Soil Carbon Stocks and Stock Changes in Irish Soils

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What is soil organic carbon?

- Carbon:
  - Elemental
  - Organic →
  - Inorganic

- **Carbon in soil organic matter**
  - Plant/animal residues in decomposition
  - Cells & tissues of soil organisms
  - Substances synthesised by soil population
  - Chemically diverse set of forms

- Soil:
  - 0 – 100 cm (except peats)
  - Fine roots & non-decomposed biomass removed
  - Litter layer treated separately

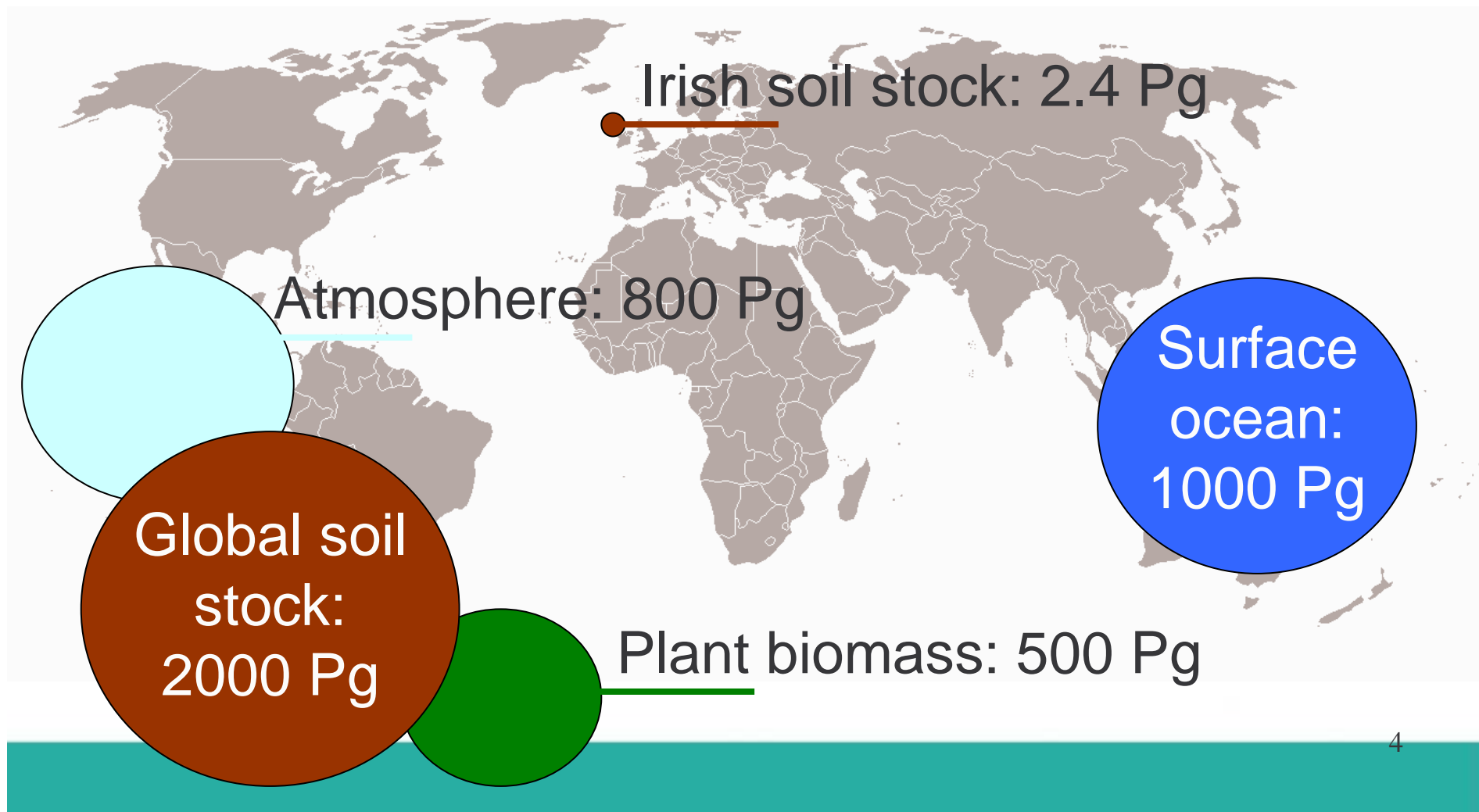# Why study soil organic carbon?

