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Groundwater resources in a changing climate

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Overview

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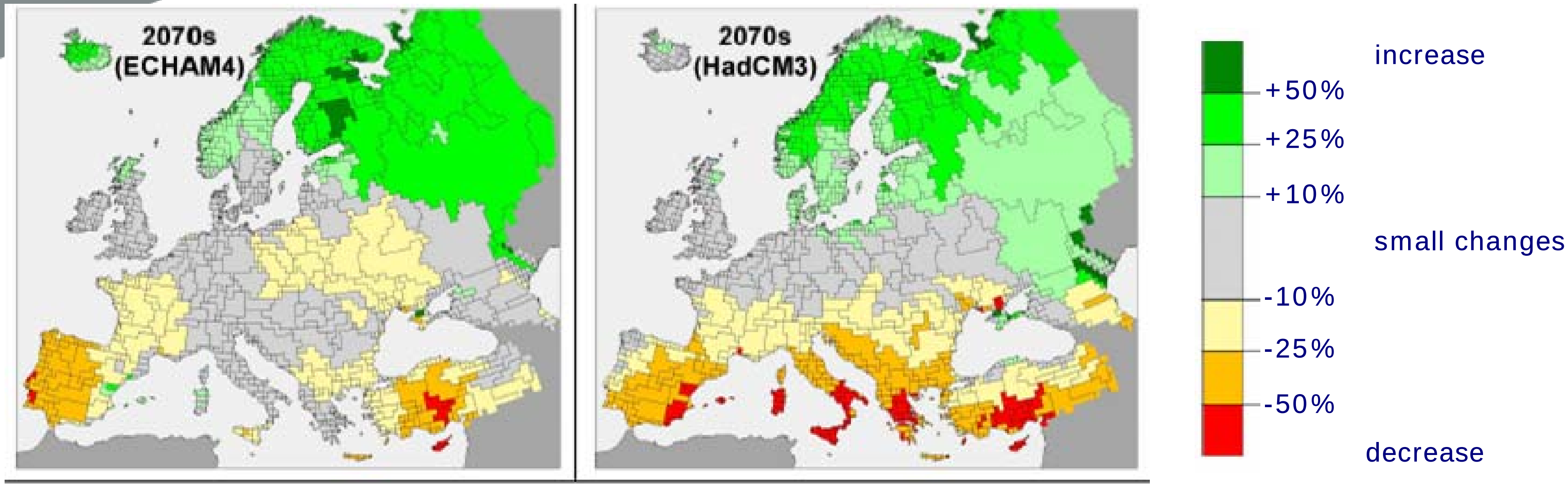
- Climate uncertainty
- Other sources of uncertainty for future groundwater resources
- Increasing resilience
- Conclusions

Climate model uncertainty

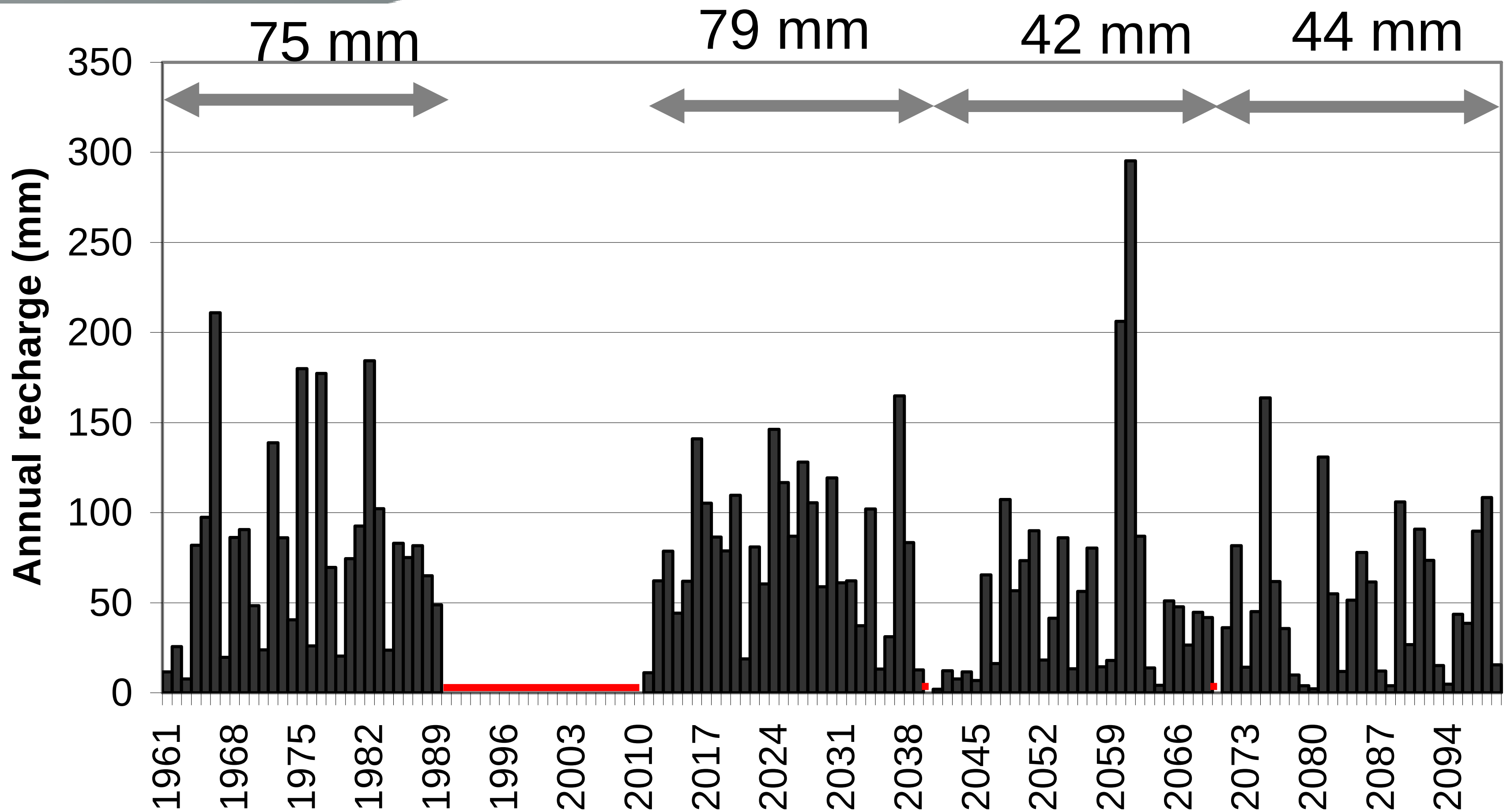
River discharge



- Baltic countries, Poland
- Italy, southern Spain

Data-sources: Erhard (2003); Center for Environmental Systems Research, national institutions

