Rothamsted Research
where knowledge grows

Modelling C,N&P cycling under agricultural systems in the UK

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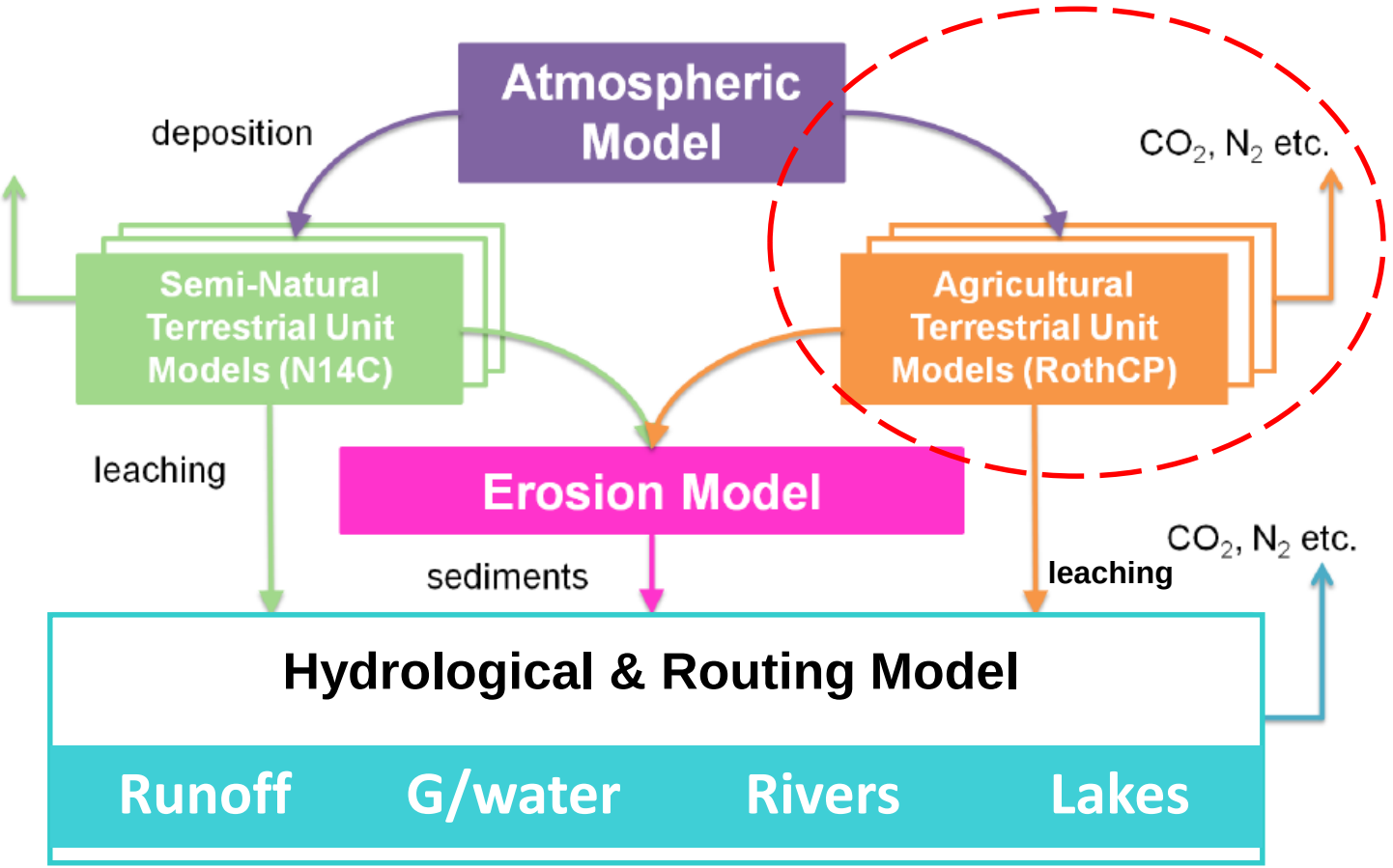
Sustainable Soils and Grassland Systems

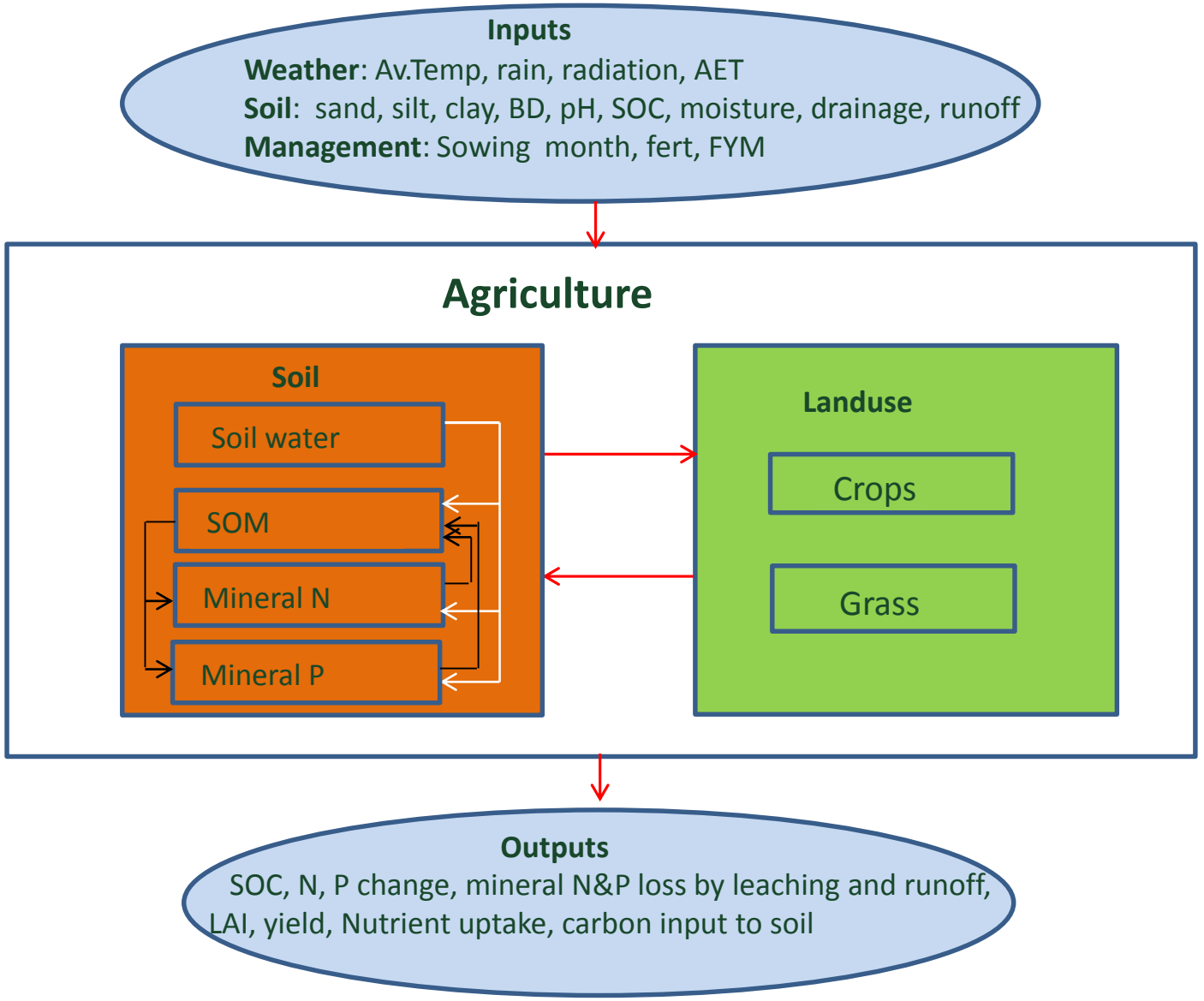
BBSRC bioscience for the future
ROTHAMSTED RESEARCH

Integrated Model (IM)



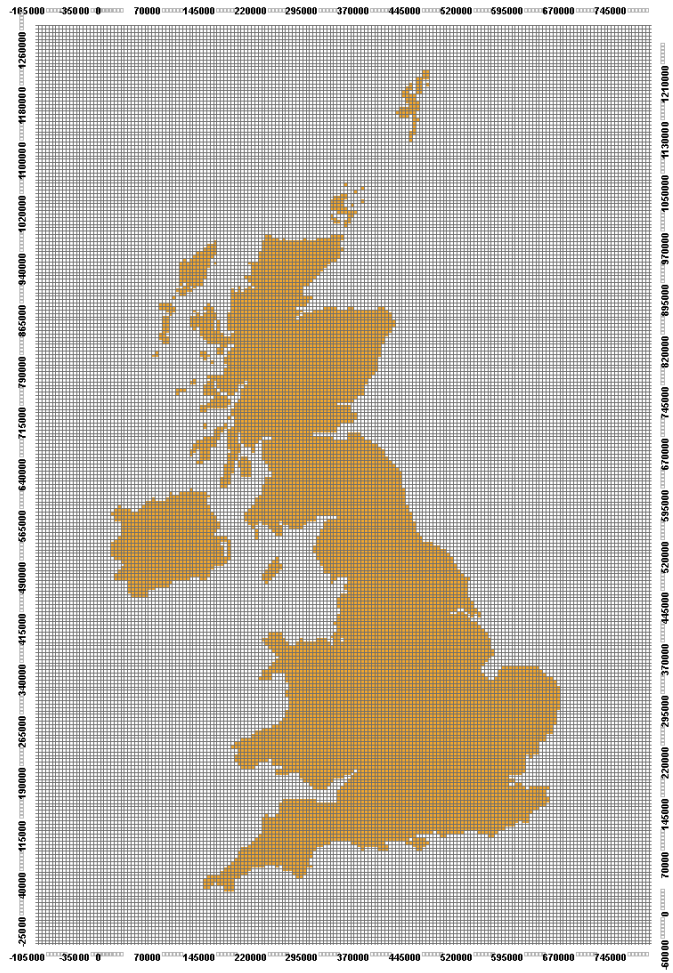
(from Bell, CEH Wallingford)

Agricultural model (AM)



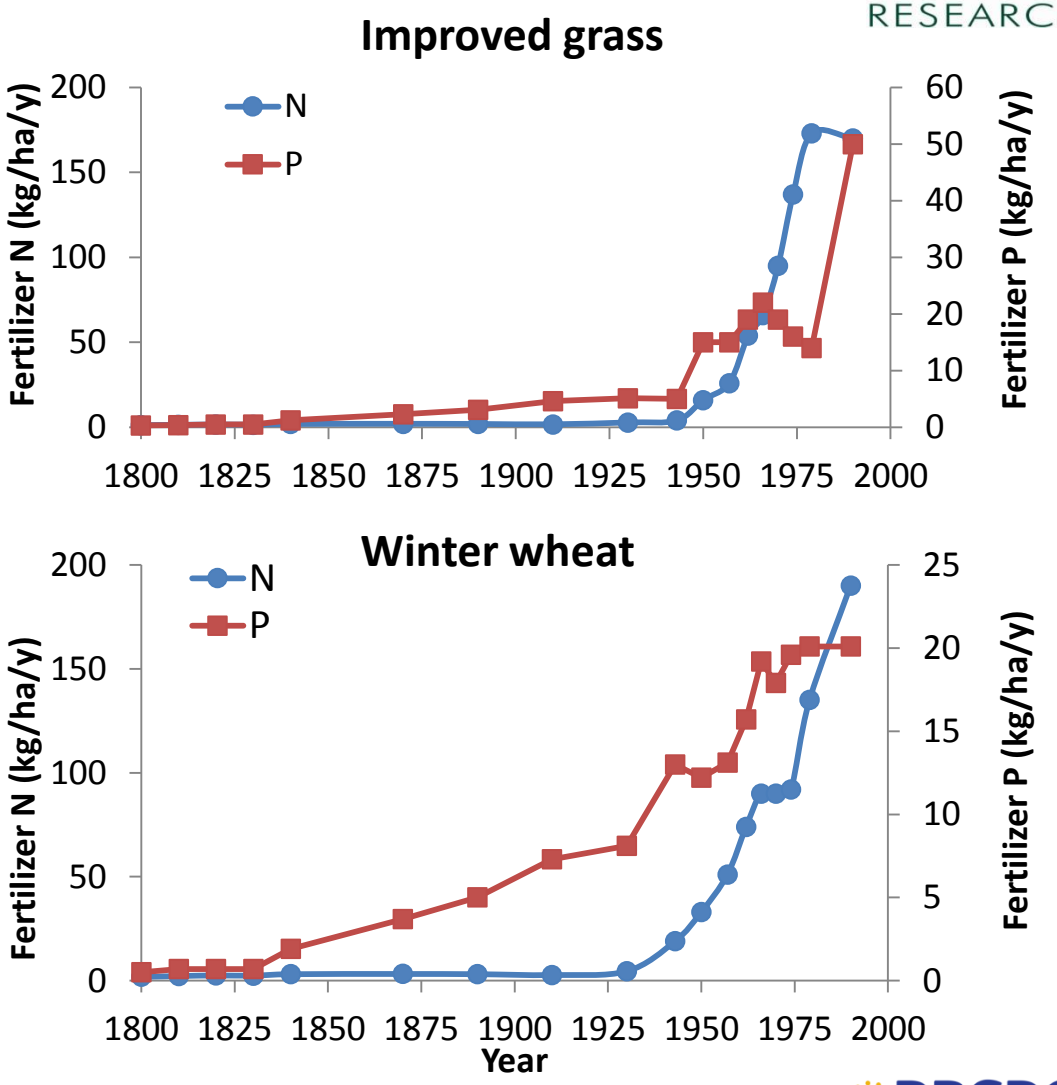
Methodology

- Run the model for (5 x 5 km) grids
- Run the model for **present (1971-2010), past (1800-2000)** and future (2001-2100)
- Landcover maps available from 1800 - 2007
- Landuse (crops and livestock) information from 1900-1990
- Soil maps from HWSD, outputs from the semi-natural system
- Hydrology data from the IM model outputs
- Weather data from Met office –gridded monthly/WATCH EU project