- Improve knowledge of carbon cycling and GHG emissions in ecosystems
- Predict emissions under climate & land use change
  - Identify C sequestration opportunities
- Ecosystem health "indicator"

Global and Irish soil C stocks

Irish soil stock: 2.4 Pg

Atmosphere: 800 Pg

Surface ocean: 1000 Pg

Global soil stock: 2000 Pg

Plant biomass: 500 Pg

Anthropogenic influences on the C cycle

- The two biggest human interventions in global C cycle:
  - Fossil fuel burning
  - Land use change

  Janzen, 2004.

- <u>Both</u> of these interventions may affect Irish soil C stocks
  - Peat extraction
  - Urbanisation; afforestation; etc.

Research questions

1. What is the distribution of the "current" stock of organic carbon in Irish soils?
2. How has the stock changed in the past?
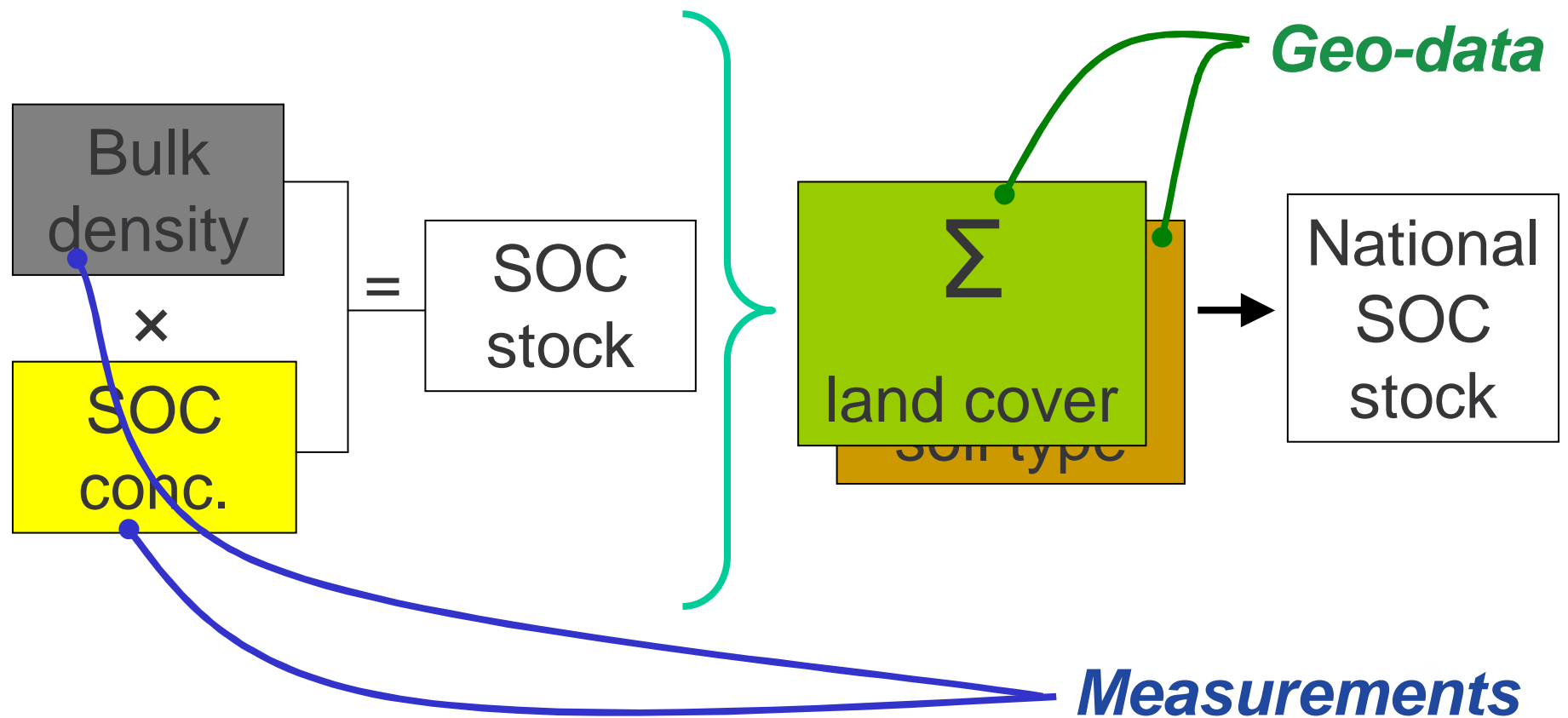3. Is the stock vulnerable to depletion in the future?

