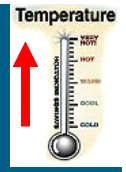
REFRESH

- Shading (lower temperatures)
- Low flows and droughts

## Key factors



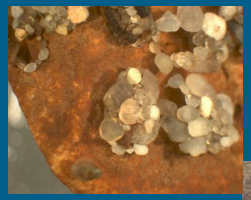
# Temperature rise



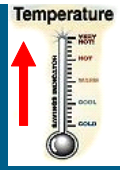

## Lab experiment

- 4 artificial streams (each with 4 replicates)
- 4 temperatures
  - ✓ 10°C control
  - ✓ 12.7°C maximum springs
  - ✓ 17.1°C maximum middle courses
  - ✓ 21.1°C (max mc plus 4°C climate change)
- sampled after 4, 8 and 12 weeks
- ANOVA per sample moment

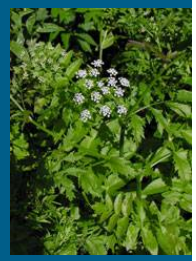
- response of the macrophyte:
  - ✓ *Berula erecta*
- response of the trichopterans:
  - ✓ *Agapetus fuscipes (springs; crenal)*
  - ✓ *Sericostoma personatum (springs + upper courses)*
  - ✓ *Beraeodes minutus (middle courses)*



# Temperature rise

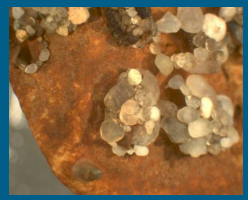



## Conclusions



Berula erecta

- temperature increase: < wet weight, > length growth (less roots) (meaning a decrease in resistance to spates?)



Agapetus fuscipes ‘cold’

- 12°C = faster development, 17+21°C > mortality

Sericostoma personatum ‘intermediate’

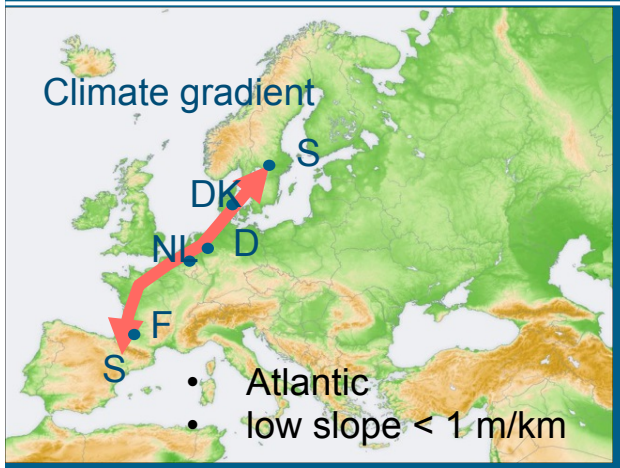
- 12+17°C = faster development, 21°C = no response

Beraeodes minuta ‘warmer’

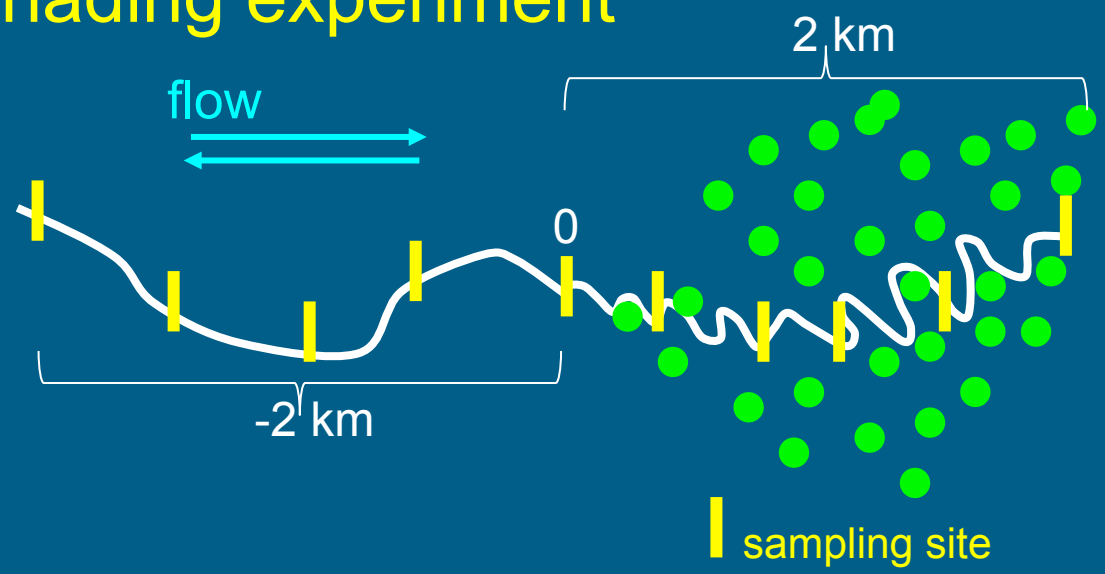
- 17+21°C predation losses => energy *S. personatum*?