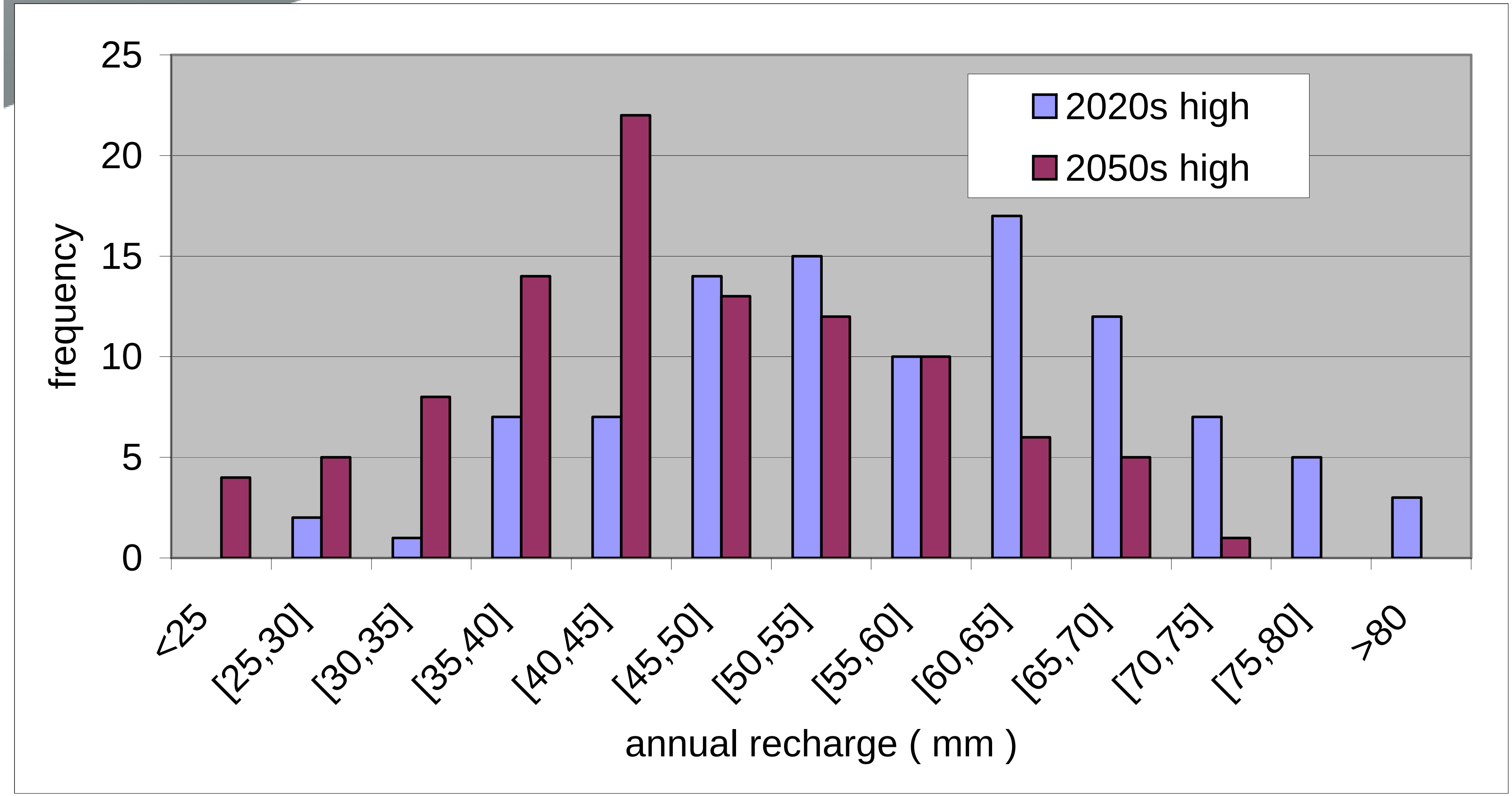
Annual recharge (Coltishall, Norfolk)



[UKCIP02 High emissions scenario / Loam soil / Fair soil condition / permanent grass]

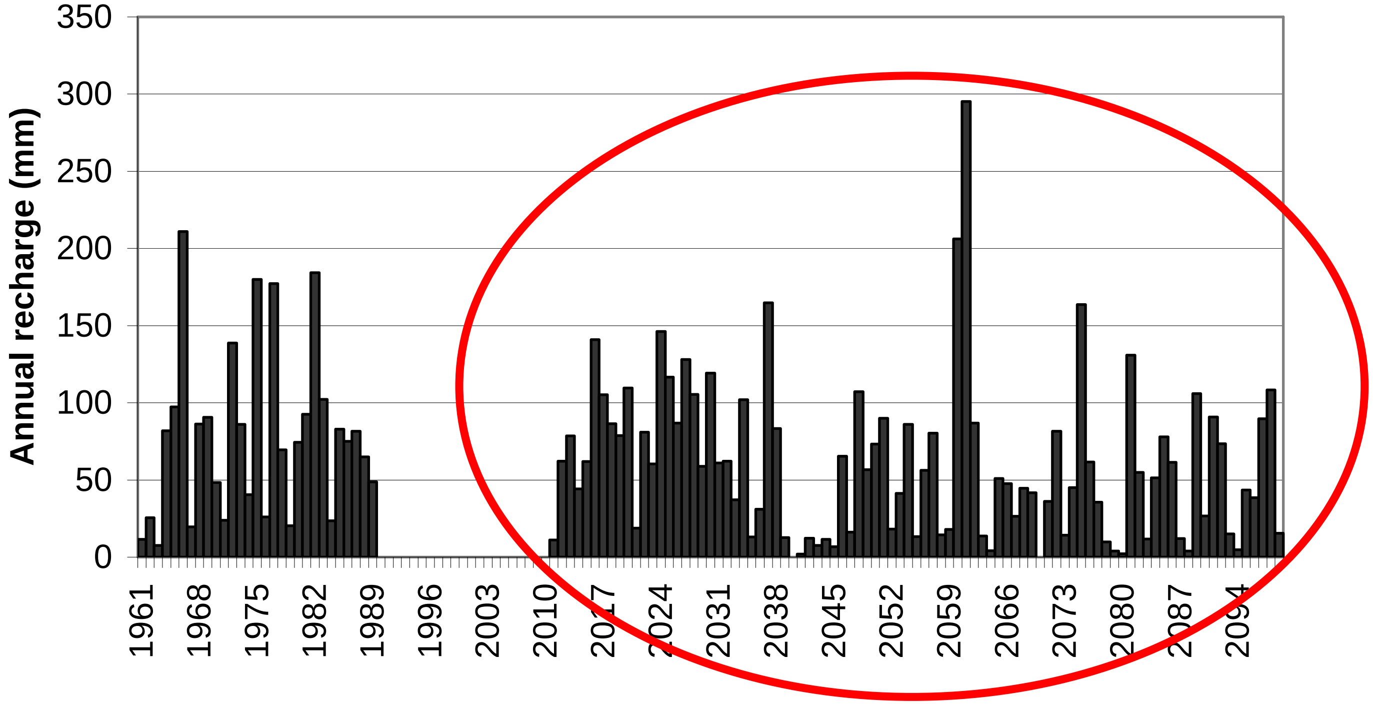
Climate data from BETWIXT - http://www.cru.uea.ac.uk/projects/betwixt/

Median annual recharge (100 simulations)

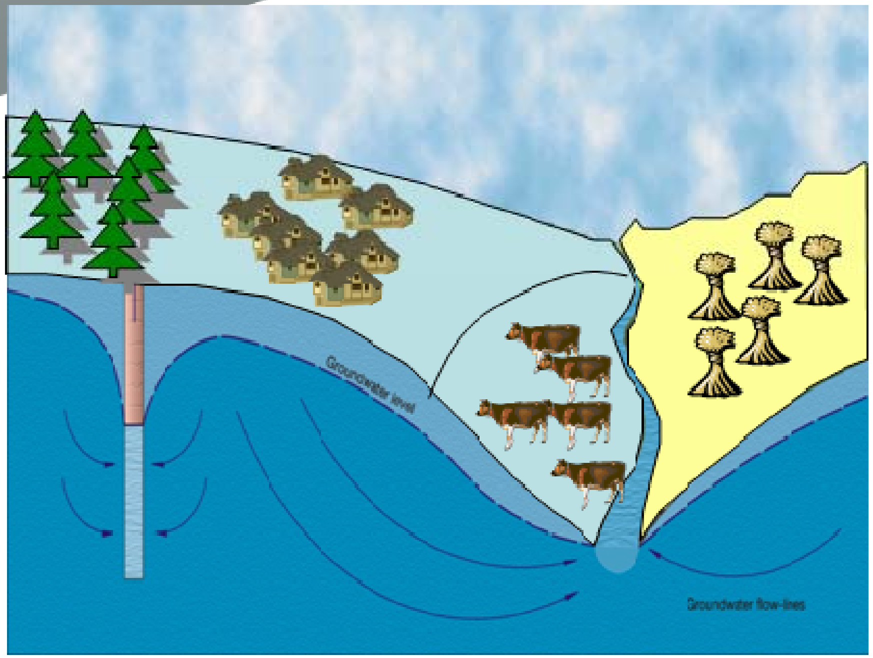


Climate scenario uncertainty

- Lots of uncertainty between climate models
- Lots of uncertainty in downscaling

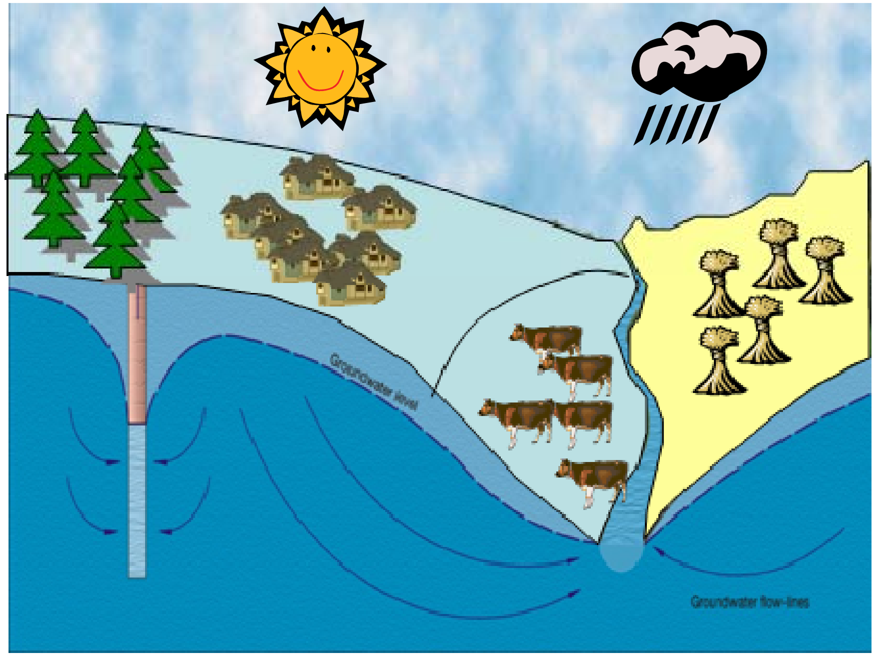


Because reality won't be like this….