Crop, grass and soil management

- Five major crops (winter wheat, Sp.barley, potato, OSR, and fodder maize) are grown in rotations
- Grass management: dairy, beef, sheep and silage systems
- Slurry and manures are applied in spring
- Fertilizer rates and timing were based on reports/RB209



Results

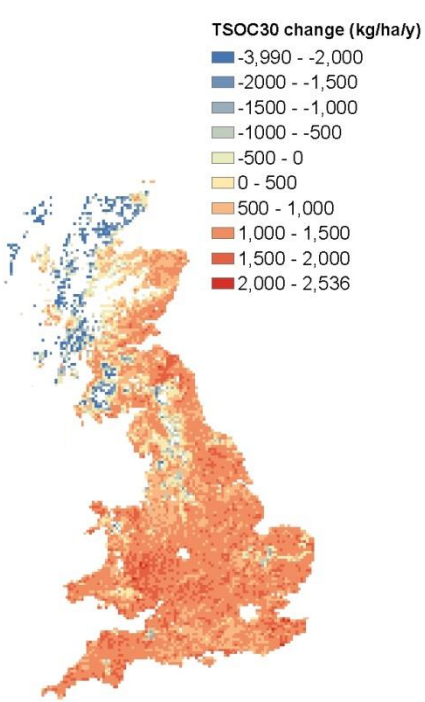
Output variables	Processes
Soil organic carbon (SOC)	Carbon input &decomposition
Nitrate-N (NO_3-N)	Leaching, runoff, soil erosion
Ammonium-N (NH_4-N)	Runoff, soil erosion
Dissolved inorganic phosphorus (DIP)	Leaching, runoff, soil erosion
Dissolved organic carbon (DOC)	Leaching+ runoff
Dissolved organic nitrogen (DON)	Leaching+ runoff
Dissolved organic phosphorus (DOP)	Leaching+ runoff
Particulate organic carbon (POC)	Soil erosion
Particulate organic N (PON)	Soil erosion
Particulate organic phosphorus (POP)	Soil erosion