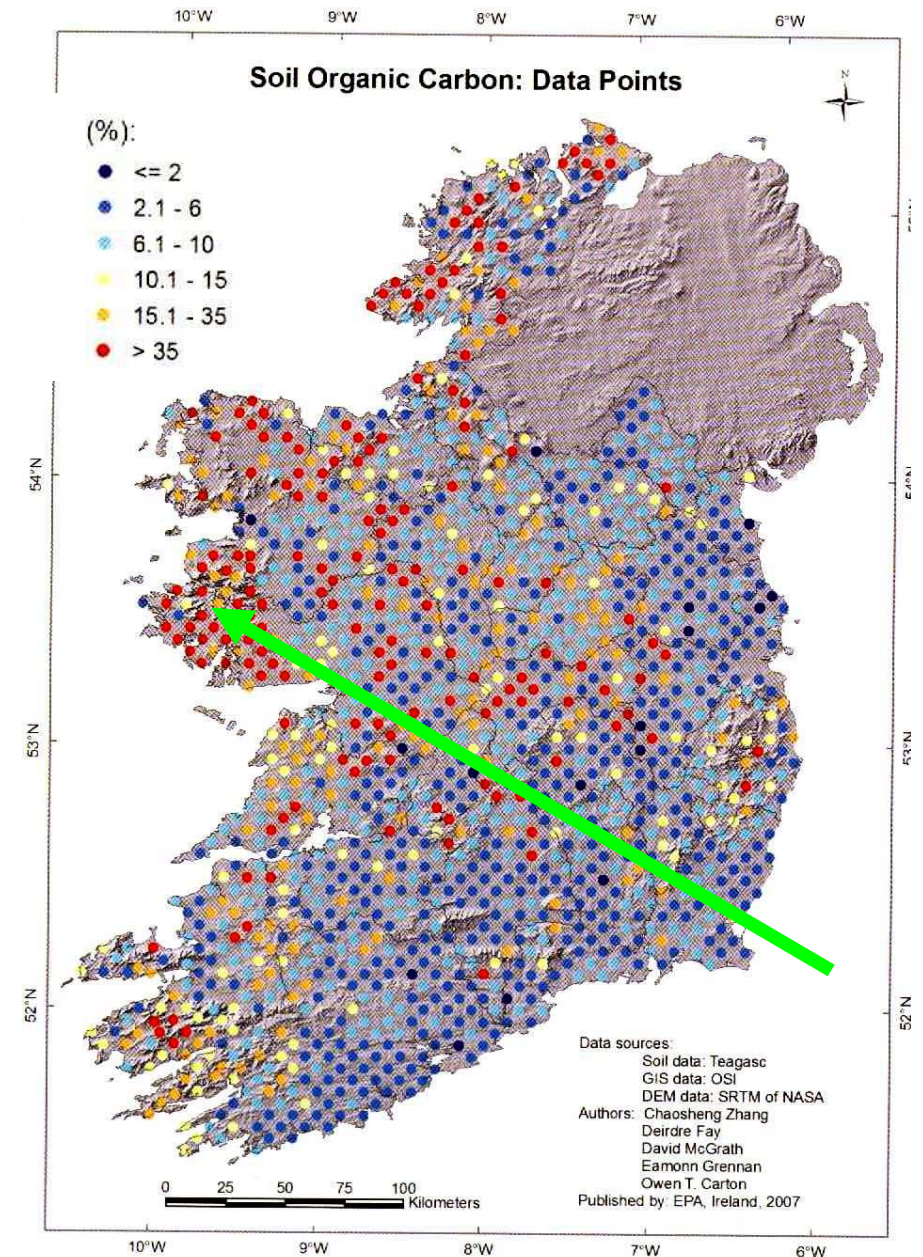■ What is the distribution of the "current" stock of organic carbon in Irish soils?

Bulk density

×

SOC conc.