>16°C ‘cold water’ species (6%) vulnerable, food web changes

# Temperature mitigation




## Shading experiment



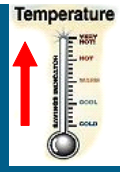

country: Sweden, Denmark, Germany, Netherlands, France, Spain

stream:

22 streams

18 streams

# Temperature mitigation



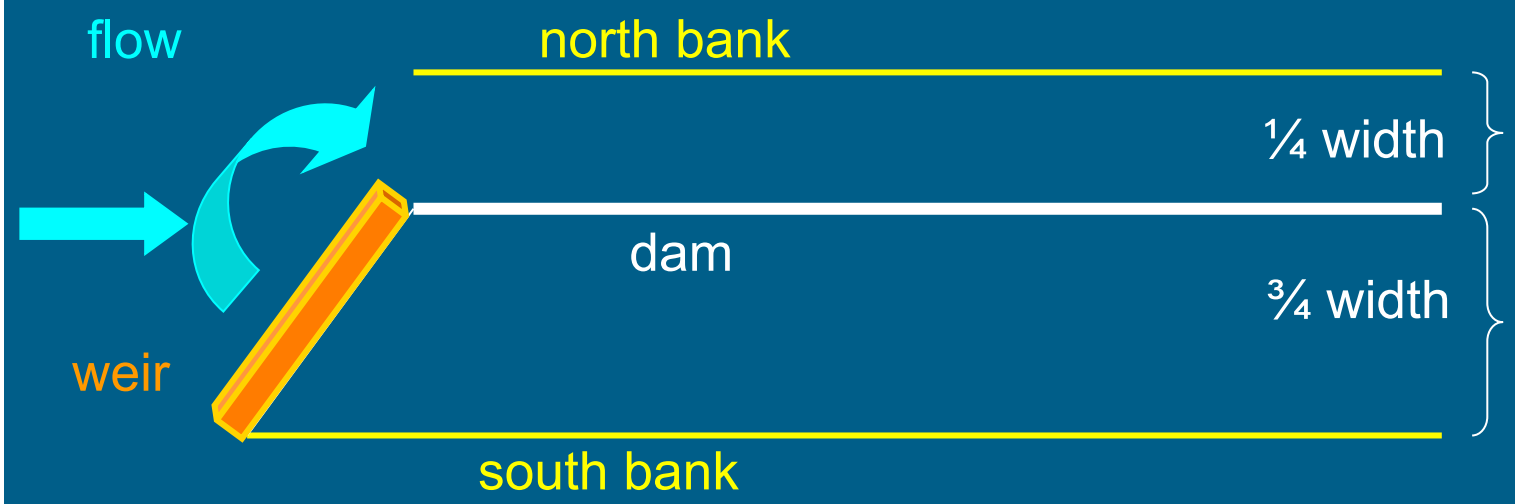

## Shading experiment: conclusions

Shading as adaptation measure in rivers:

- Wooded buffer strips improve WFD ecological status in a river and mitigate climate change.
- Planting 500 m wooded buffer strip decreases water temperature minimally by 2.5°C (up to 12.5°C), provides 20-40 days of cooling >2°C and for a stable community 1000 m is preferable!
- Cooling down river water takes somewhat longer than warming it up.
- South-sided wooded buffer strips or mosaic landscapes of open and shaded stretches (partial shading: 50:50 lengths) are possibly equally effective on ecological status in rivers.