SOC change: 0-30 cm

ROTHAMSTED RESEARCH

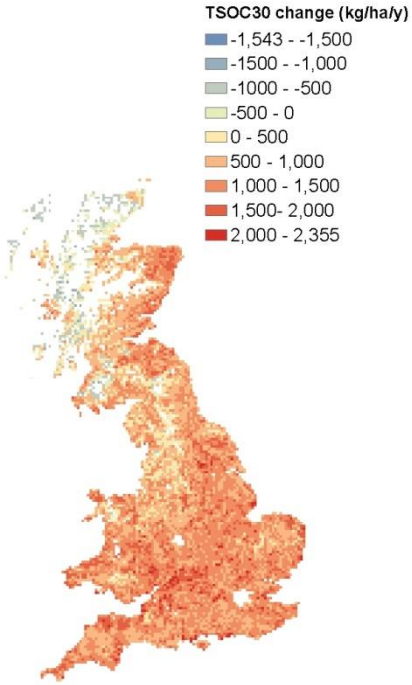
Improved grass

1971-1980



Mean= 681 kg C $ha^{-1}y^{-1}$

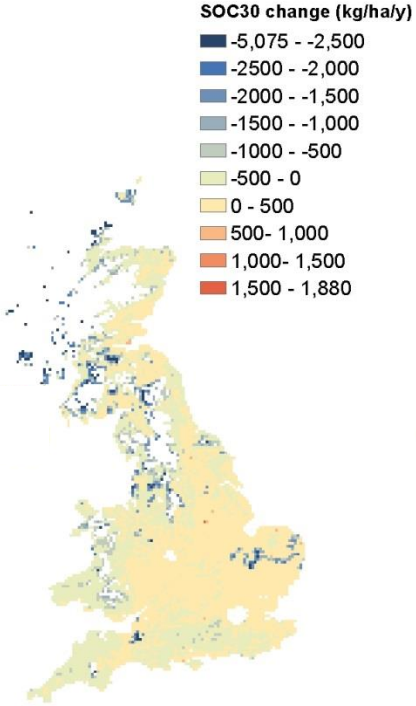
2001-2010



866 kg C $ha^{-1}y^{-1}$

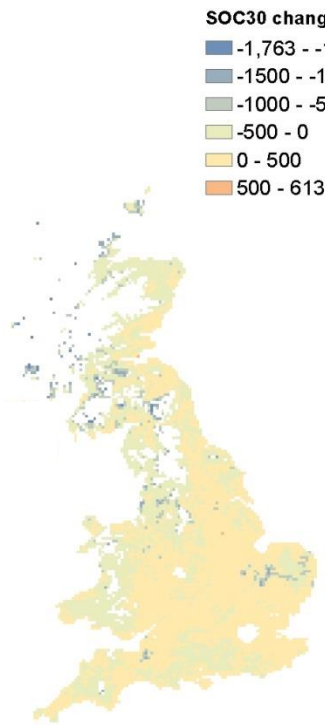
Arable land

1971-1980



-232 kg C $ha^{-1}y^{-1}$

2001-2010



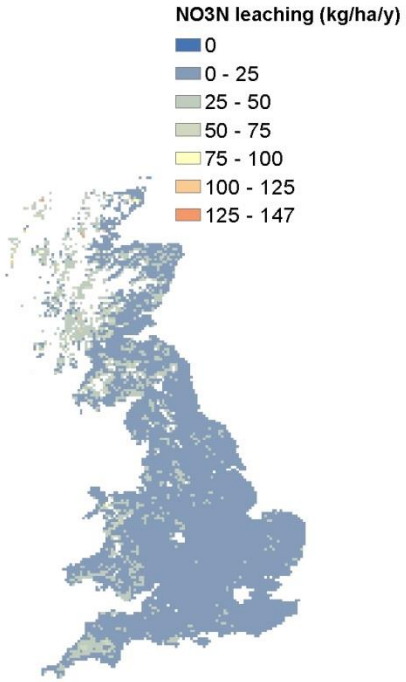
-84 kg C $ha^{-1}y^{-1}$

BBSRC bioscience for the future

NO_3N leaching

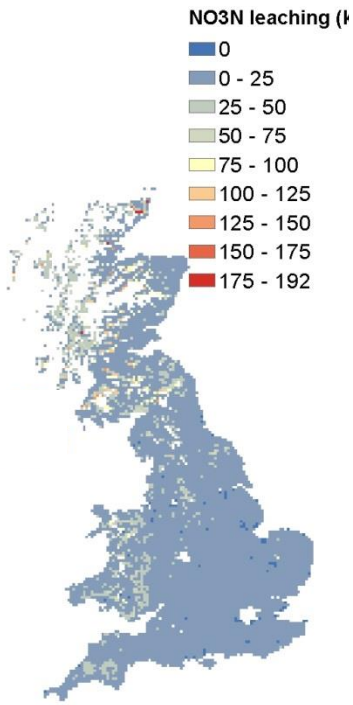
Improved grass

1971-1980



Mean=7 kg N $ha^{-1}y^{-1}$

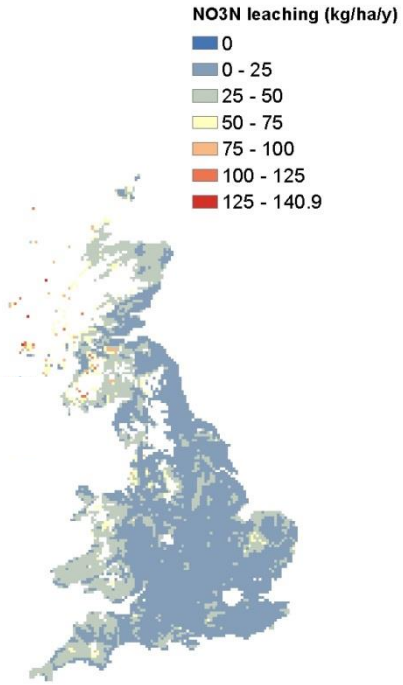
2001-2010



11 kg N $ha^{-1}y^{-1}$

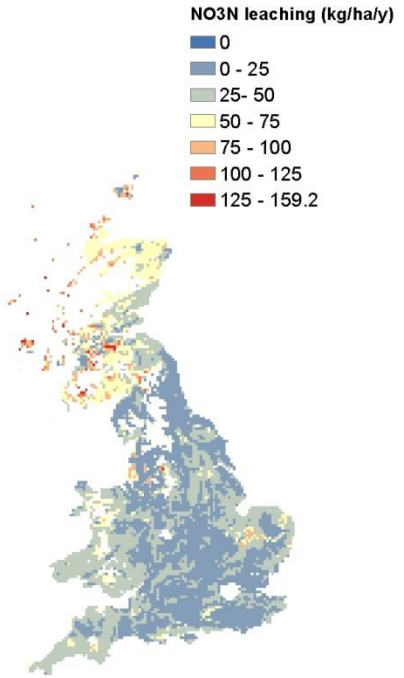
Arable land

1971-1980



25 kg N $ha^{-1}y^{-1}$

2001-2010

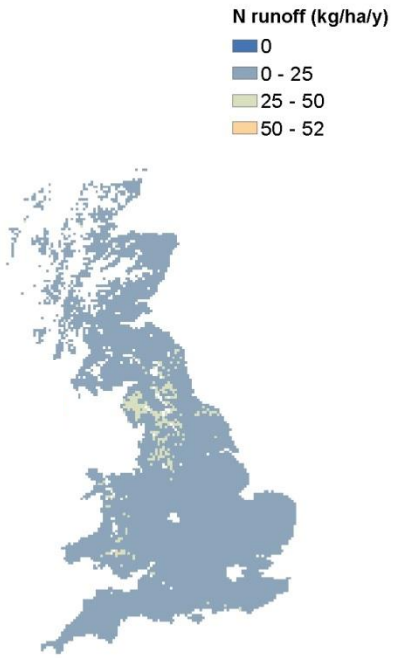


37 kg N $ha^{-1}y^{-1}$

Total N (NH_4 + NO_3N) runoff

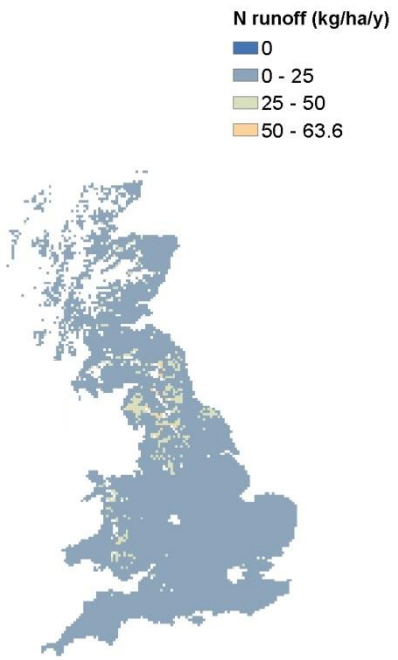
Improved grass

1971-1980



Mean=7 kg N $ha^{-1}y^{-1}$

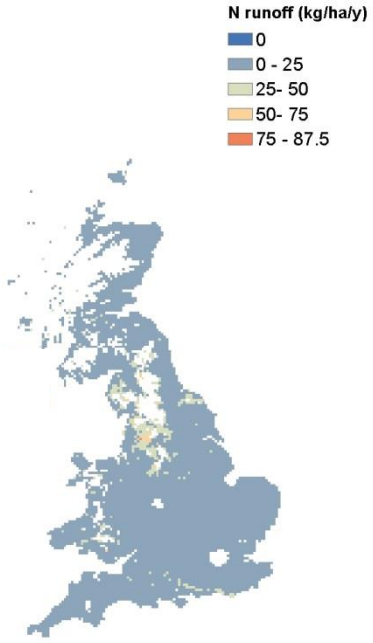
2001-2010



9 kg N $ha^{-1}y^{-1}$

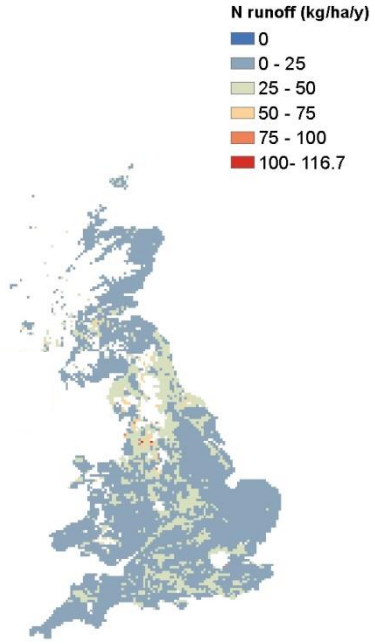
Arable land

1971-1980



10 kg N $ha^{-1}y^{-1}$

2001-2010



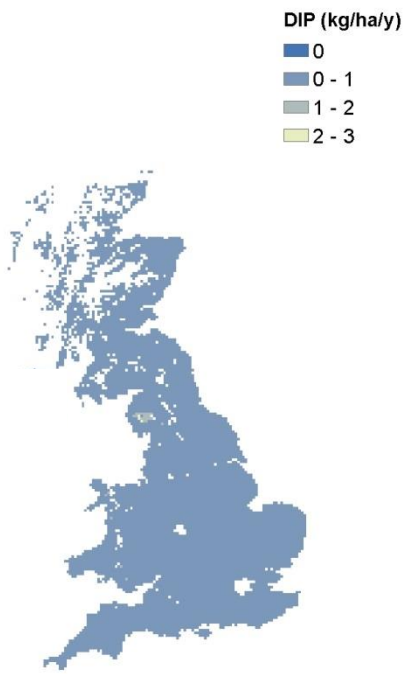
16 kg N $ha^{-1}y^{-1}$

Dissolved inorganic P (leaching + runoff)