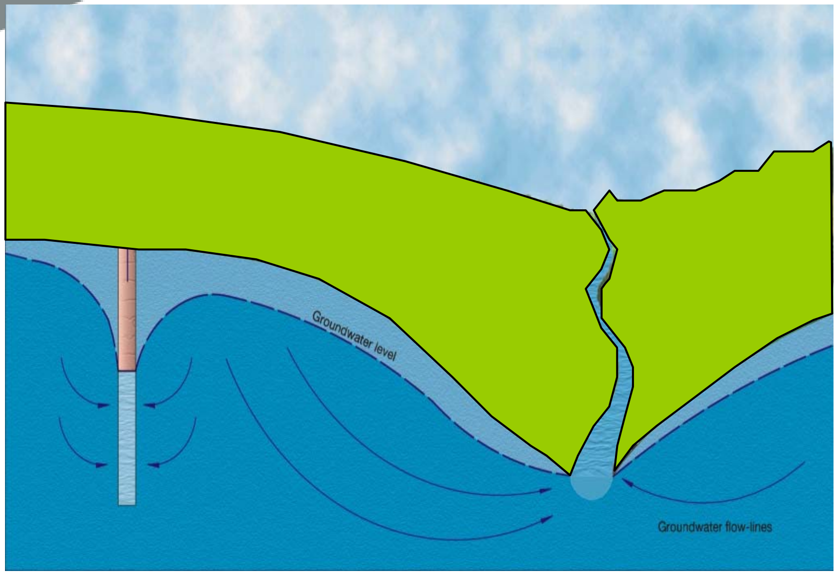


Present day

2050



And it definitely won't be like this….



Present day

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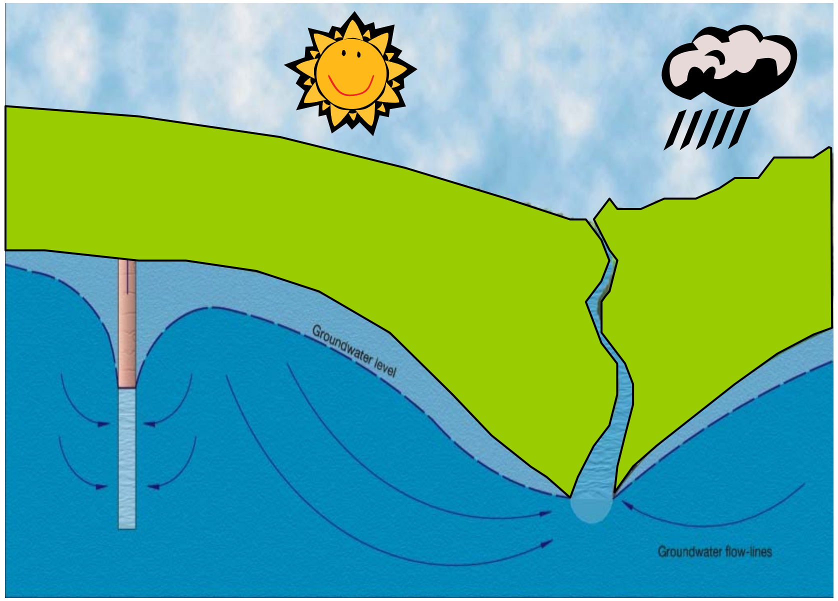

The landscape is more like this….

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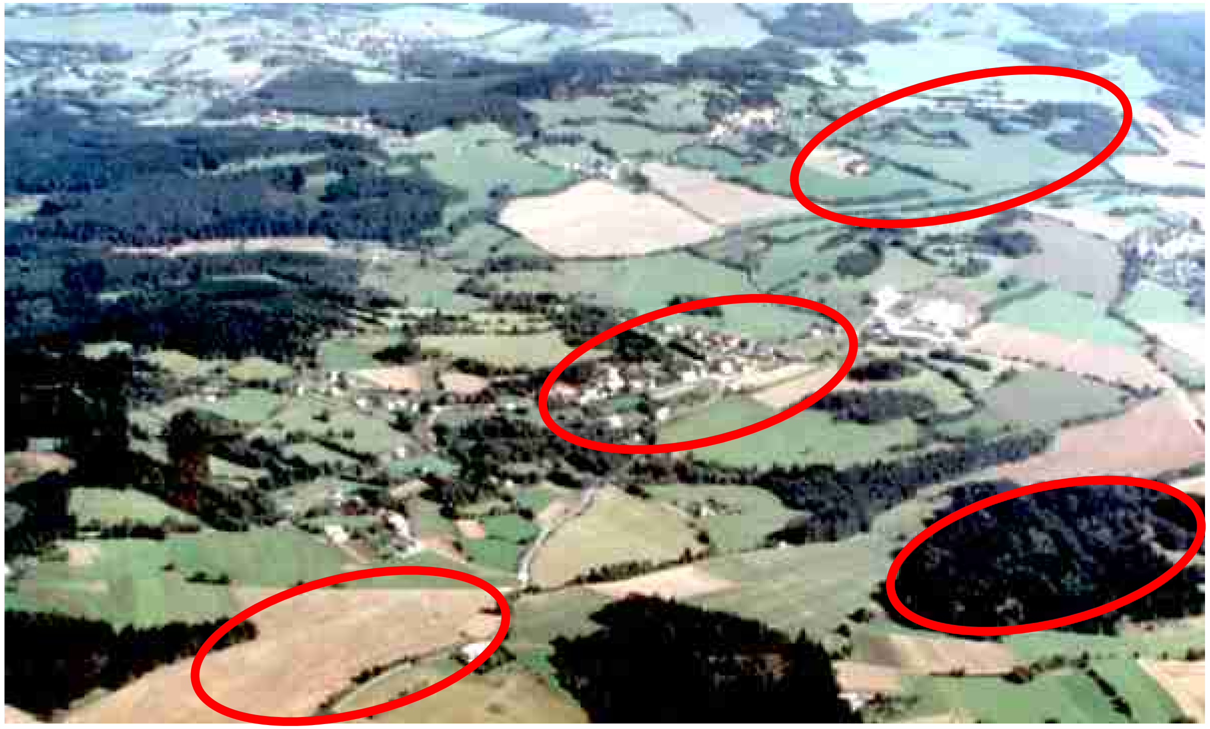


Different 'natural' vegetation

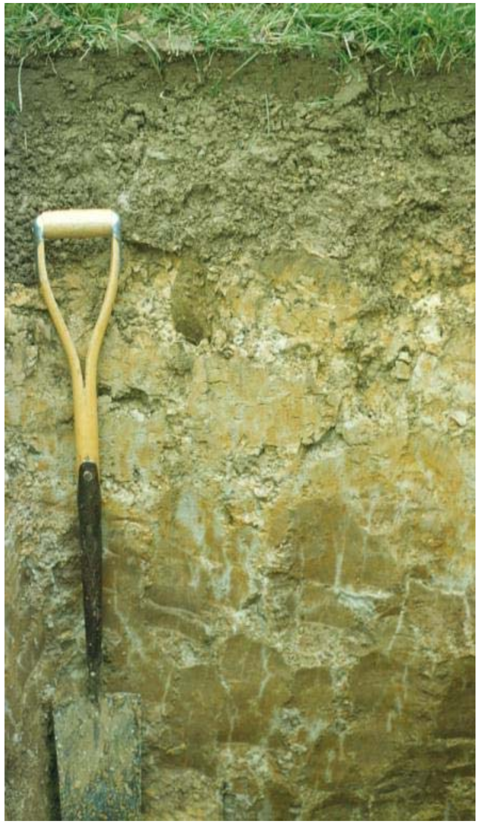
Expanding/ contracting towns and villages