# High flow extremes

## Spate simulation




semi-natural stream

| | |
|---|---|
| spate simulation: | closing and opening weir |
| time period: | 5-6 hours |
| frequency: | 1 or 5 spates |
| magnitude: | 6x base flow |

natural stream

# High flow extremes

## Spate simulation: conclusions

| effect: | *habitat* | *macroinvertebrates* |
|---|---|---|
| natural stream | | |
| one spate | no effect | no effect |
| multiple spates | loss of silt | no effect |

Macroinvertebrates adapted to spates by using refugia '?'

**resistance**

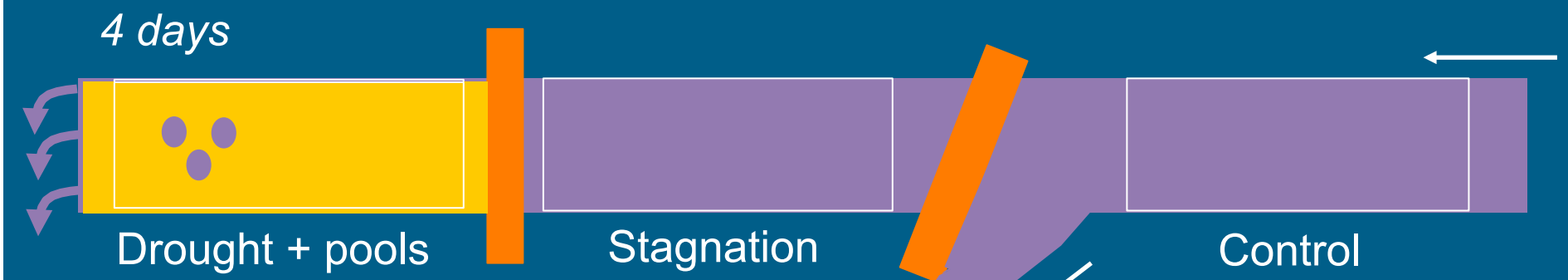
| semi-natural stream | | |
|---|---|---|
| one spate | no effect | no effect |
| multiple spates | loss of silt | clear # effect |

Macroinvertebrates loss # and 'fast' recovery (multiple spates)

**resilience**

# Low flows and drought

Sandy lowland stream 2 m wide, 0.2 m deep, v = 18 cm/s




BACI-design to test effects of:

1. Drought + remnant pool formation
2. Stagnation

Sampling: 5 weeks before + 4 after:

- Invertebrates: 6 Surbers.wk$^{-1}$
- EC, DO, T
- Substrate cover

# Stagnation

## Low flow / drought simulation: nutrient poor vs rich

Stagnation V↓

Drought = immediate change↓

Water quality no change

*Poor stream*

*Rich stream*

$O_2$ no change

$O_2$ ↓ from <6 mg/l on!