ROTHAMSTED RESEARCH

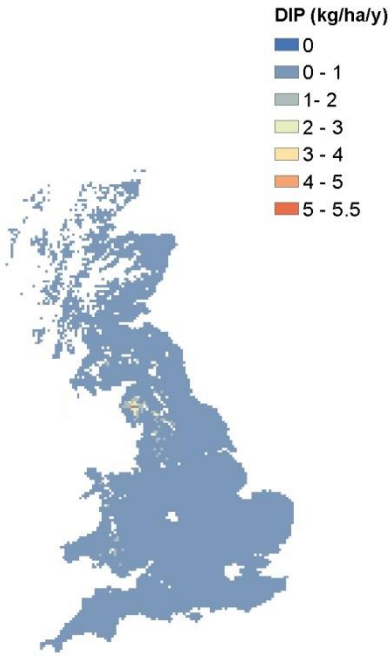
Improved grass

1971-1980



Mean= 0.12 kg P $ha^{-1}y^{-1}$

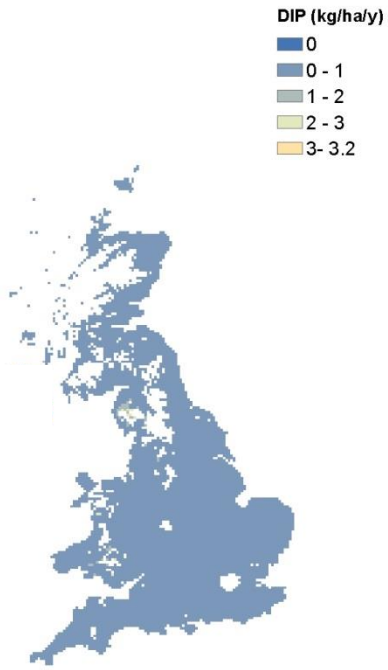
2001-2010



0.15 kg P $ha^{-1}y^{-1}$

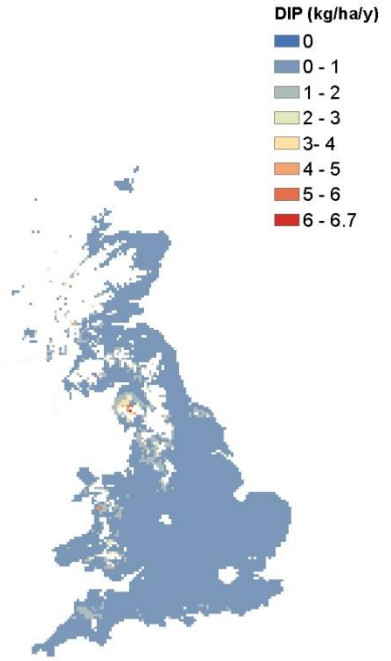
Arable land

1971-1980



0.16 kg P $ha^{-1}y^{-1}$

2001-2010



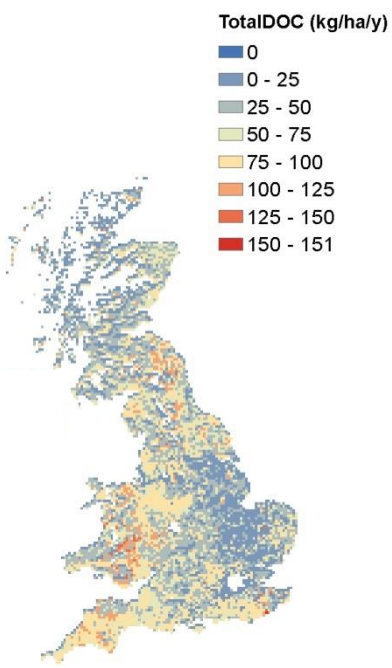
0.32 kg P $ha^{-1}y^{-1}$

BBSRC bioscience for the future

DOC loss

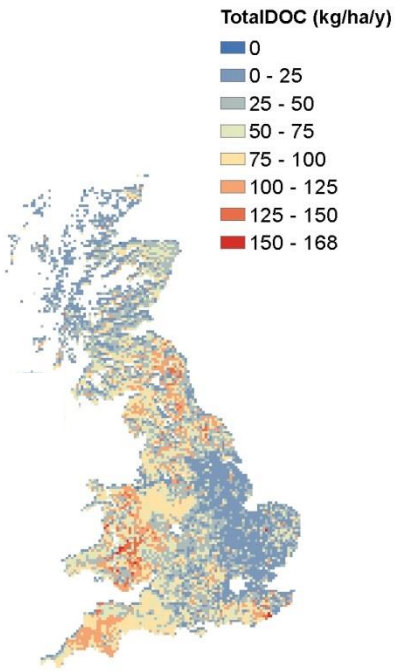
Improved grass

1971-1980



Mean= 50 kg C $ha^{-1}y^{-1}$

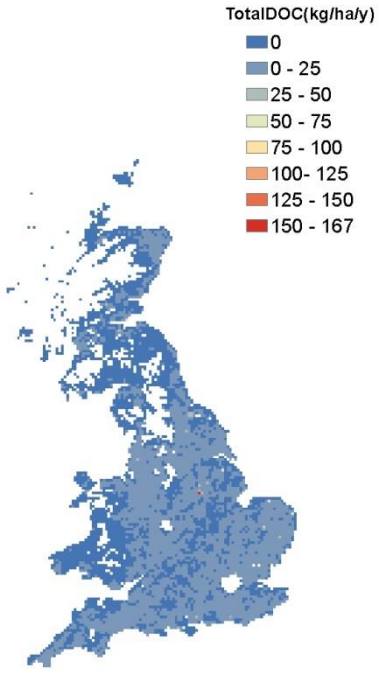
2001-2010



56 kg C $ha^{-1}y^{-1}$

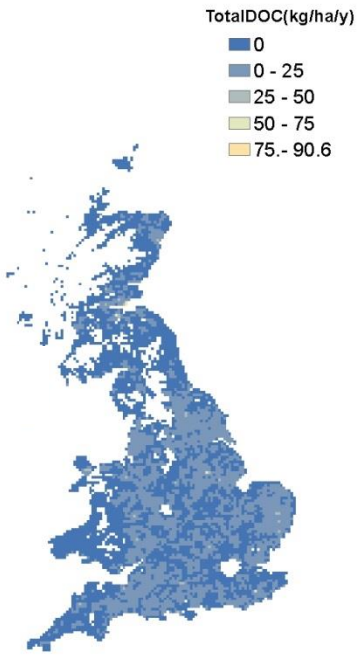
Arable land

1971-1980



1.7 kg C $ha^{-1}y^{-1}$

2001-2010

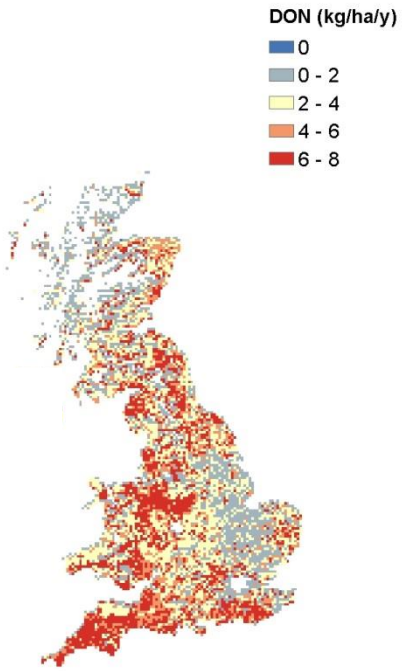


1.6 kg C $ha^{-1}y^{-1}$

DON loss

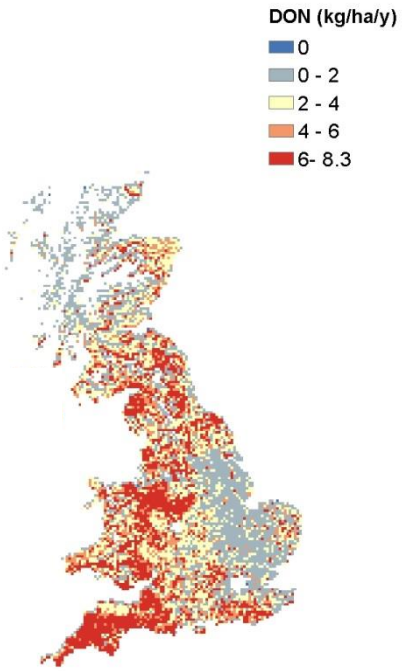
Improved grass

1971-1980



Mean= 3.9 kg N $ha^{-1}y^{-1}$

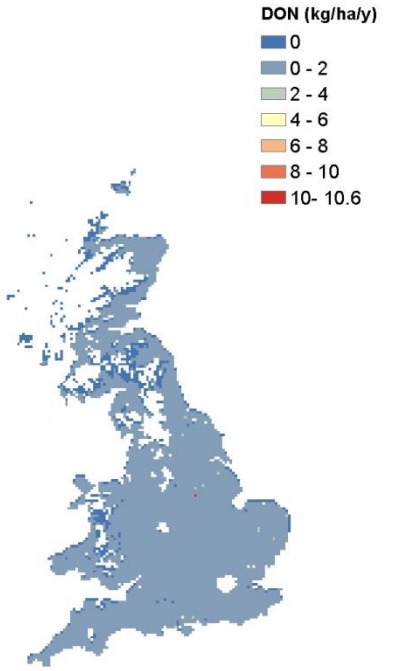
2001-2010



4.0 kg N $ha^{-1}y^{-1}$

Arable land

1971-1980



0.17 kg N $ha^{-1}y^{-1}$

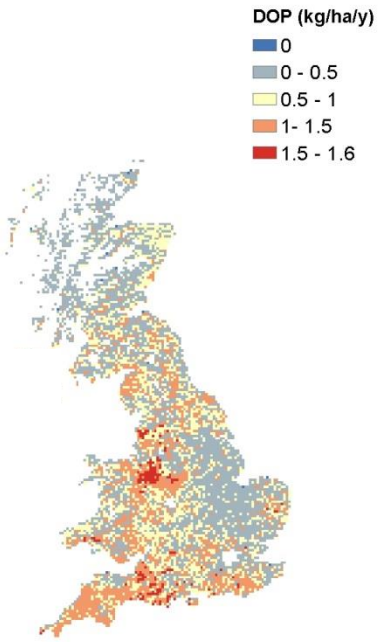
2001-2010

0.18 kg N $ha^{-1}y^{-1}$

DOP loss

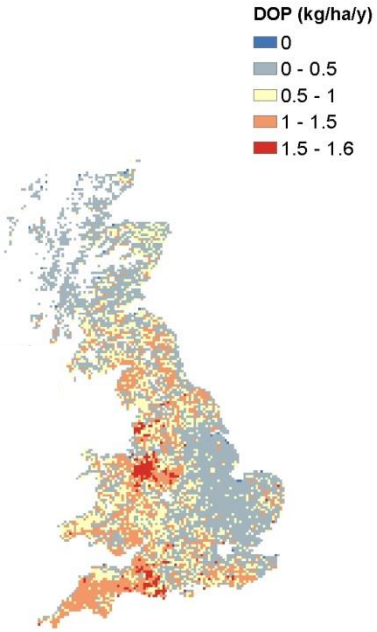
Improved grass

1971-1980



Mean= 0.7 kg P $ha^{-1}y^{-1}$

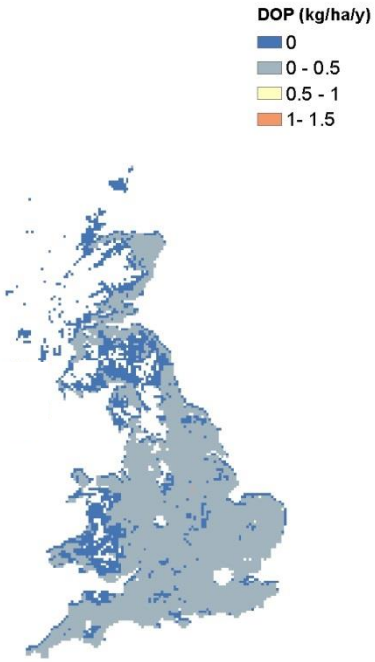
2001-2010



0.7 kg P $ha^{-1}y^{-1}$

Arable land

1971-1980



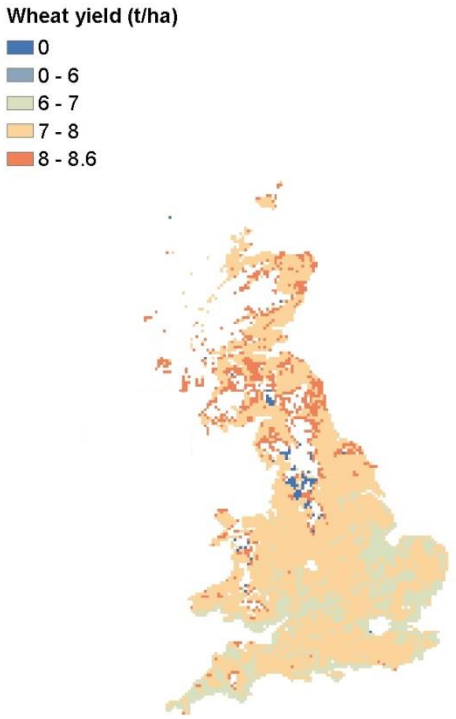
0.03 kg P $ha^{-1}y^{-1}$

2001-2010

0.03 kg P $ha^{-1}y^{-1}$

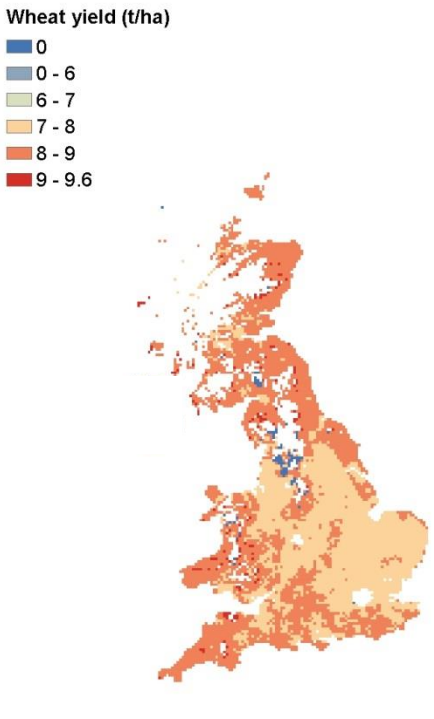
Average crop yields: wheat

1971-1980

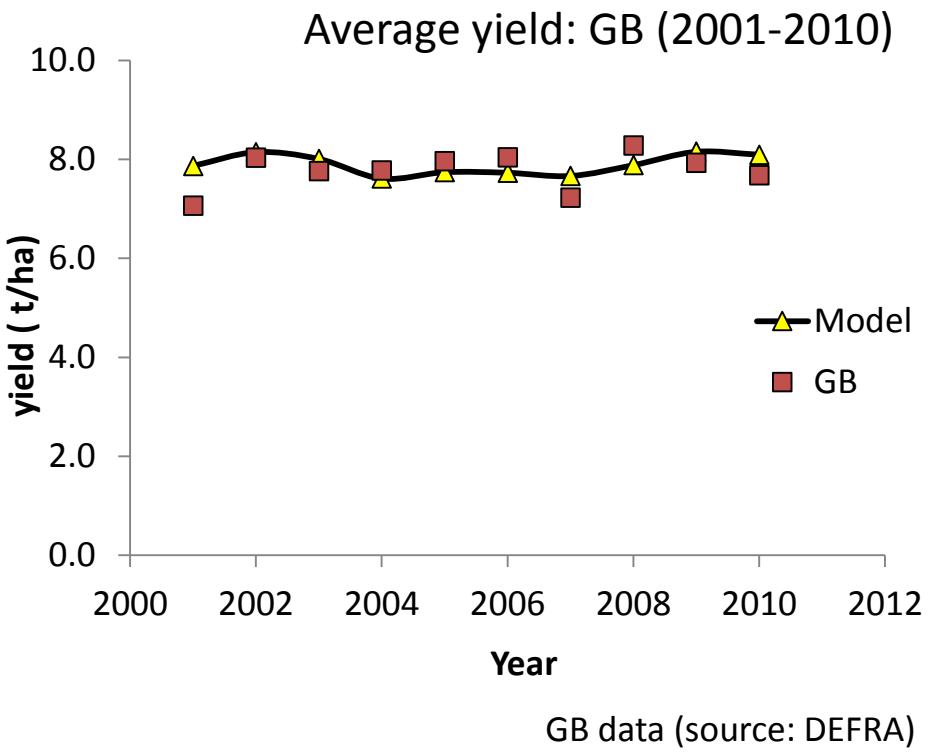


Mean=7.2 t $ha^{-1}y^{-1}$

2001-2010



7.9 t $ha^{-1}y^{-1}$



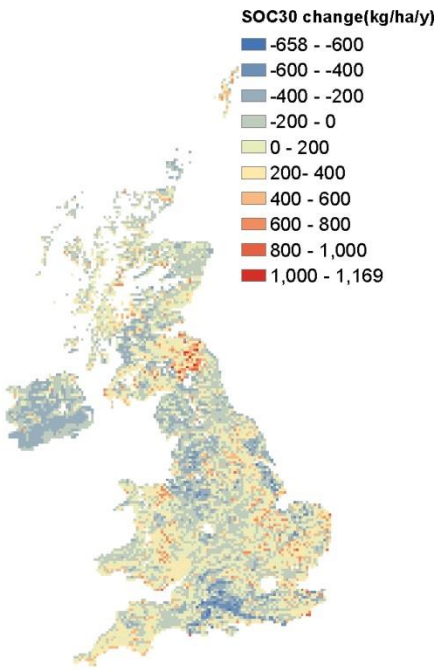
GB data (source: DEFRA)

Historical SOC change (1800-1950)

ROTHAMSTED RESEARCH

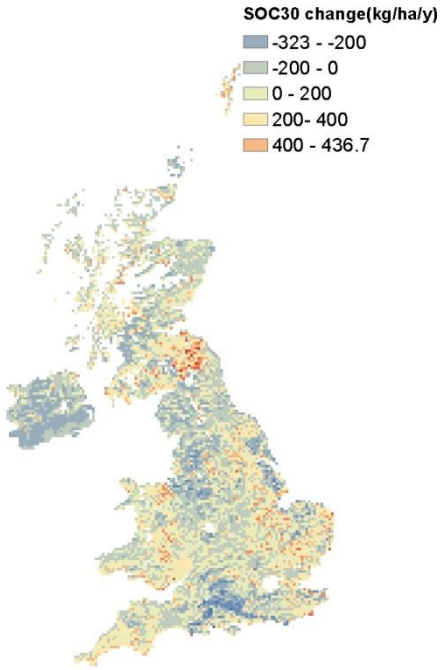
Improved grass

1800-1850



Mean= -55 kg C $ha^{-1}y^{-1}$

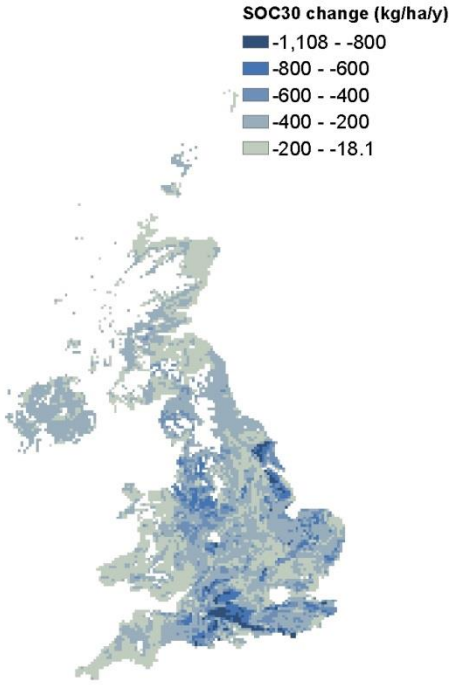
1900-1950



-38 kg C $ha^{-1}y^{-1}$

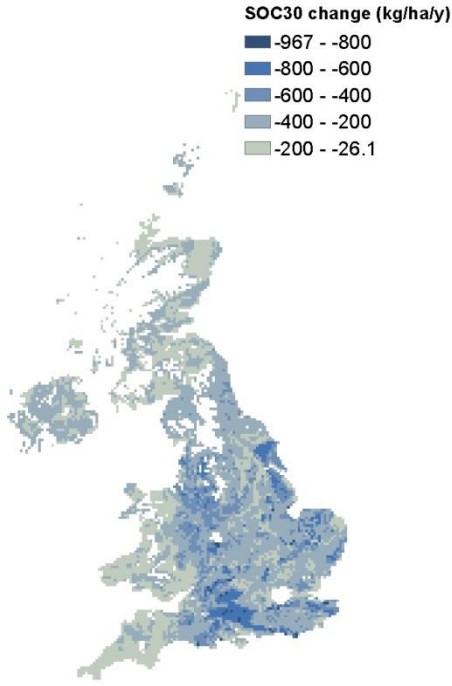
Arable land

1800-1850



-301 kg C $ha^{-1}y^{-1}$

1900-1950



-308 kg C $ha^{-1}y^{-1}$

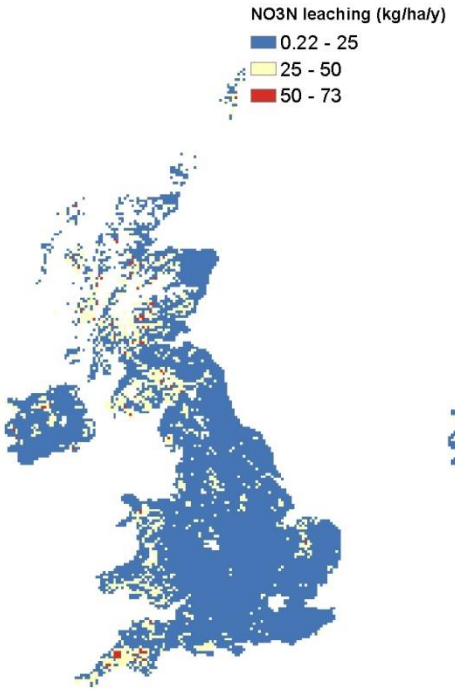
BBSRC bioscience for the future

Historical NO_3N leaching (1800-1950)