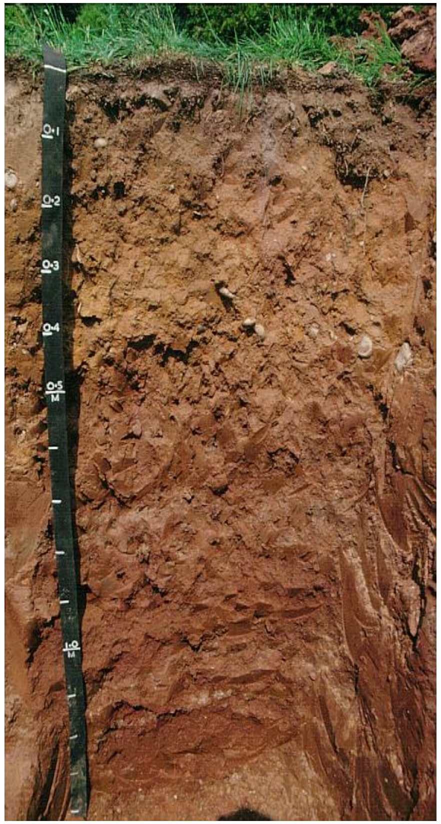
Planting, growth and felling of trees

Spatially & temporally varying cropping

And this…..

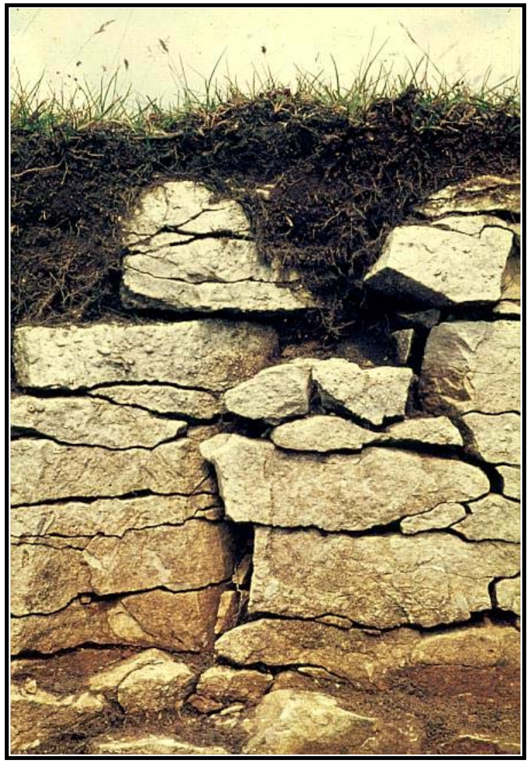
Stagnic Albeluvisol





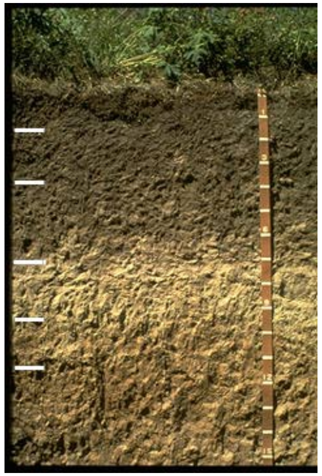
Chromic Luvisol

Rendzic Leptosol



Groundwater and the landscape

If any component of these change:

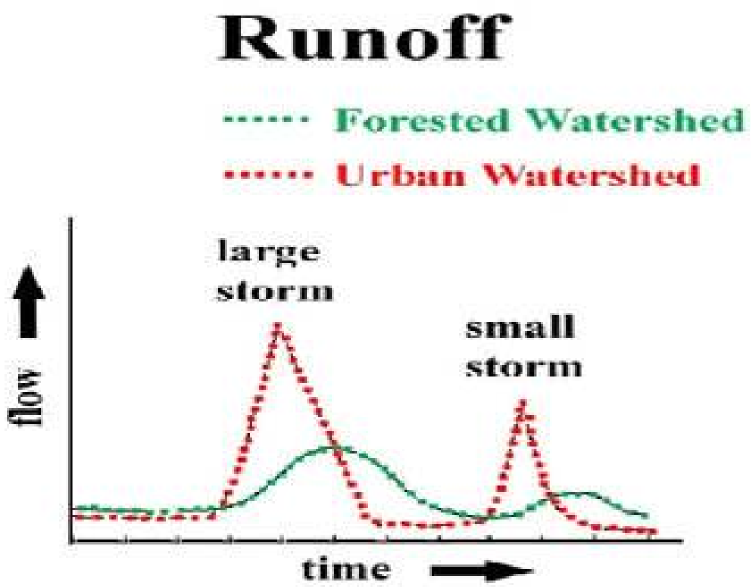


……………….then so does recharge.

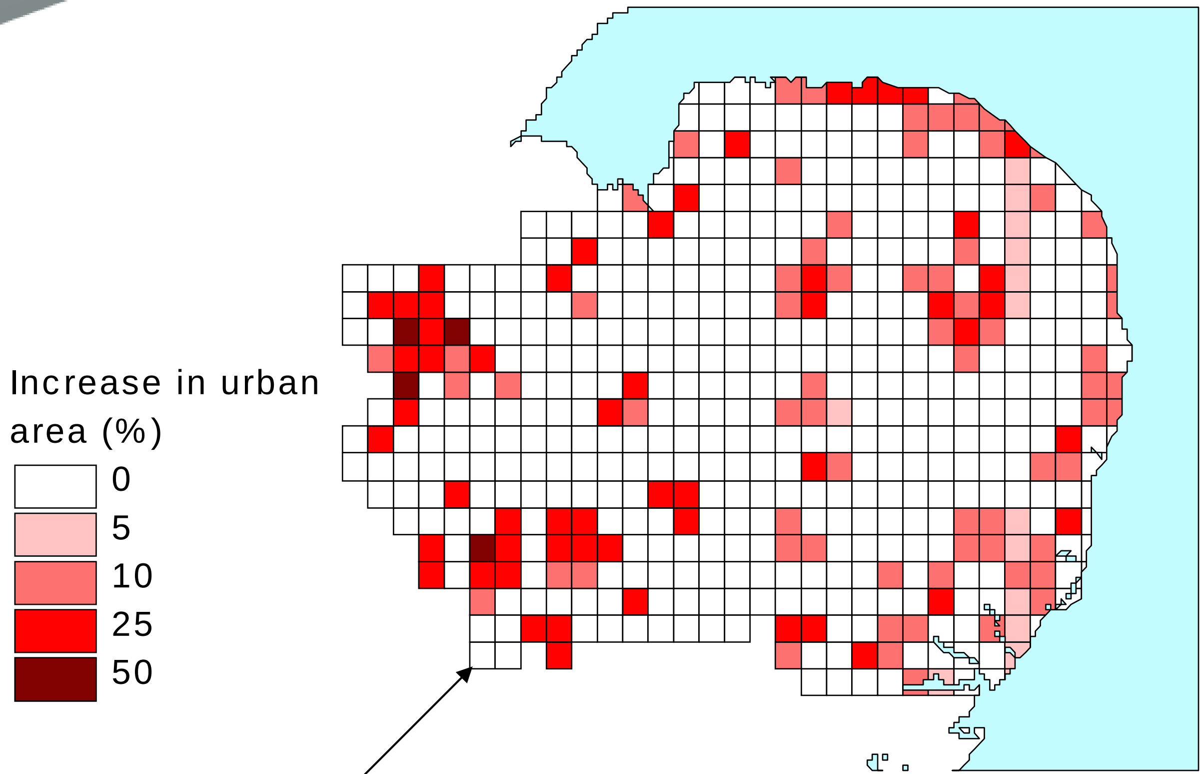
What changes might happen?
What might the consequences be?

Urbanization

From this to…………………………… this!



Local-scale urbanization scenario



Each grid square is 5 km x 5 km

Holman et al. (2001)

Urbanization

From this to…………………………… this!