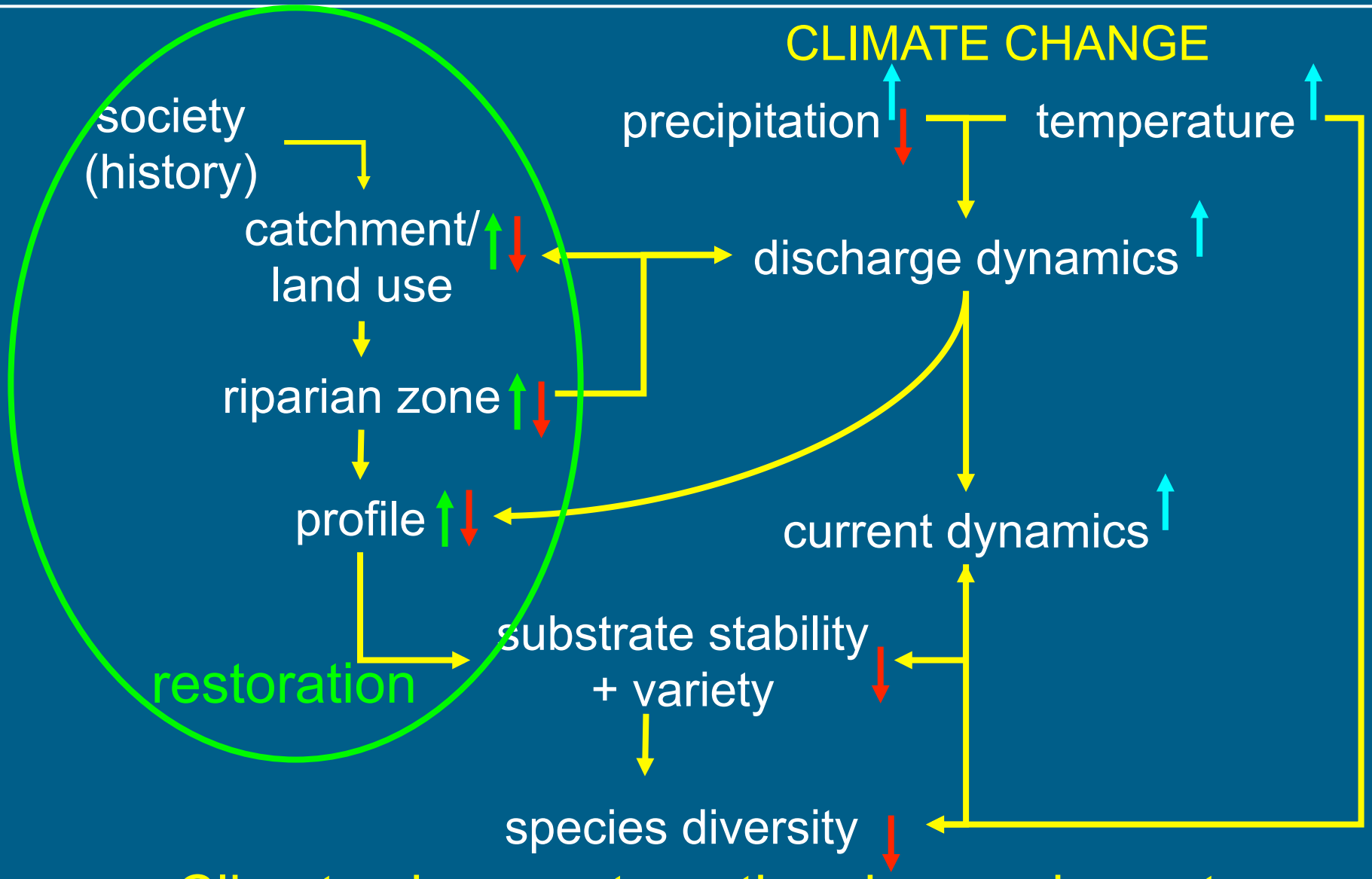
rheophilic taxa ↓ *disappear < 1 month*

rheophilic taxa ↓
oxyphilic taxa ↓
*disappear < 1 week*

- A stagnant <u>but normoxic</u> reach provides a refuge for all other lowland stream taxa, despite major changes in substrates.
- Pools are NO refugia. Within 2 weeks the pools are colonized and dominated by polysaprobic pool-dwellers.