ROTHAMSTED RESEARCH

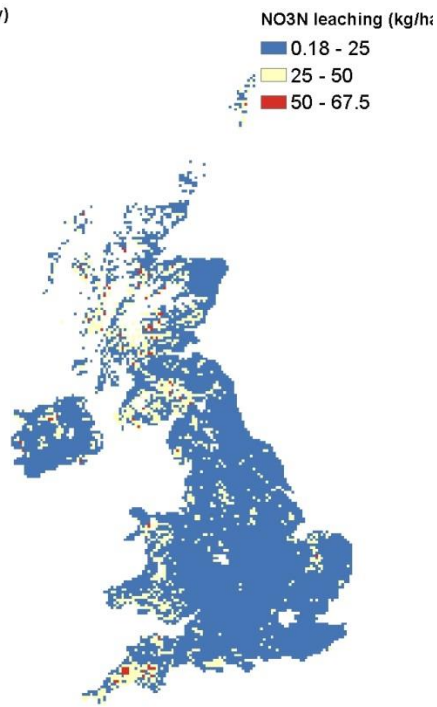
Improved grass

1800-1850



Mean=11 kg N $ha^{-1}y^{-1}$

1900-1950



10 kg N $ha^{-1}y^{-1}$

Arable land

1800-1850

8.5 kg N $ha^{-1}y^{-1}$

1900-1950

9.4 kg N $ha^{-1}y^{-1}$

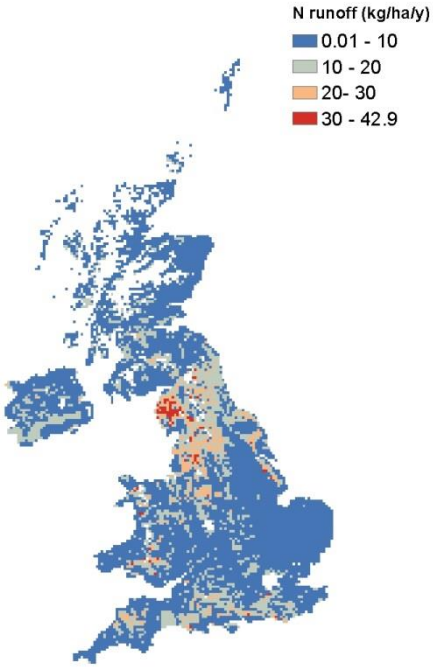
BBSRC bioscience for the future

Historical total N runoff (1800-1950)

ROTHAMSTED RESEARCH

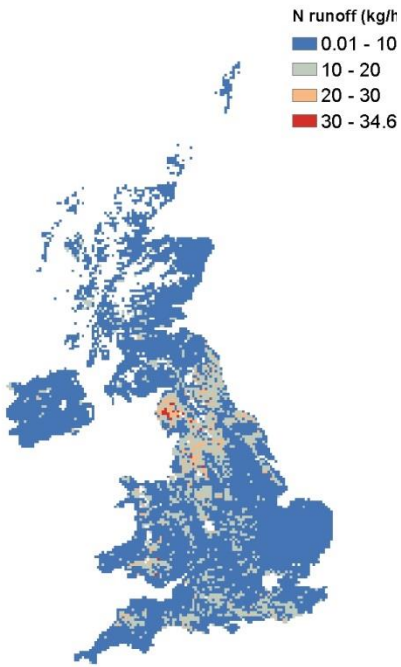
Improved grass

1800-1850



Mean= 6.8 kg N $ha^{-1}y^{-1}$

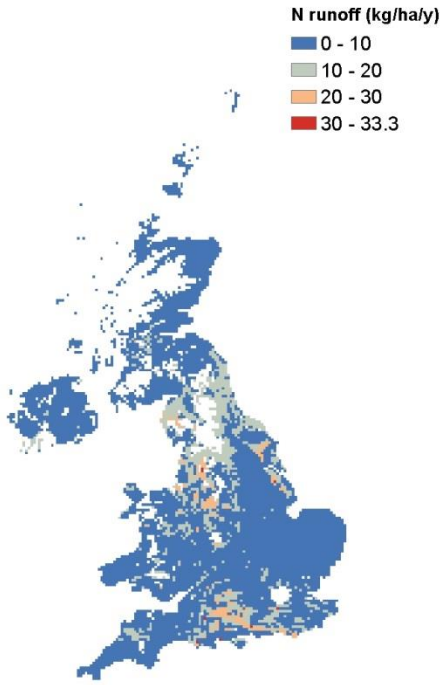
1900-1950



5.5 kg N $ha^{-1}y^{-1}$

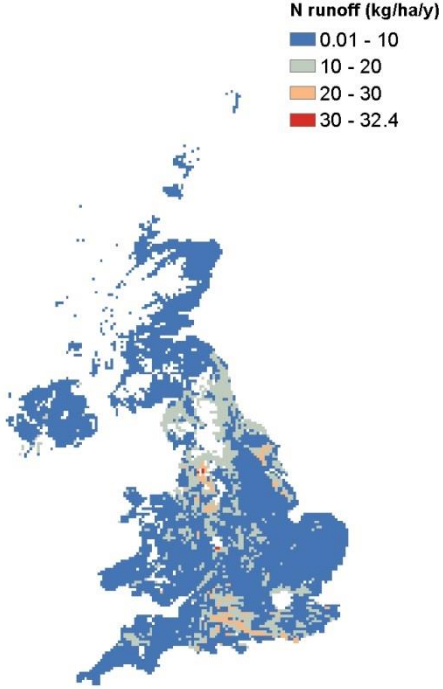
Arable land

1800-1850



4.2 kg N $ha^{-1}y^{-1}$

1900-1950



4.5 kg N $ha^{-1}y^{-1}$

BBSRC bioscience for the future

Historical dissolved inorganic P (1800-1950)

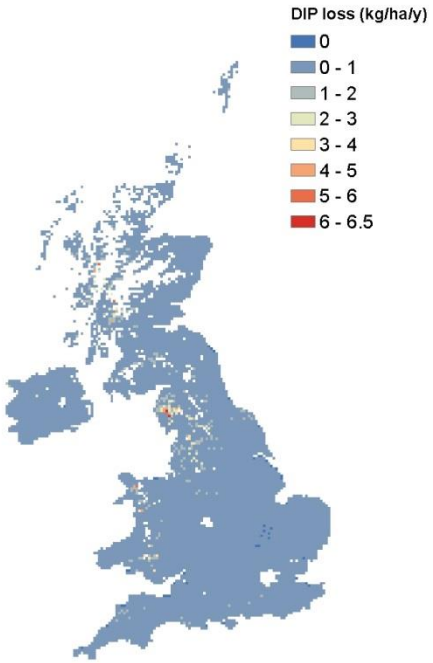
ROTHAMSTED RESEARCH

Improved grass

1800-1850

Mean= 0.05 kg P $ha^{-1}y^{-1}$

1900-1950



0.12 kg P $ha^{-1}y^{-1}$

Arable land

1800-1850

0.03 kg P $ha^{-1}y^{-1}$

1900-1950

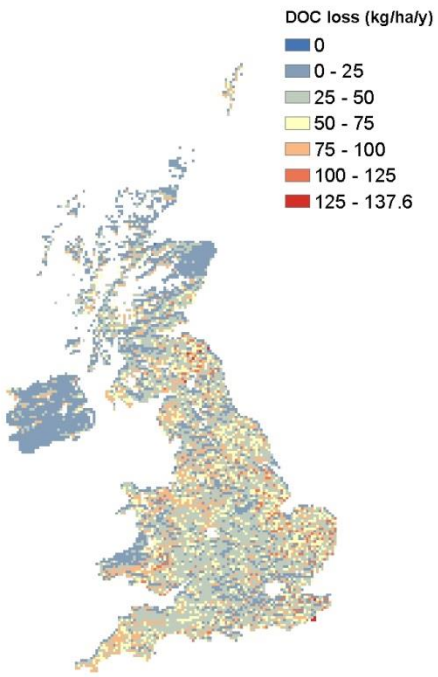
0.07 kg P $ha^{-1}y^{-1}$

BBSRC bioscience for the future

Historical DOC (1800-1950)

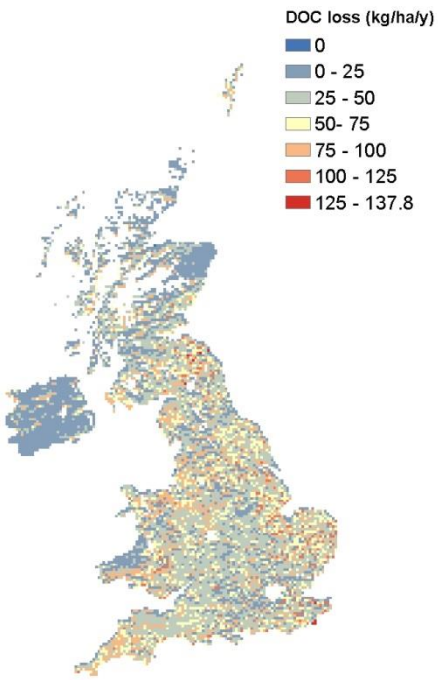
Improved grass

1800-1850



Mean= 30.0 kg C $ha^{-1}y^{-1}$

1900-1950



30.0 kg C $ha^{-1}y^{-1}$

Arable land

1800-1850

0.7 kg C $ha^{-1}y^{-1}$

1900-1950

1.3 kg C $ha^{-1}y^{-1}$

Summary/Next steps

- Model is partially tested for the **present** and found to be satisfactory
- Model results for the **past** are now checked
- Finalising scenarios for the **future**

ROTHAMSTED RESEARCH

Thank you!