= SOC stock

Σ land cover soil type

National SOC stock

Geo-data

Measurements

The National Soils Database

- Baseline database of soil geochemistry
- 1310 sites sampled
- Soil organic carbon in top 10 cm layer
- Wide range of geochemical data but no bulk density

Soil Organic Carbon: Data Points

(%):
- <= 2
- 2.1 - 6
- 6.1 - 10
- 10.1 - 15
- 15.1 - 35
- > 35

Data sources:
Soil data: Teagasc
GIS data: OSI
DEM data: SRTM of NASA
Authors: Chaosheng Zhang
Deirdre Fay
David McGrath
Eamonn Grennan
Owen T. Carton
Published by: EPA, Ireland, 2007

- 62 National Soils Database sites resampled at 3 depths
  - 0-10 cm; 10-25 cm; 25-50 cm
  - Bulk density : 15 intact cores/site
  - SOC concentration : 27 samples/site
  - Selected to best represent variation in soil types & land cover

- http://soilcarbon.ucc.ie/ contains:
  - Site locations;
  - Land cover classes;
  - Photos;
  - Soils information

National land cover and soils data

- **Present day**
  - CORINE Land Cover 1990, 2000
  - Soils map of Ireland (Gardiner & Radford, 1980)
  - The peatlands of Ireland (Hammond, 1981)
  - Soil C content: Bradley et al. (1995); Cruickshank et al. (1998);
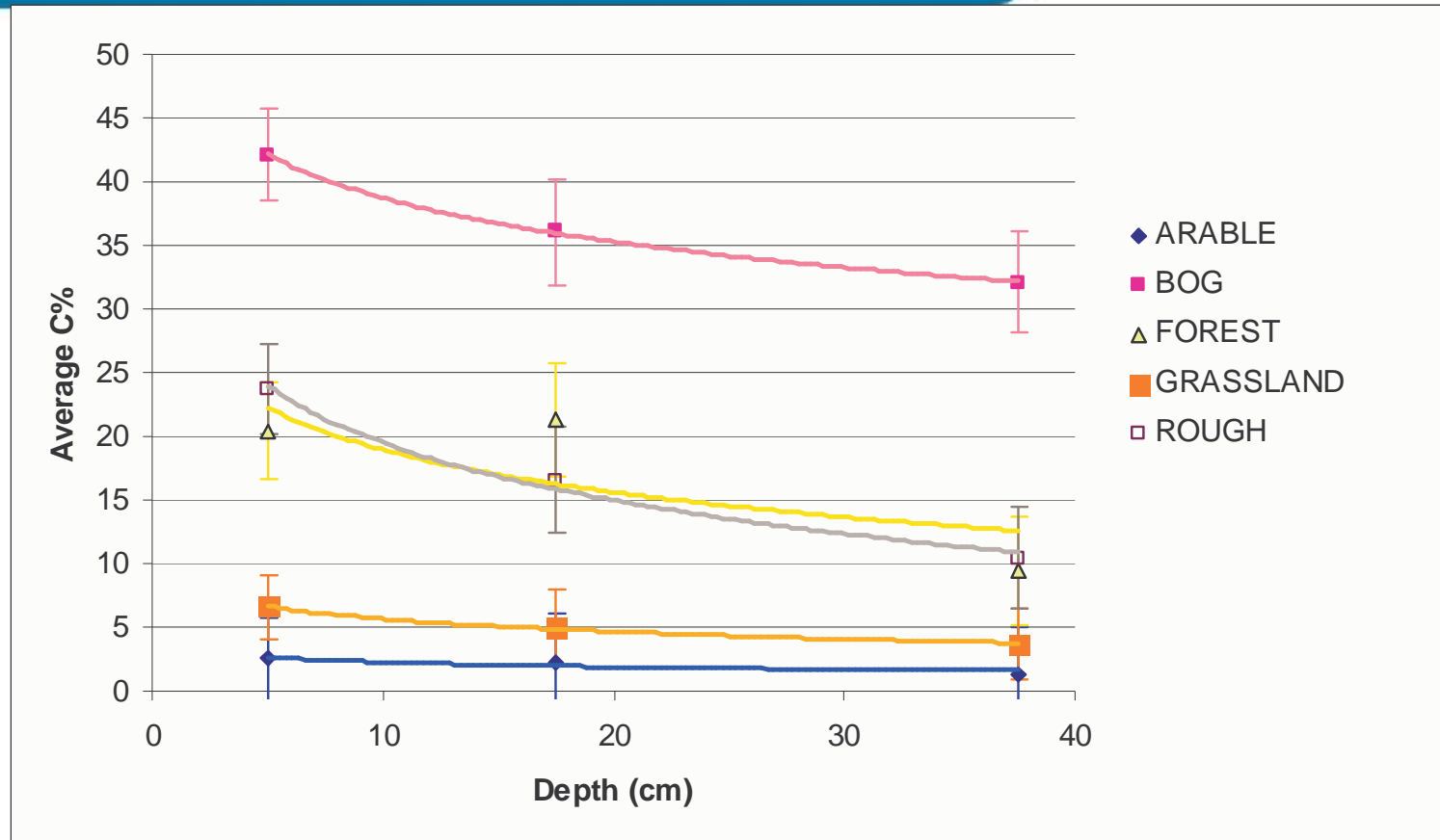 - National Soils Database