# Use knowledge in practice

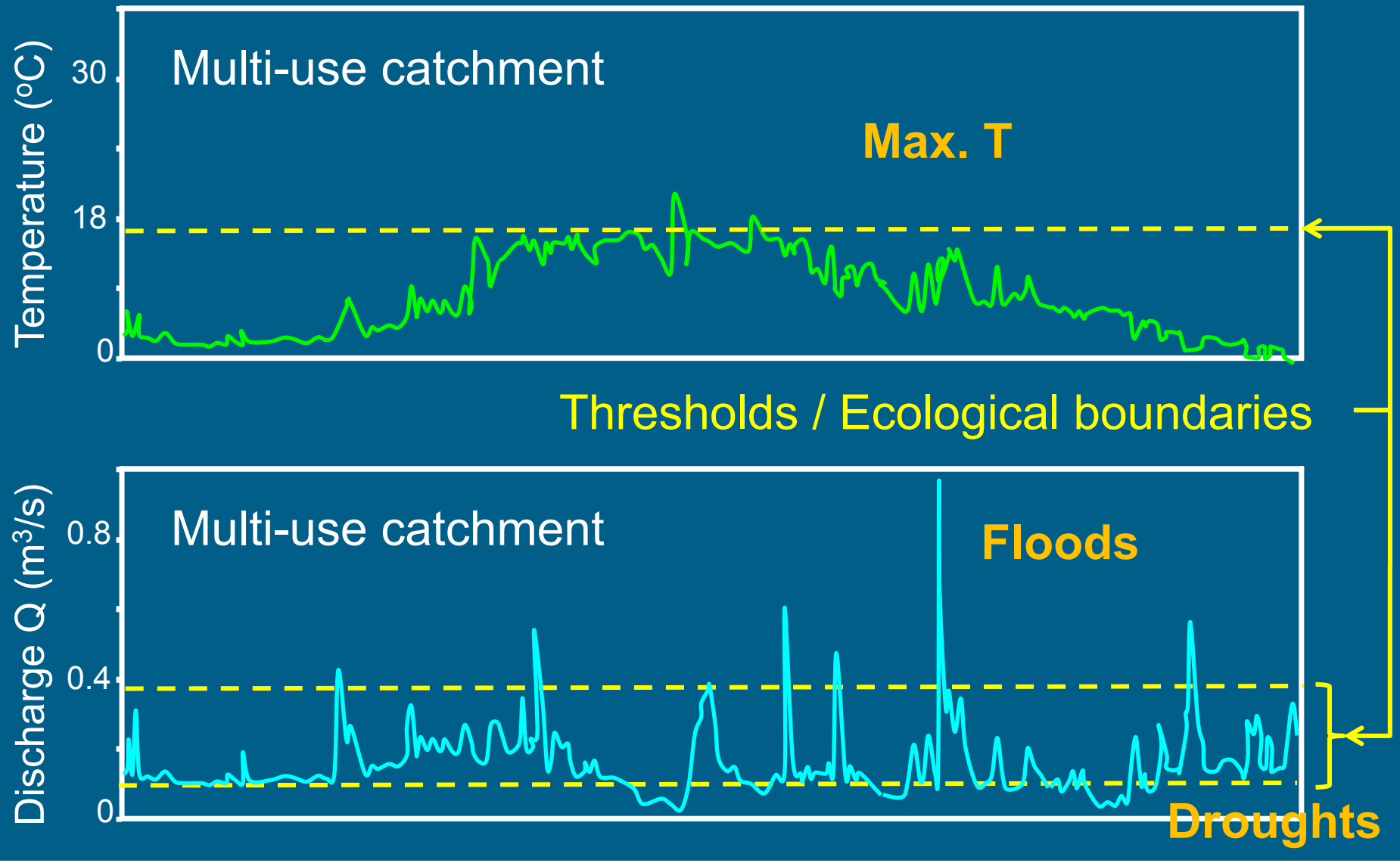
# Human vs. climate impacts




Climate change strengthen human impacts

# Chosing measures = focus on extremes

Thresholds: Ensure sustainable environments



# Top-measures in river restoration

- Vision on stream network infrastructure

Hydrology

- Store by infiltration
- Retain by inundation
- Retard by profile reduction

Morphology

- Develop wooded riparian zone
- Introduce CPOM
- Reduce size profile (supply sand)

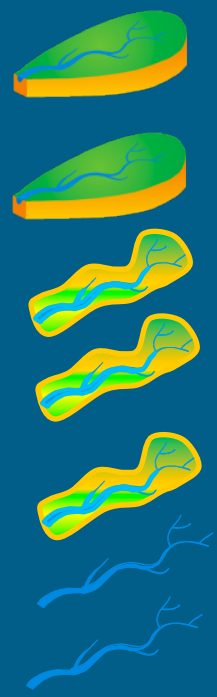
Chemistry

- Purify in bleu veins (chemistry)
- Separate urban flows (chemistry)

Biology

- Re-introduce species (biology)
- Adapt / abandon maintenance

scale



Landscape ecological watersystem analysis

Floods:
max. 7 x baseflow

Droughts:
no stagnation

1000 m wooded zone ↓5°C
+ substrate heterogeneity

No eutrophication
$O_2$>6 mg/l

Active re-introduction

# Select ‘best’ measures

## Climate adaptation label

EU developed Database + Website

| | adaptation strategies | measures |
|---|---|---|
| Lakes | 11 | 40 |
| Rivers | 15 | 51 |

www.climate-and-freshwater.info

*Table 2. Climate change adaptation labels.*

| colour code | colour | number of climate induced pressures | explanation |
|---|---|---|---|
| | dark green | 4-5 (+++) | win-win measure |
| | light green | 2-3 (++) | win-win measure |
| | pale green | 1 (+) | no regret measure |
| | yellow | 0 | |
| | red | - | regret measure |