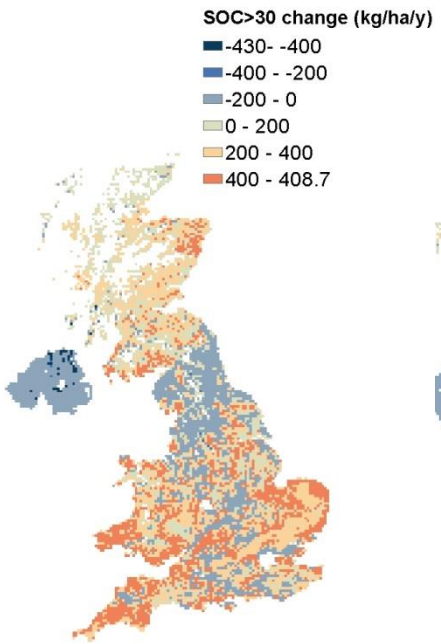
BBSRC bioscience for the future

SOC change: below 30 cm

ROTHAMSTED RESEARCH

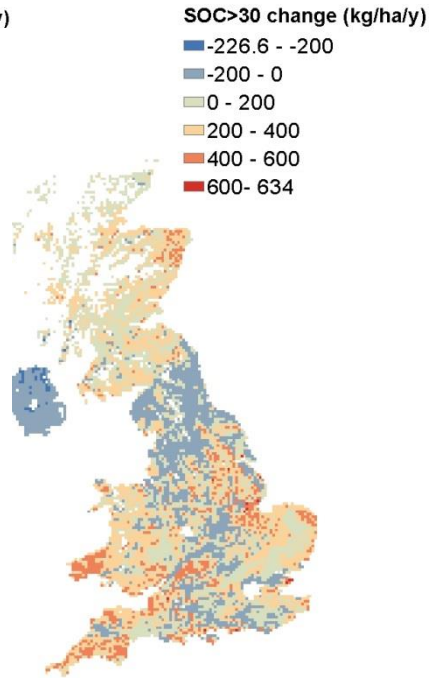
Improved grass

1971-1980



Mean= 152 kg C $ha^{-1}y^{-1}$

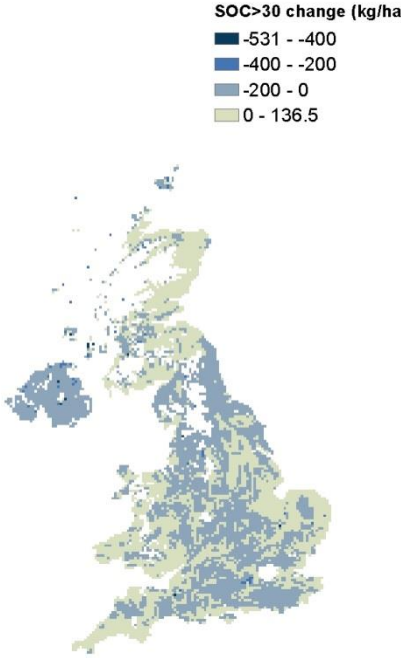
2001-2010



255 kg C $ha^{-1}y^{-1}$

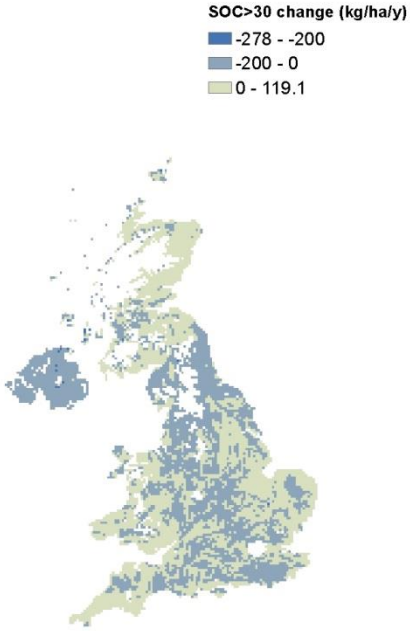
Arable land

1971-1980



22 kg C $ha^{-1}y^{-1}$

2001-2010



28 kg C $ha^{-1}y^{-1}$

BBSRC bioscience for the future

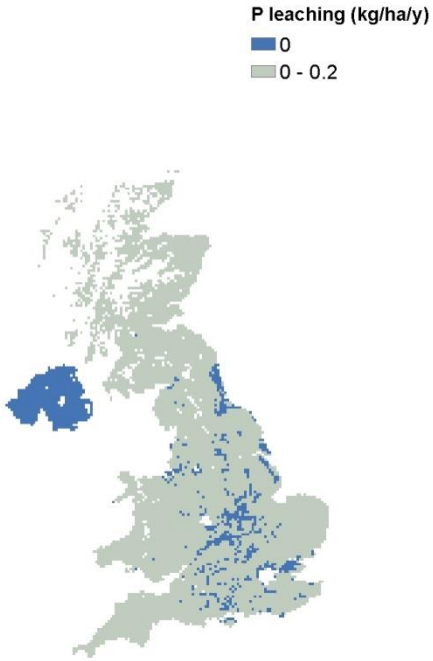
P leaching

Improved grass

1971-1980

Mean=0.04 kg P $ha^{-1}y^{-1}$

2001-2010



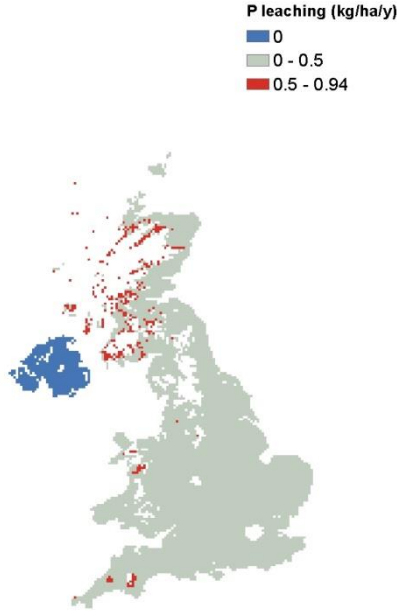
0.05 kg P $ha^{-1}y^{-1}$

Arable land

1971-1980

0.1 kg P $ha^{-1}y^{-1}$

2001-2010



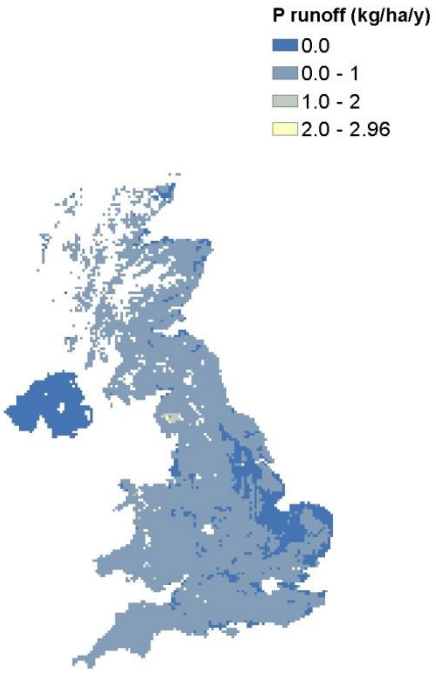
0.2 kg P $ha^{-1}y^{-1}$

P runoff

Improved grass

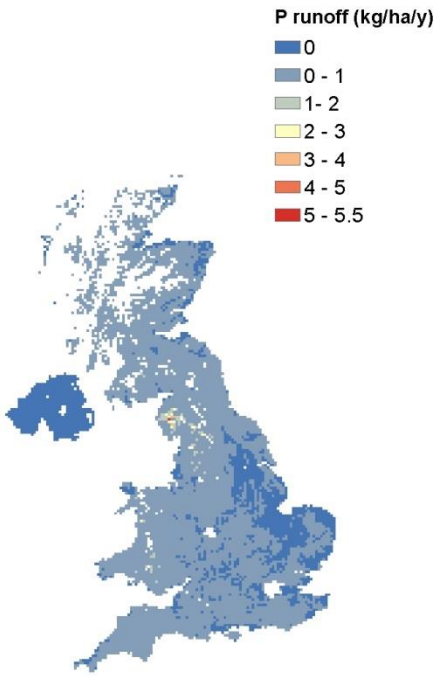
Arable land

1971-1980



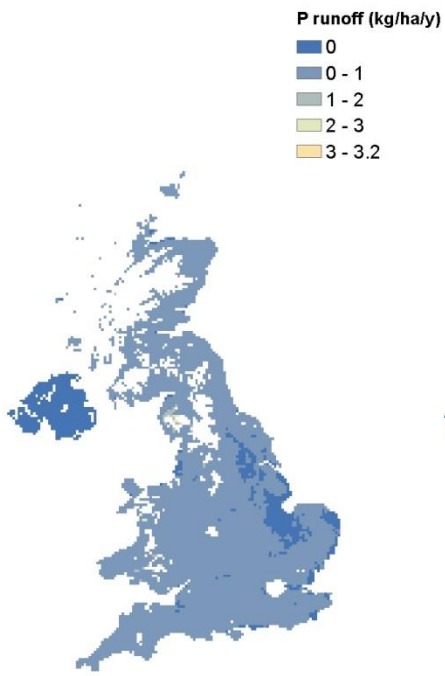
Mean= 0.08 kg P $ha^{-1}y^{-1}$

2001-2010



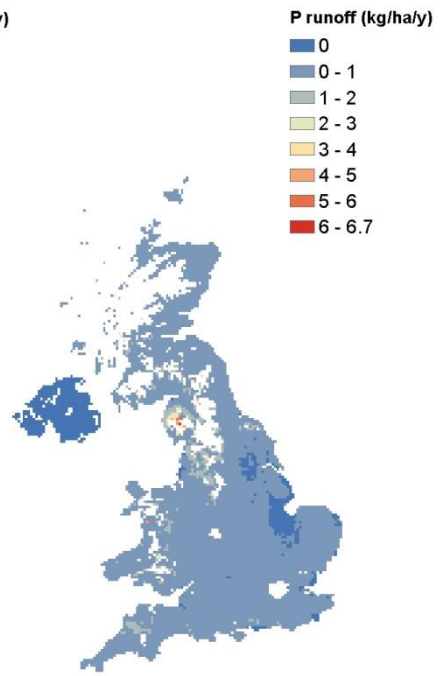
0.1 kg P $ha^{-1}y^{-1}$

1971-1980



0.1 kg P $ha^{-1}y^{-1}$

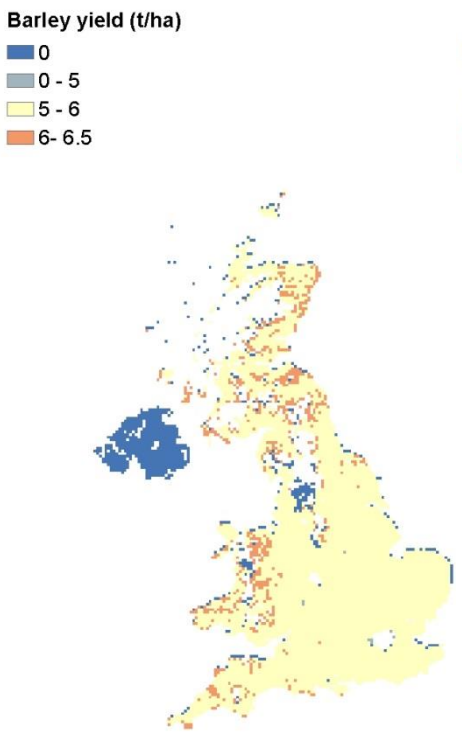
2001-2010



0.3 kg P $ha^{-1}y^{-1}$

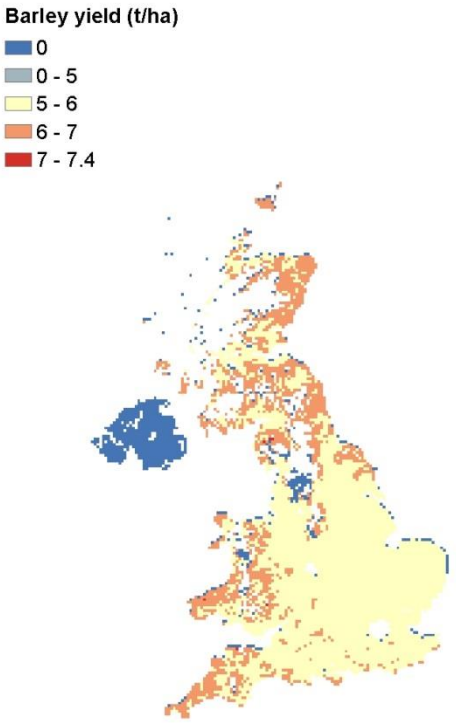
Average crop yields : barley (2001-2010)

1971-1980



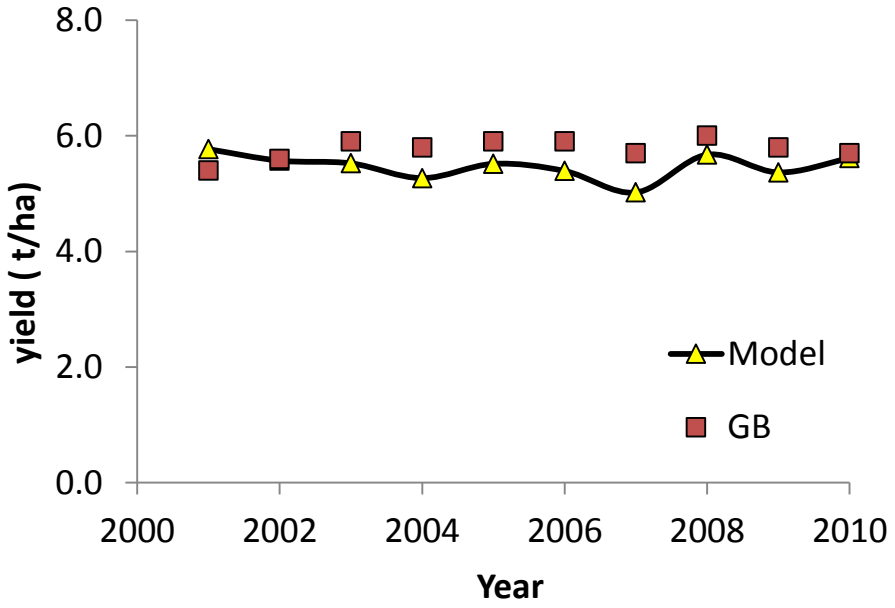
Mean=5.5 t $ha^{-1}y^{-1}$

2001-2010



Mean=5.4 t $ha^{-1}y^{-1}$

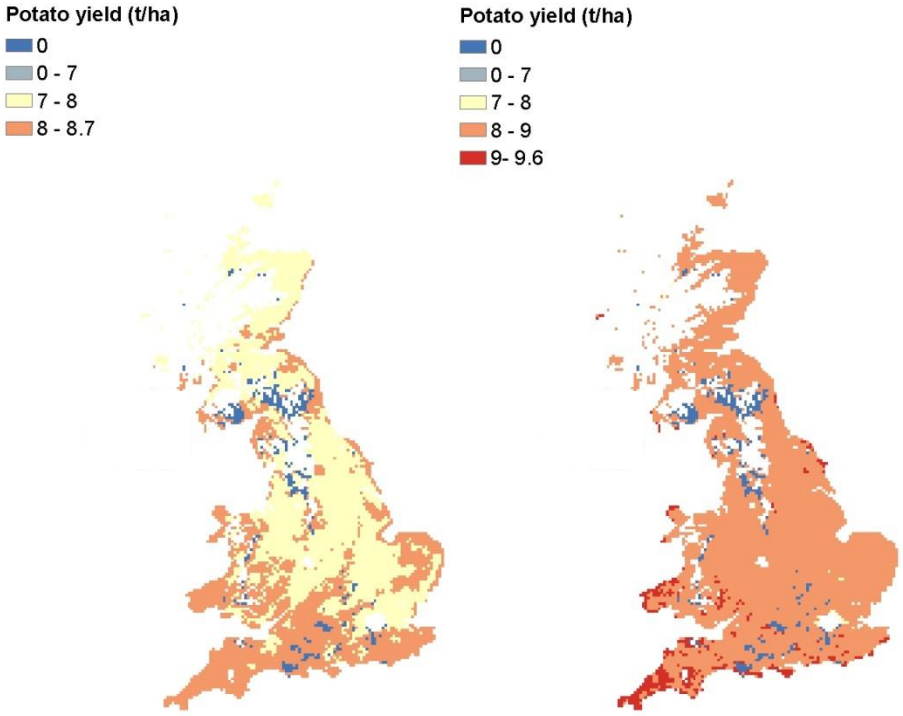
Average yield: GB (2001-2010)