Yang et al. (1999) – Nottingham – 65% recharge (138mm/a) leaking water mains

Hooker et al (1999) – Wolverhampton – 120-250mm/a (pre-urban) to 220-300mm/a

Appleyard (1995) – Perth, Austr. – doubling of recharge

Land use

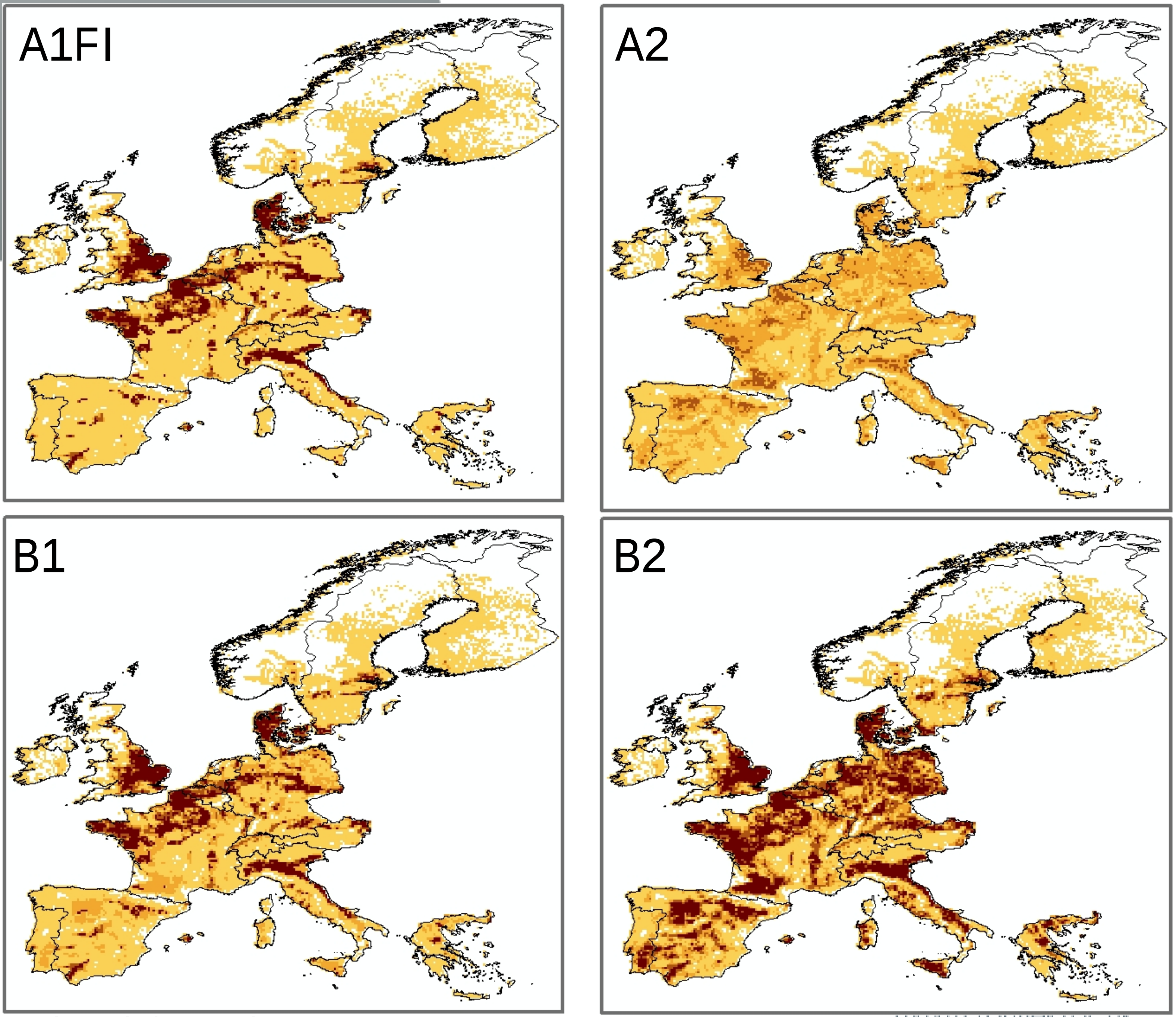
Agriculture is an industry, and responds to market and policy forces

Changes in landuse will be a function of:

- Crop yields – function of technological development
- Prices – function of demand / policy (subsidies)
- Consumer demands
- Legislation – Nitrate Dir., WFD etc etc

Crop land in 2080

(HADCM3)



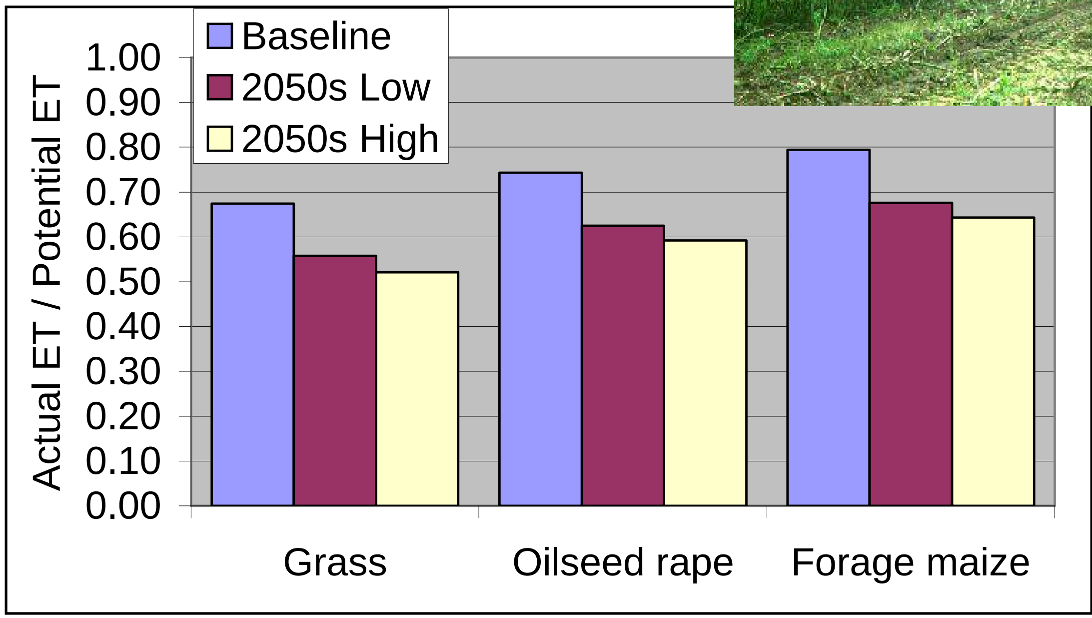
Percentage of arable land per ATEAM cell

- 0
- 1 - 25
- 26 - 50
- 51 - 75
- 76 - 100

ATEAM
http://www.pik-potsdam.de/ateam/

Consequences of landuse change

Wheat/grass to energy crops- HER reduces by 100-180mm/a
(Stephens et al., 2001)



Henriques (2007)