- **5 simplified land use classes**
  - Arable
  - Bog
  - Forest
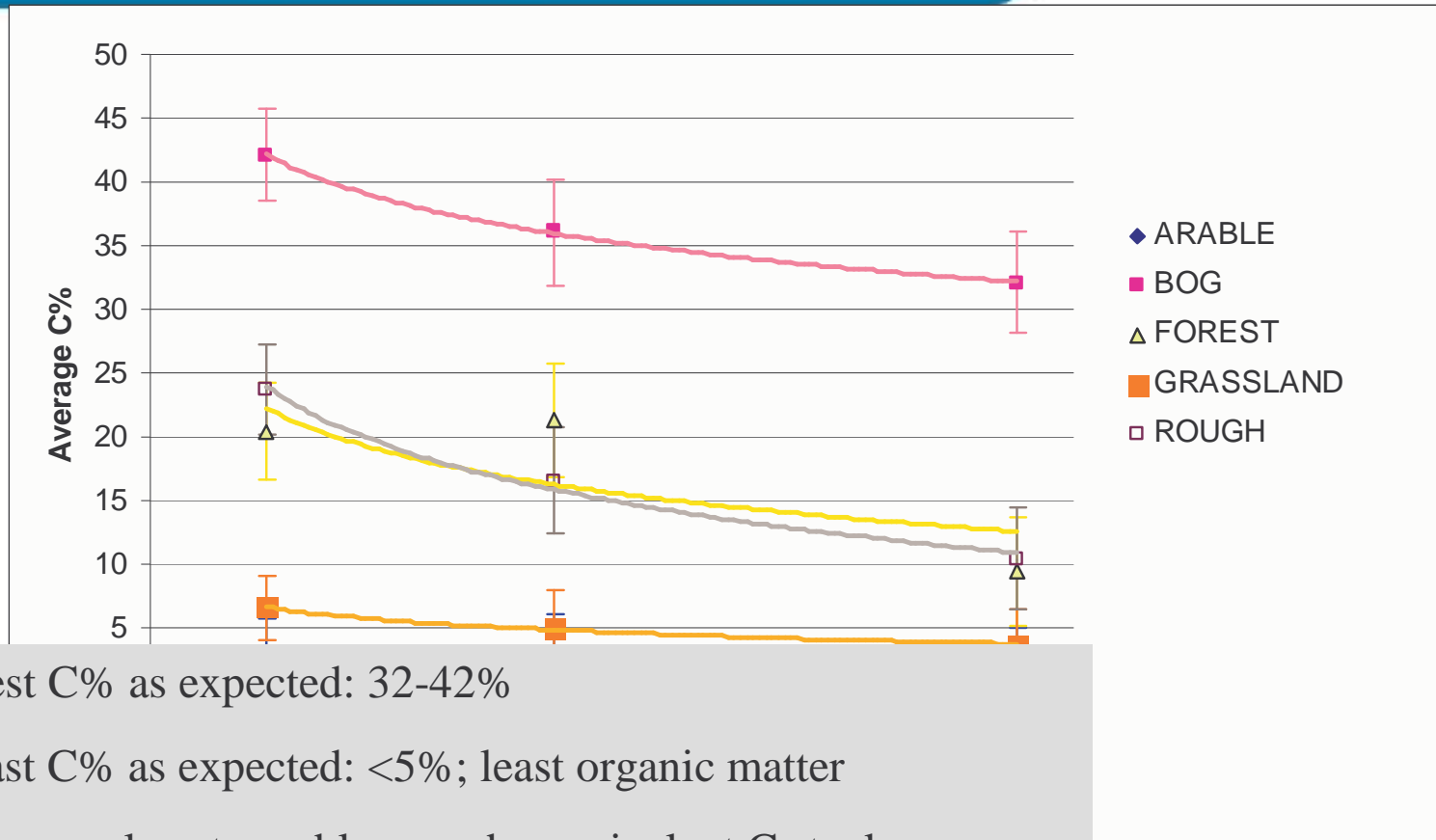 - Grassland
  - + Rough
- **10 simplified soil types**