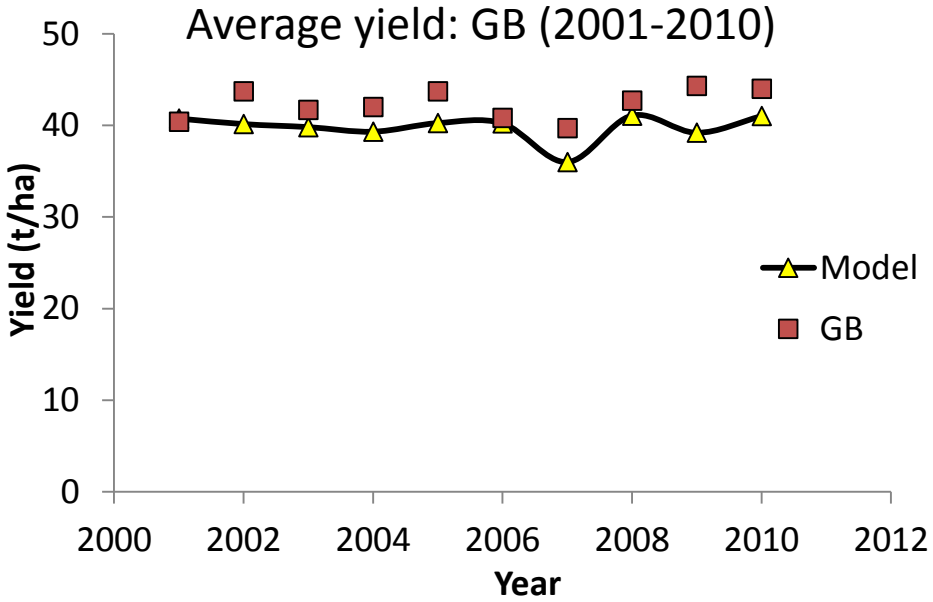


GB data (source: DEFRA)

Average crop yields : potato (2001-2010)

1971-1980 2001-2010



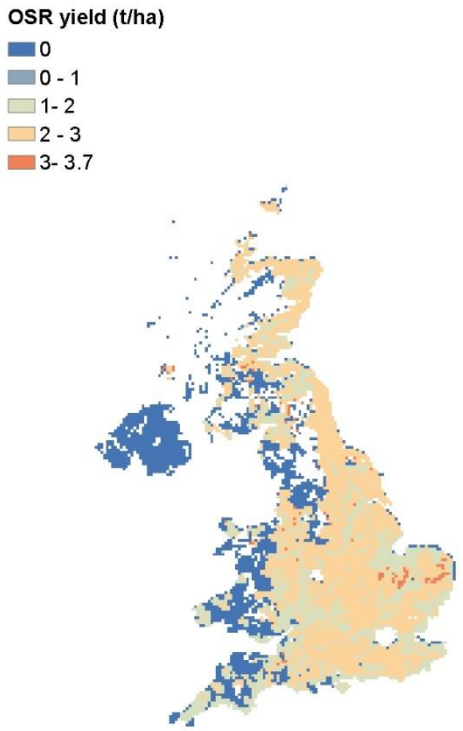


GB data (source: DEFRA)

Mean=8.6 t $ha^{-1}y^{-1}$ Mean=8.8 t $ha^{-1}y^{-1}$

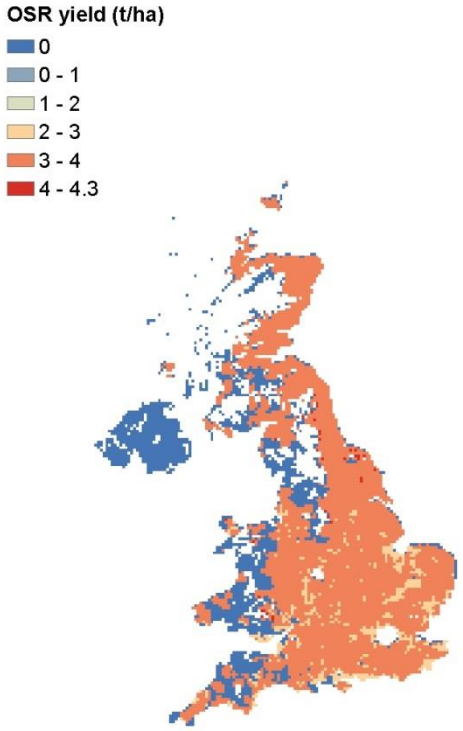
Average crop yields : OSR (2001-2010)

1971-1980



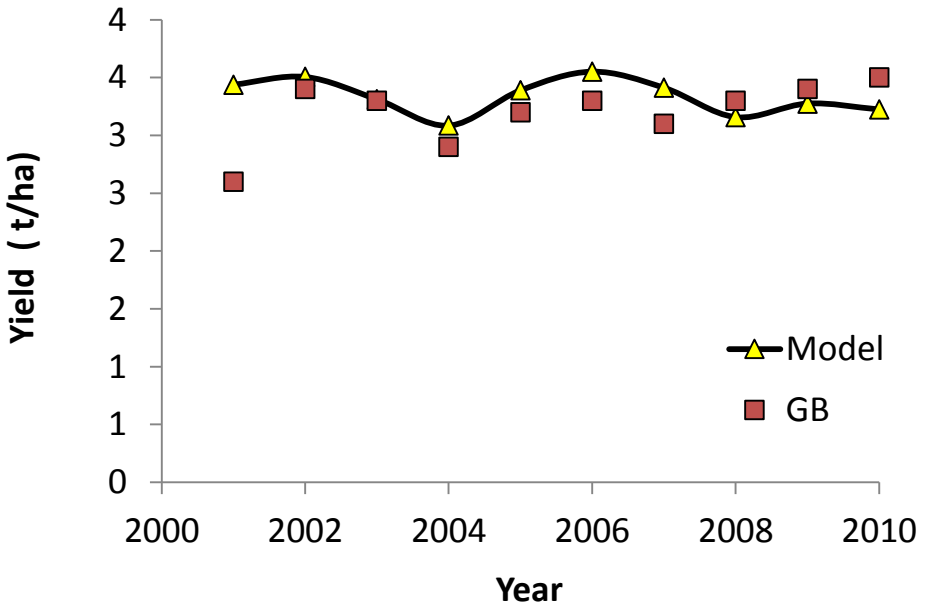
Mean=2.0 t $ha^{-1}y^{-1}$

2001-2010



Mean=3.4 t $ha^{-1}y^{-1}$

Average yield: GB (2001-2010)



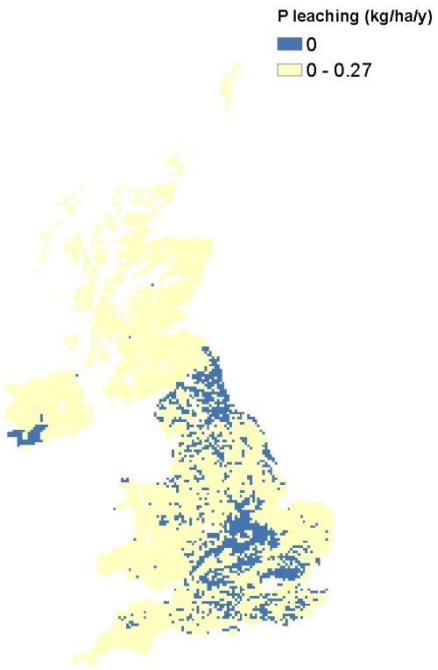
GB data (source: DEFRA)

Historical P leaching (1800-1950)

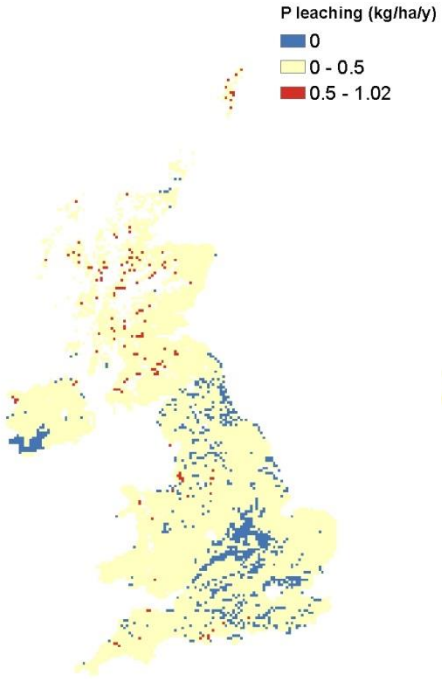
ROTHAMSTED RESEARCH

Improved grass

1800-1850

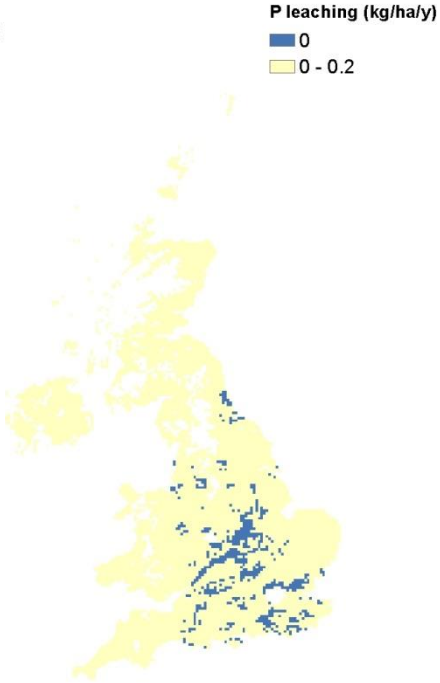


1900-1950

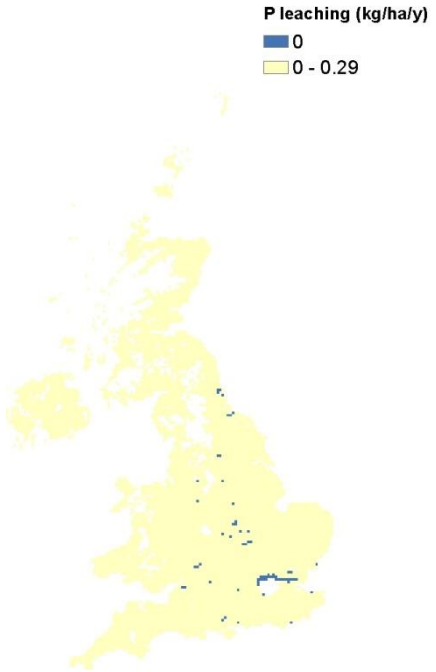


Arable land

1800-1850



1900-1950



BBSRC bioscience for the future

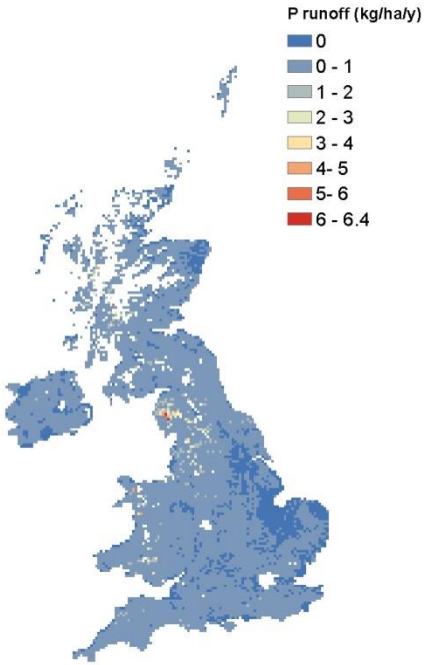
Historical P runoff (1800-1950)