2050s High Global Market:
rural landscape change ~ -35 Ml/d

Consequences of landuse change

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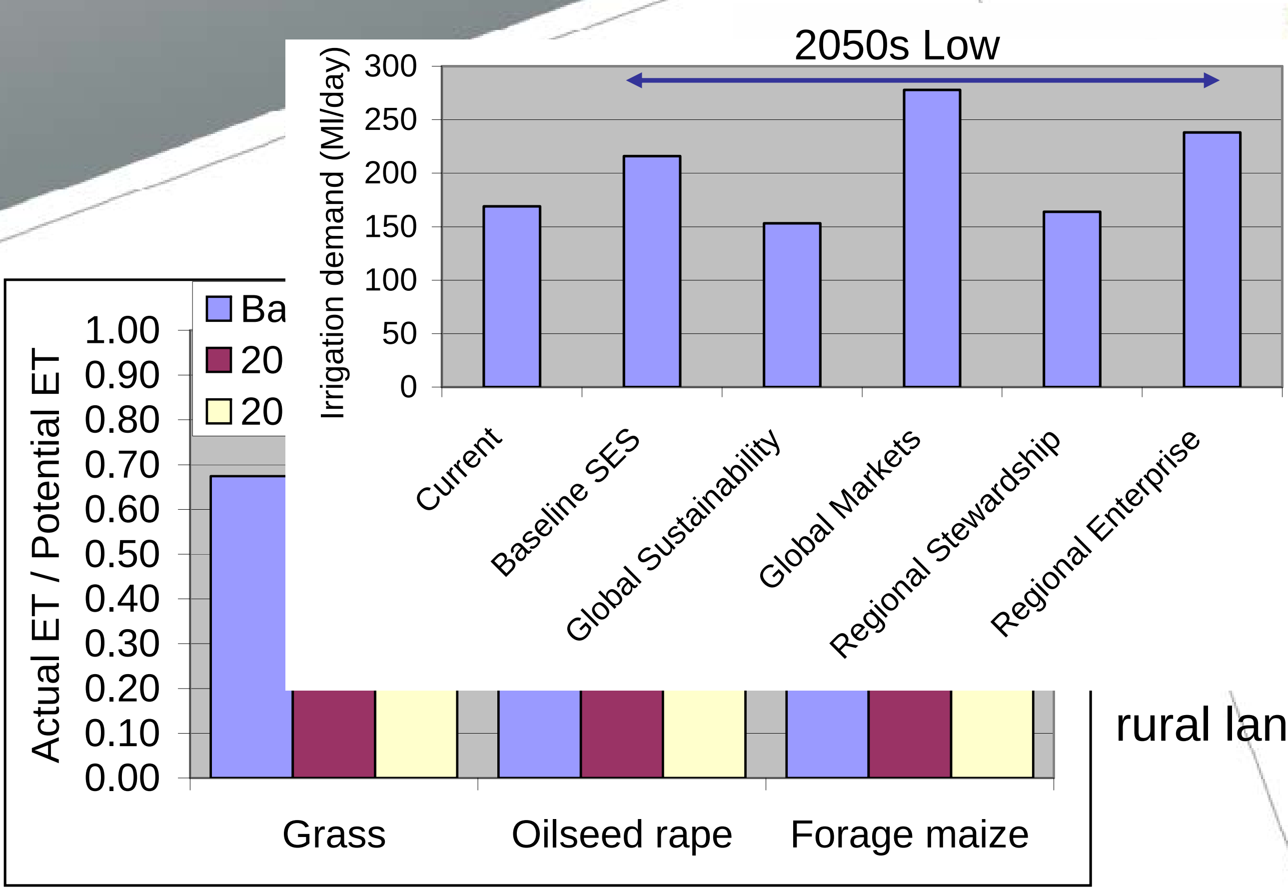

Henriques (2007)

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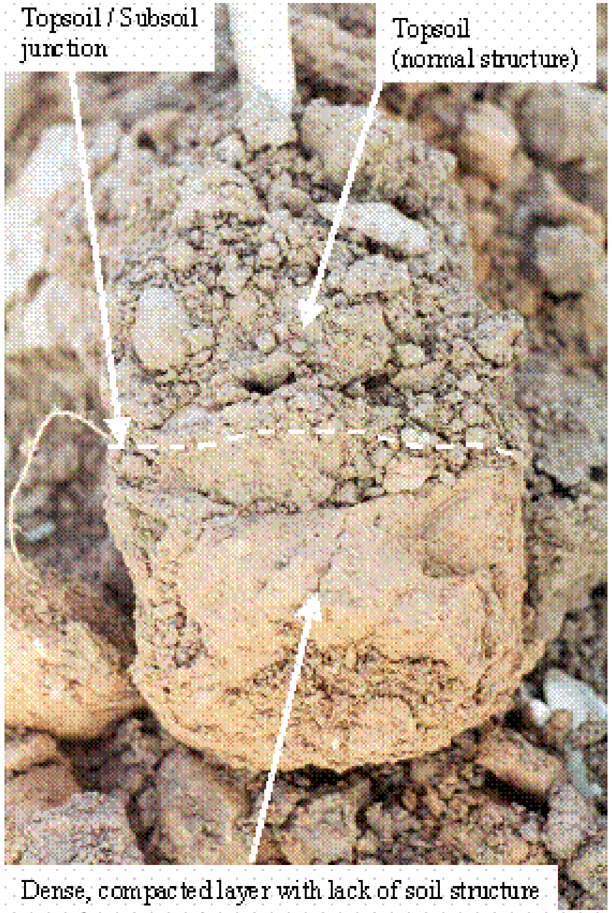
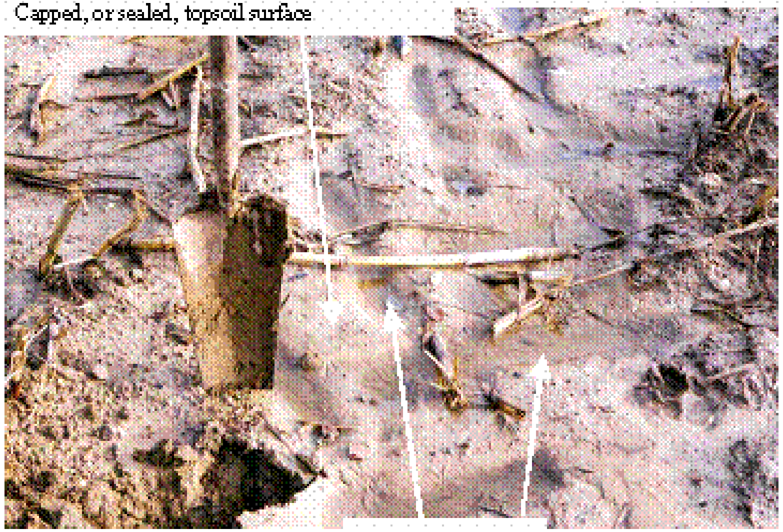
rural landscape change ~ -35 Ml/d