# Select ‘best’ measures

## Climate adaptation label

| | | | | water type | | European ecozone | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **ecosystem component/ scale** | climate change effect | adaptation strategy | adaptation measure | stream | river | atlantic | boreal | alpine | conti-nental | mediter-ranean |
| **tempera-ture** | warming of surface water | cooling | (re)forestation | 1 | | 1,2,3 | 1,2,3 | 1,3,4 | 1,2,3,4 | 1,2,3 |
| | | cooling | development of a wooded bank | 1 | | 1 | 1 | 1,4 | 1,4 | 1,4 |
| | | cooling | cutting wooded bank | | | 1 | 1 | 1,4 | 1,4 | 1,4 |
| **hydrology** | change in flow regime | increase water storage capacity | drainage removal | 1 | | 2,3,4 | 2,3,4 | 2,3,4 | | 1,3,4 |
| | | increase water storage capacity | extra irrigation | 1 | | 2,3,4 | 2,3,4 | 2,3,4 | | 1,3,4 |
| | | increase water storage capacity | groundwater storage | 1 | 1 | 3 | 3 | 2,3 | 3 | 1,3,4 |

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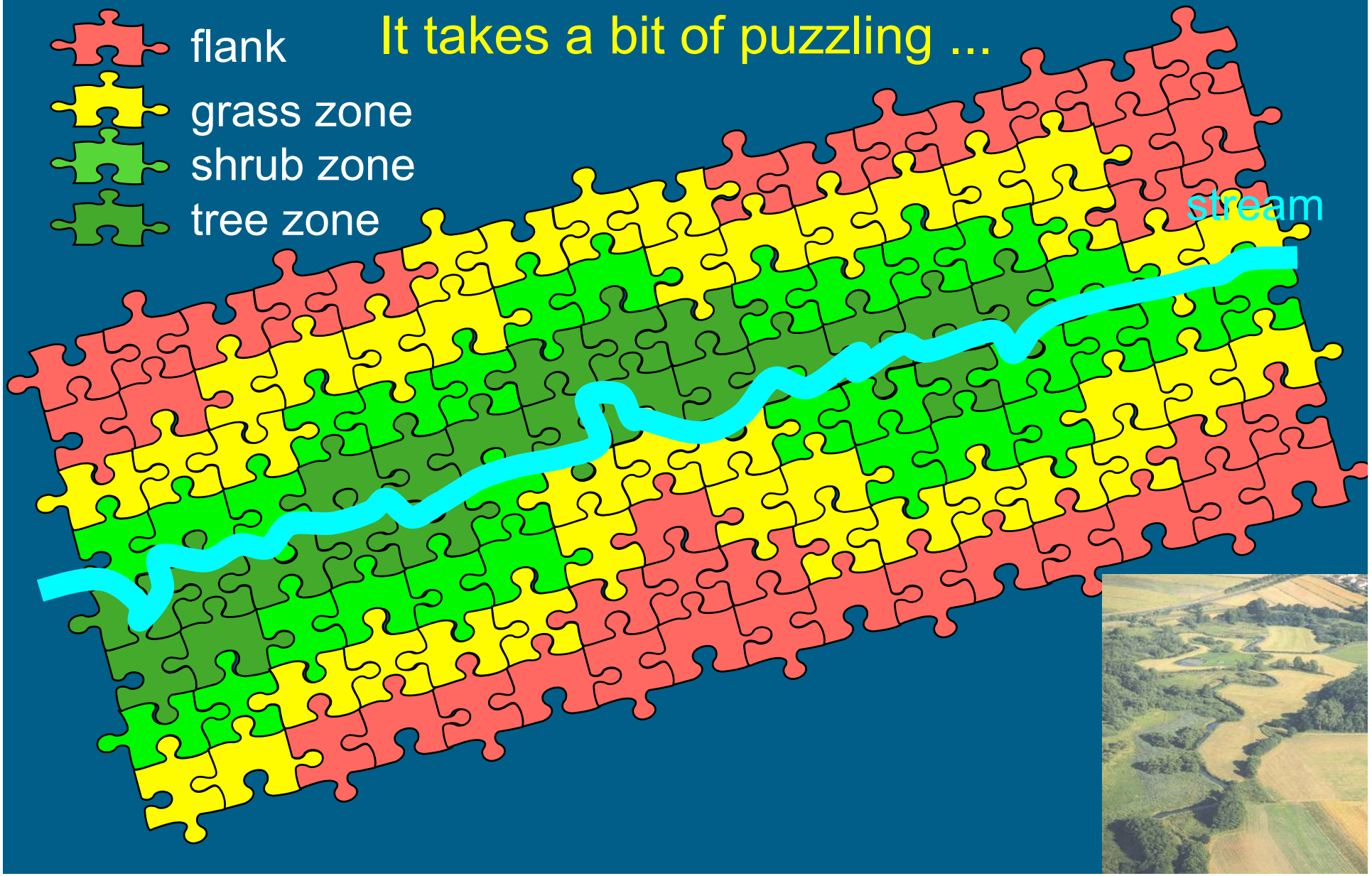
| score | climate change induced pressure | example |
|---|---|---|
| 0 | no climate change related pressure | |
| 1 | temperature rise | (direct, like warming, stratiphication) |
| 2 | increase winter precipitation | (direct effects, like run off, water level fluctuation, spates, inundation) |
| 3 | summer extremes | (direct effects, like droughts, spates) |
| 4 | water quality | (indirect effects, like nutrient cycling, eutrphication, oxygen regime changes, salt seepage) |
| 5 | others | (indirect effects, like exotic species, terrestrialisation) |