ROTHAMSTED RESEARCH

Improved grass

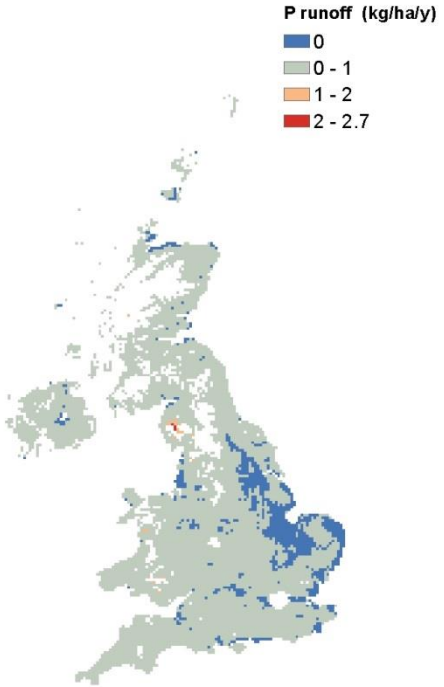
1800-1850

1900-1950

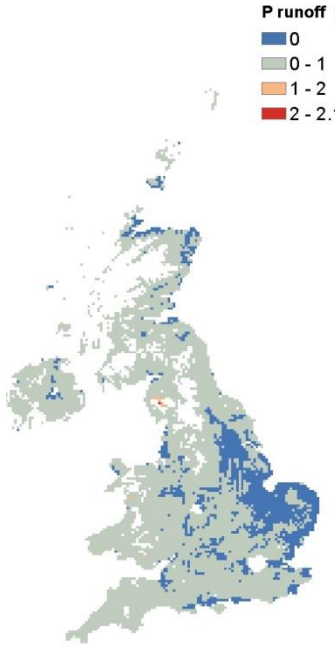


Arable land

1800-1850



1900-1950

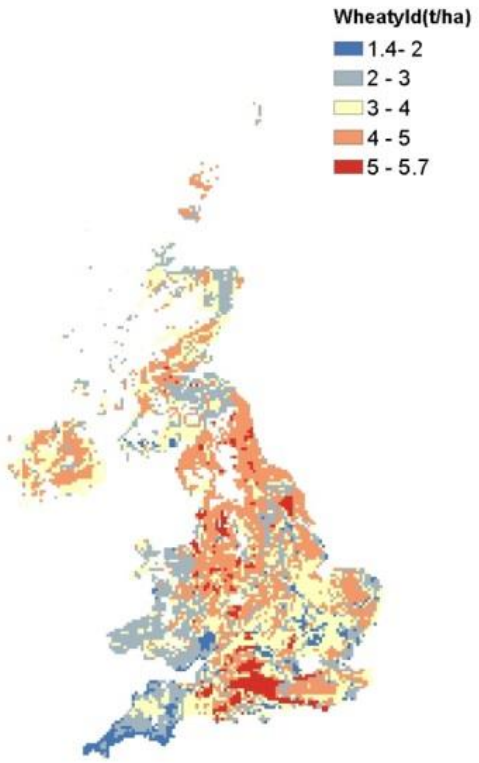


BBSRC bioscience for the future

Historical average wheat yields (1800-1950)

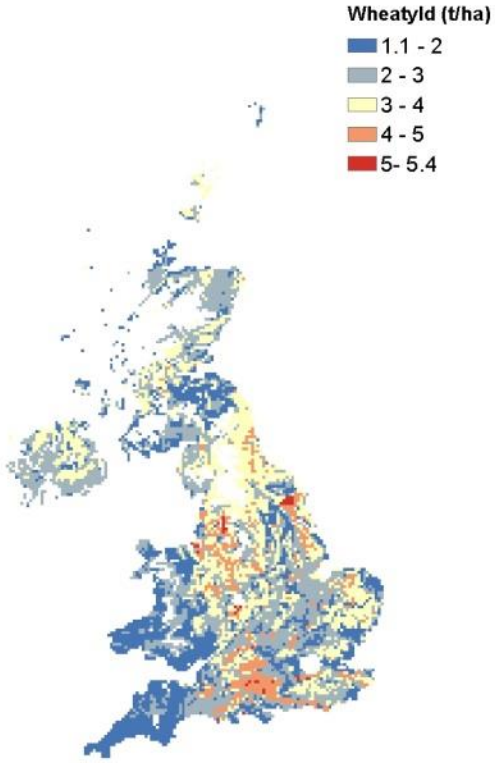
ROTHAMSTED RESEARCH

1800-50



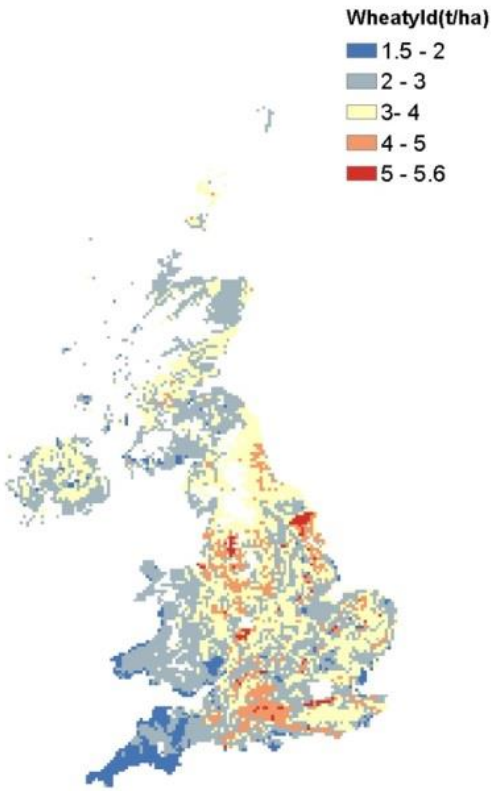
Mean=3.7 t $ha^{-1}y^{-1}$

1850-1900



2.7 t $ha^{-1}y^{-1}$

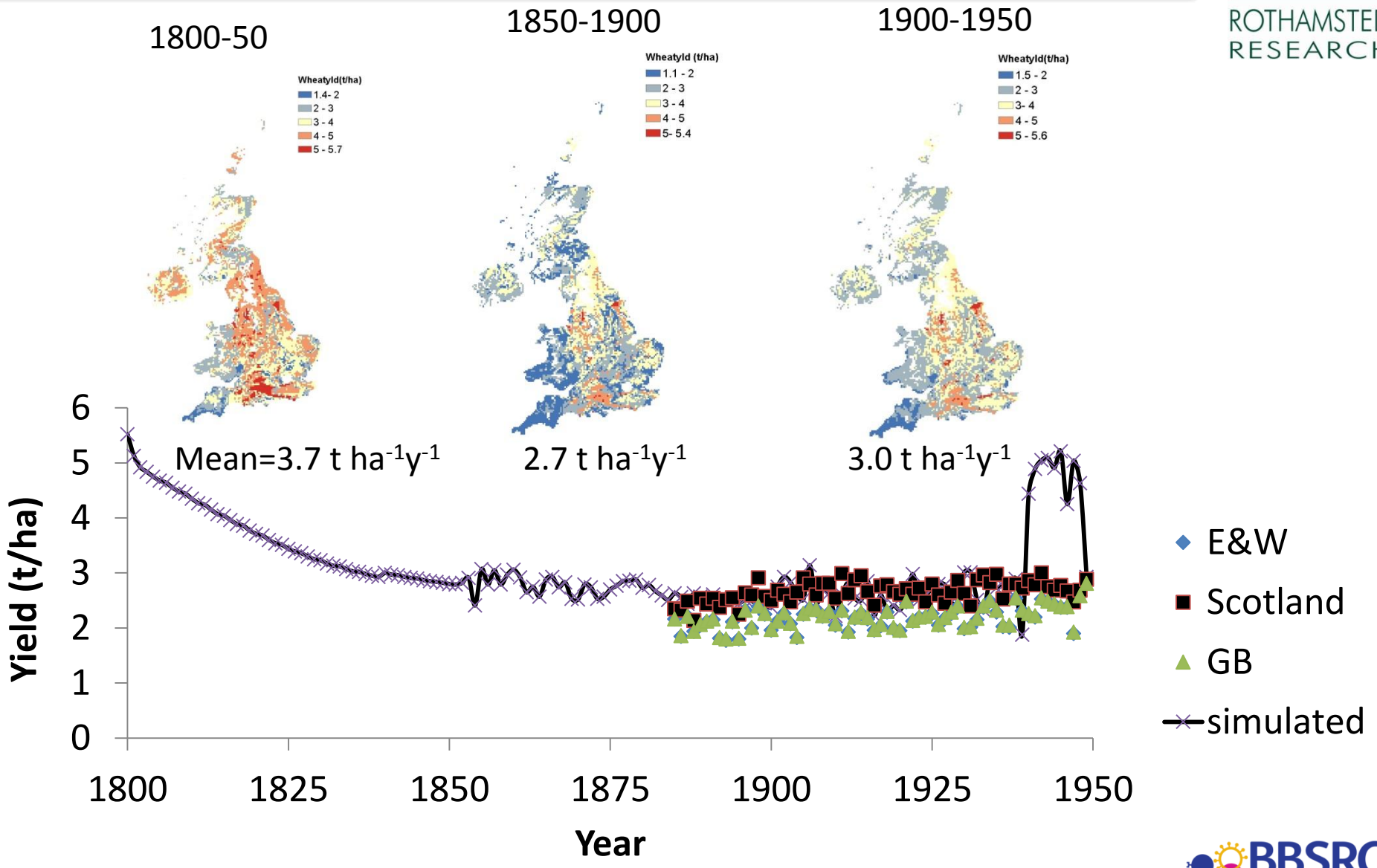
1900-1950



3.0 t $ha^{-1}y^{-1}$

BBSRC bioscience for the future

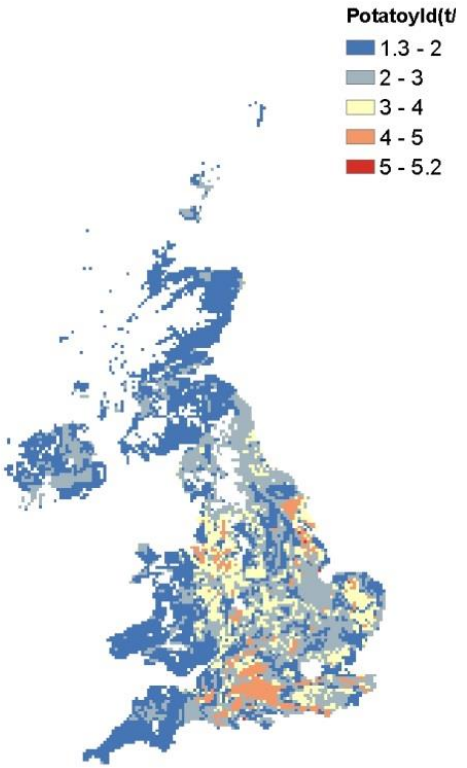
Historical average wheat yields (1800-1950)



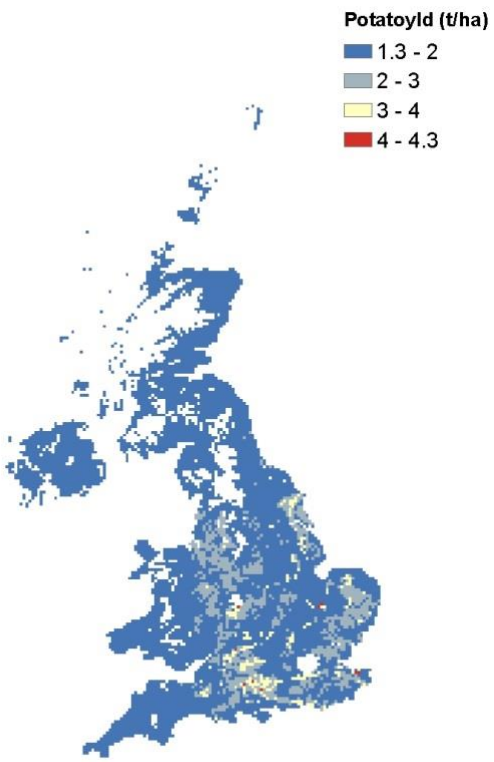
Historical average Potato yields (1800-1950)

ROTHAMSTED RESEARCH

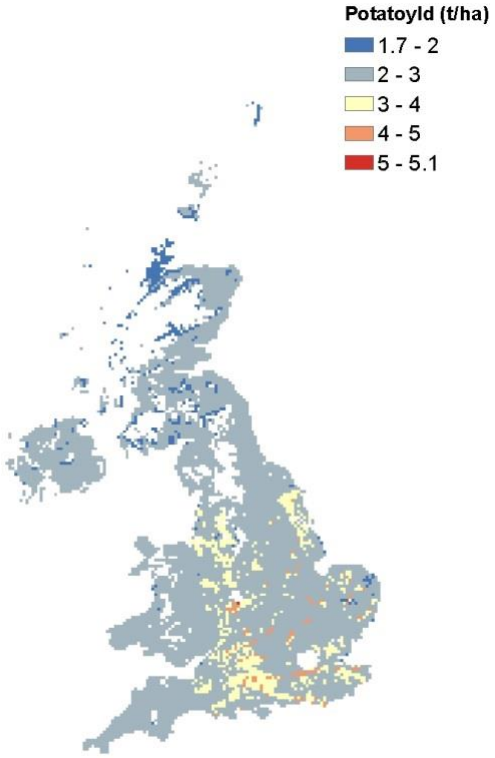
1800-50



1850-1900



1900-1950



BBSRC bioscience for the future