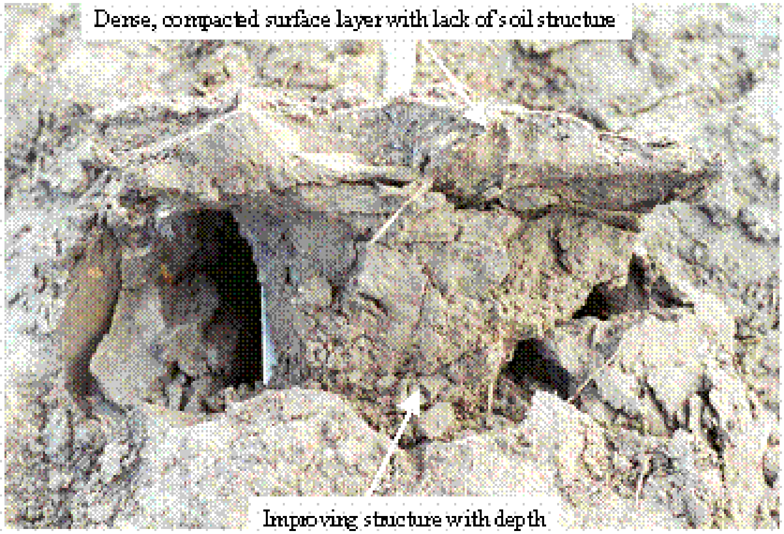
Impacts of land management



Plough pan



Capping



Compaction

Spatial significance

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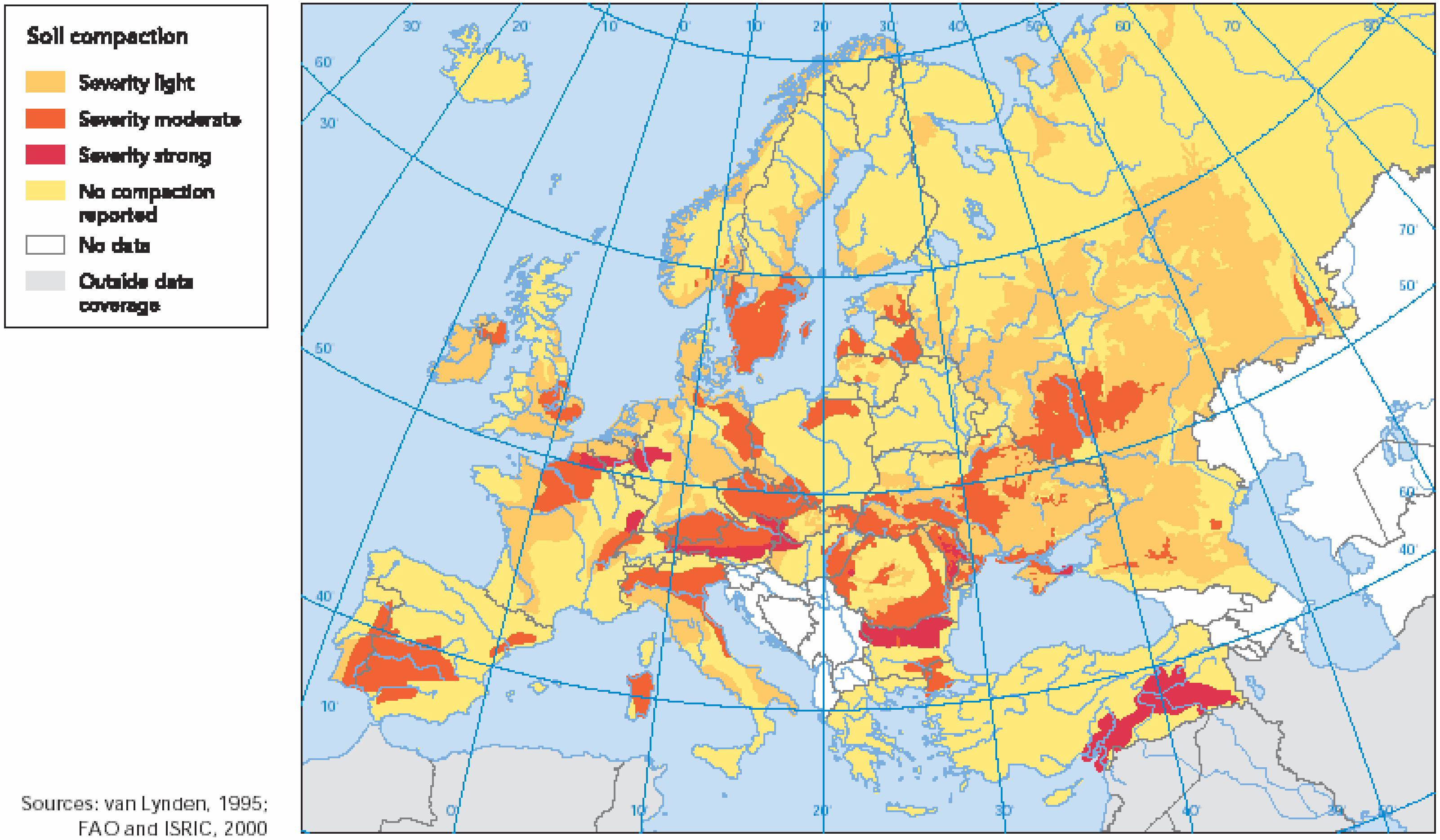
Extensive structural degradation was found on:

- 60-70% of cereal and ley grass sites in Tone
- < 50% of cereal and ley grass sites in Parrett
- >= 70% of maize, potato and sugarbeet sites in the Severn, Yorkshire Ouse & Uck
- 80% of cereal sites in the Uck
- >=30% of cereal and ley grass sites in the Severn and Yorkshire Ouse

Holman et al. (2003)

Severity of compaction



EEA- Europe's environment: the third assessment

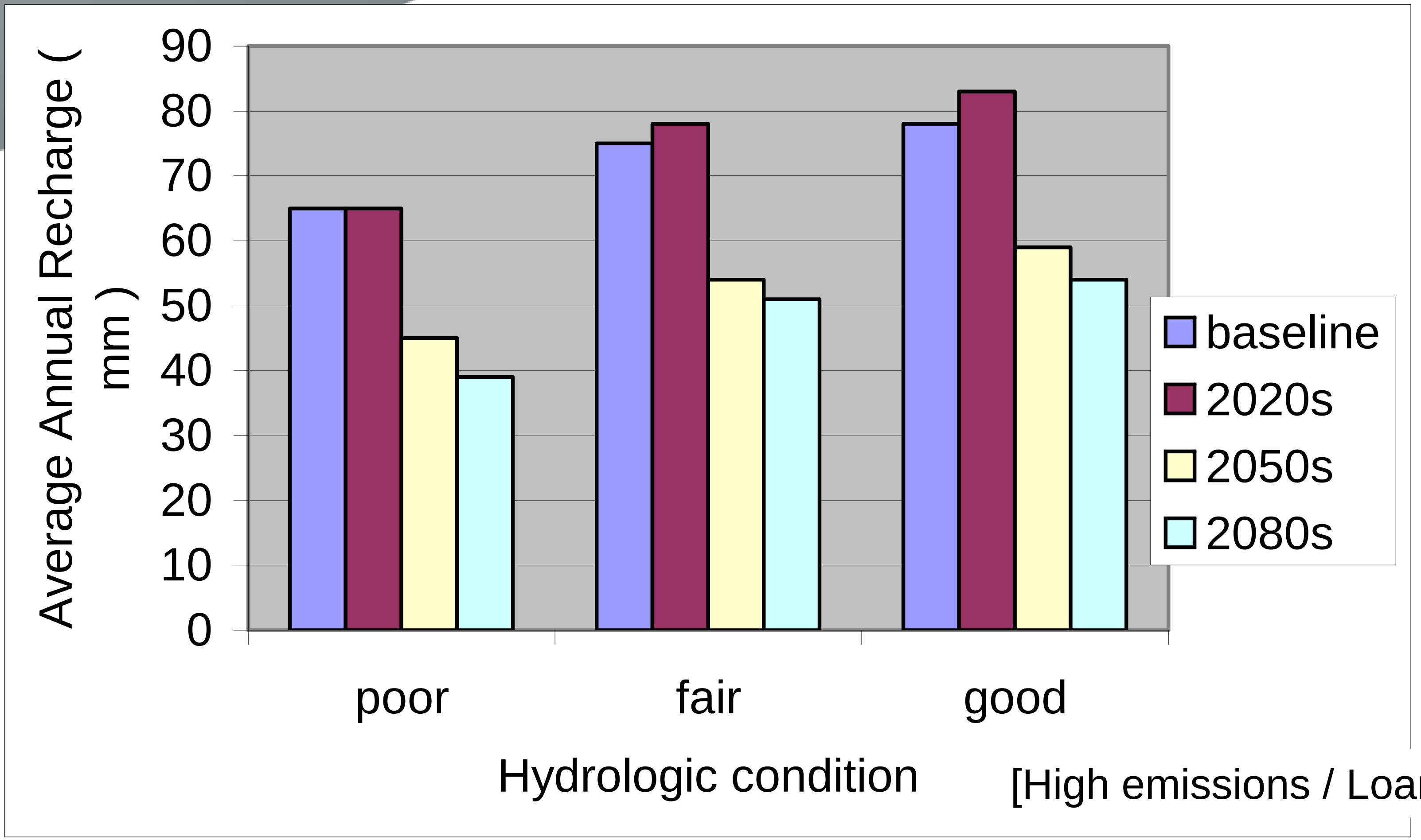
Consequences

Evidence of ‘lost’ recharge

Consequences…

Surface runoff across finely cultivated, sandy soil during rainfall of about 1.9 mm per hour. The dye was introduced 1 minute before the photo was taken (T Harrod, NSRI).

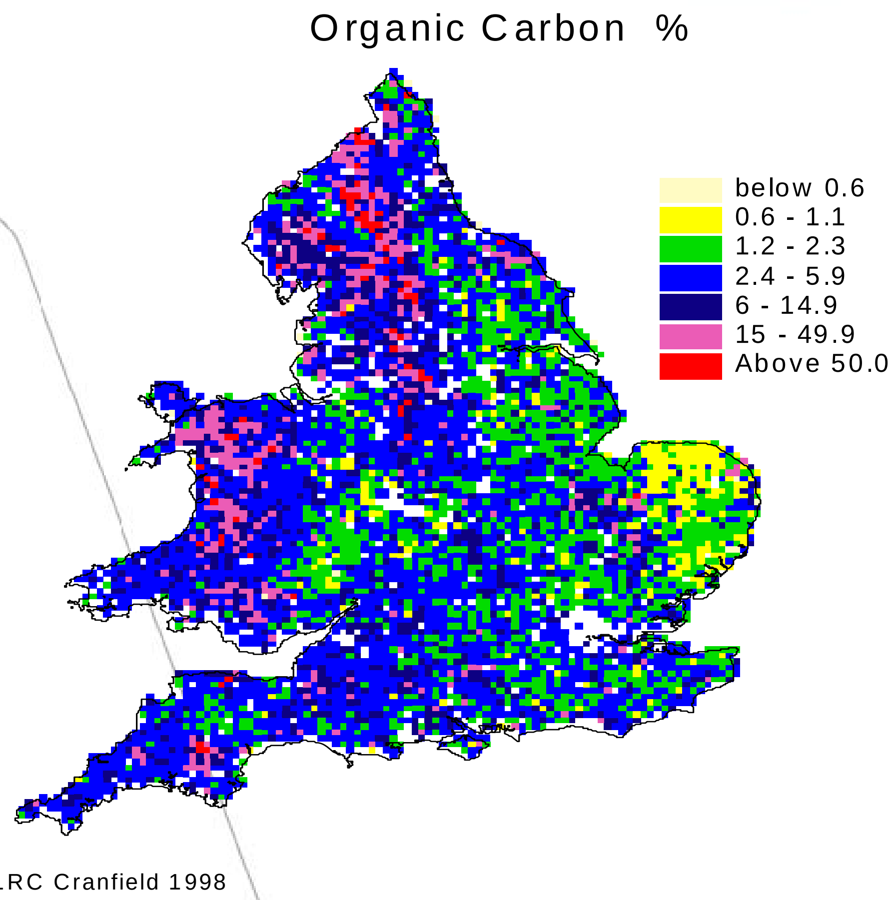
Consequences on recharge…..