# Spatial configuration

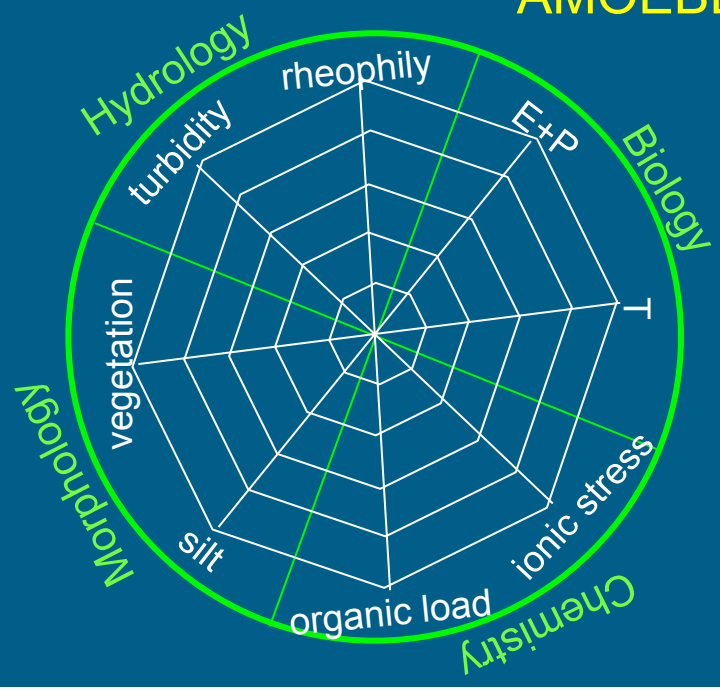
It takes a bit of puzzling ...

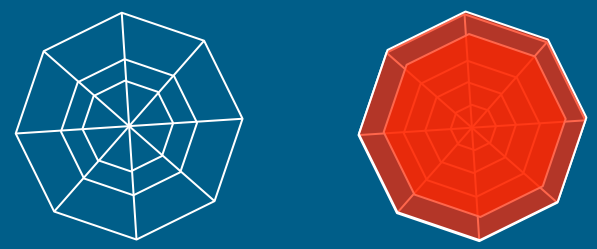


# ‘Climate change’ proof assessment

- WFD assessment is based on a comparison to reference conditions
  But... reference conditions will change!
  And... southern species will come in, are they considered non-native?
- Make assessment independent from species lists
- Focus on diagnosis
- Option: use biological and ecological traits

AMOEBE assessment: diagnostic tool



Undisturbed Disturbed

# Thank you!

## Mitigation measures