[High emissions / Loam soil]

- Poor soil conditions reduce recharge by up to ~ 25 %

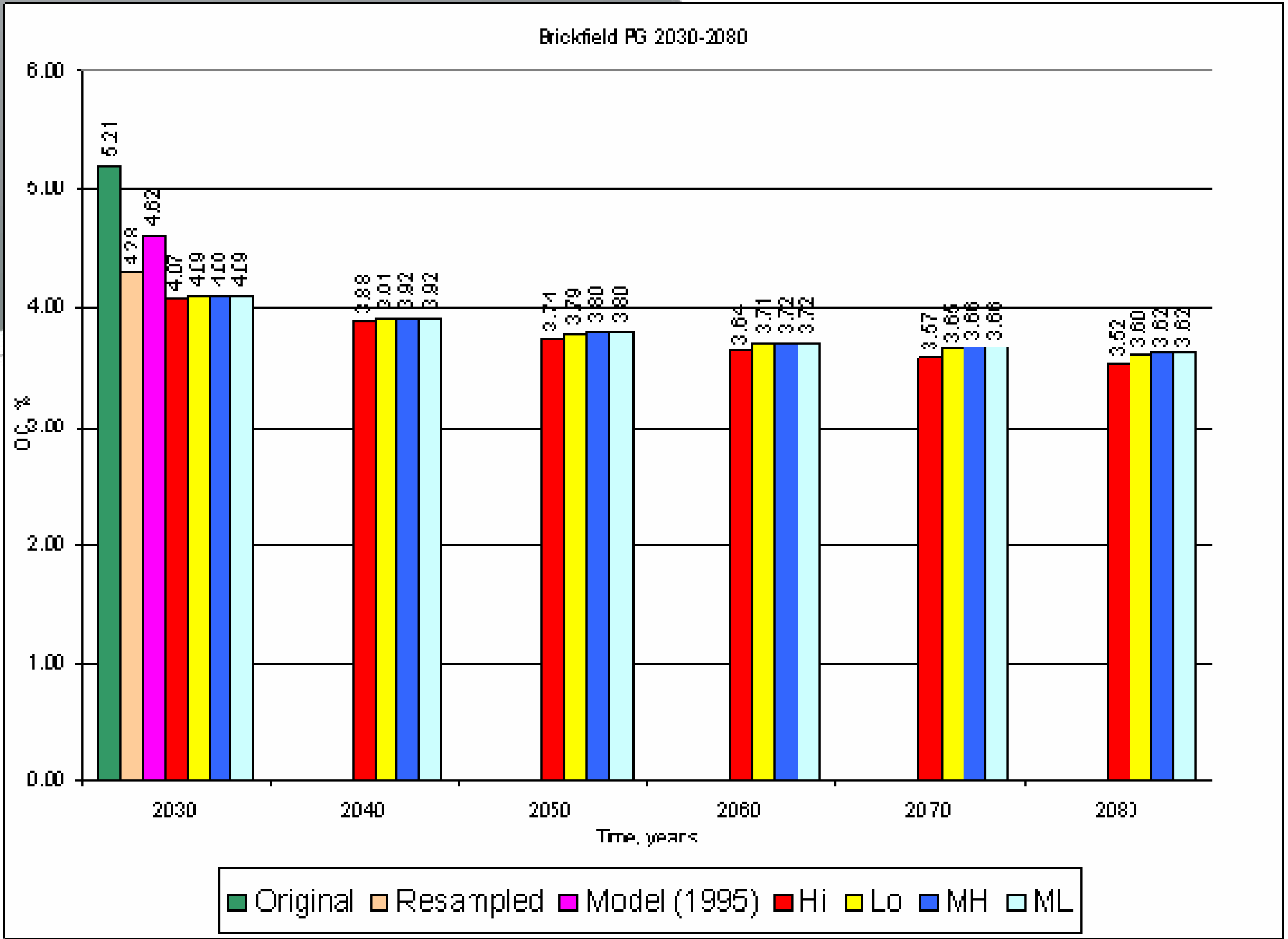
Soils will also change…..



Climate change will affect:

- soil organic carbon - important for structural stability
- depth & duration of waterlogging - important for hydrological response

Consequences…..



Declining soil organic carbon

Hollis et al. (2005)

Consequences…..

Hydrology of Soil Types (HOST) – used in hydrogeology (recharge estimation) and hydrology (flood studies, low flows)

Soils in:

- HOST class 24 may change to class 18
- HOST class 25 may change to class 20
- HOST class 15 may change to classes 17 and 4

Hollis et al. (2005)

Increasing resilience

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- Climate change effects on future groundwater recharge are likely to be significant

- But we can increase the ‘permeability’ of the landscape of allow a greater proportion of potential recharge

Urban environments

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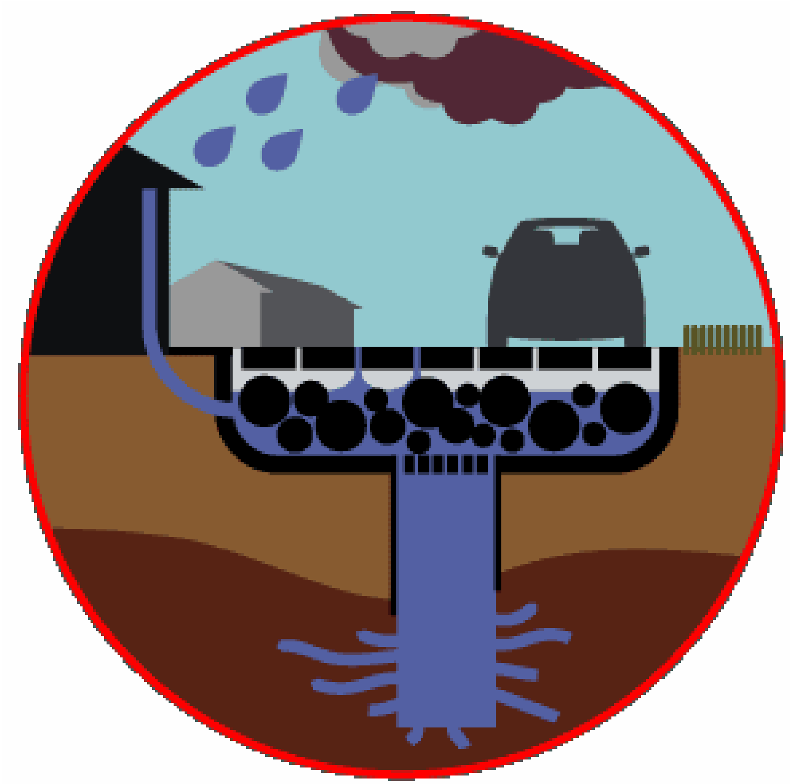
SUDS



Cultivation methods

Depressional storage / AQUEEL

The non-Aqueeled surface shows signs of

Post-harvest treatments

Runoff from harvested maize fields

Treatment	Overland flow (m^3/ha)
Conventional	433
Chisel ploughing	10
Under-sowing	160
Cover-crop	381

[Martyn et al., 2000]

Conclusions

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- Direct climate change effects on future groundwater recharge are significant, but uncertain
- Climate change will also lead to changes in landuse and land management
- Future soils won’t necessarily have the same infiltration properties as current soils
- These have implications for future groundwater resources
- But ‘farming water’ may allow a greater proportion of potential recharge and increase system resilience