SOC concentration profiles by land cover family

SOC concentration profiles by land cover family

Legend:
- ◆ ARABLE
- ■ BOG
- △ FOREST
- ■ GRASSLAND
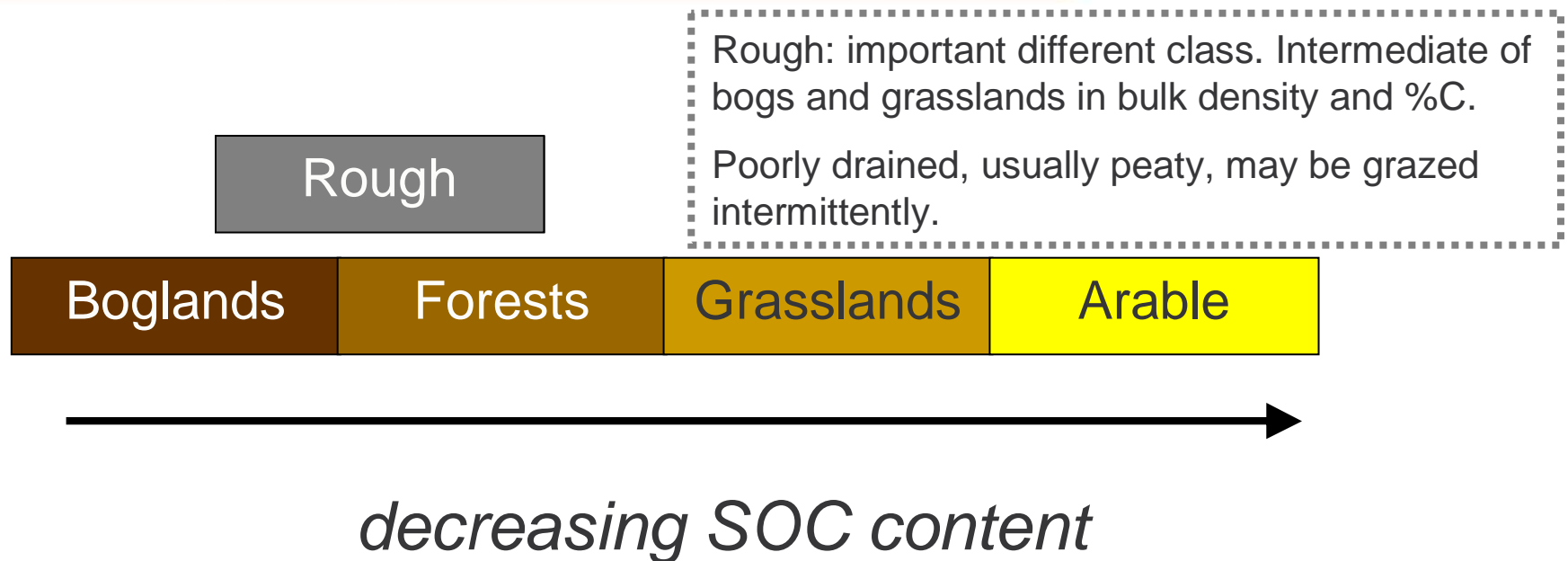- □ ROUGH

Bog highest C% as expected: 32-42%

Arable least C% as expected: <5%; least organic matter

Grassland very close to arable; may be equivalent C stocks once bulk density is considered

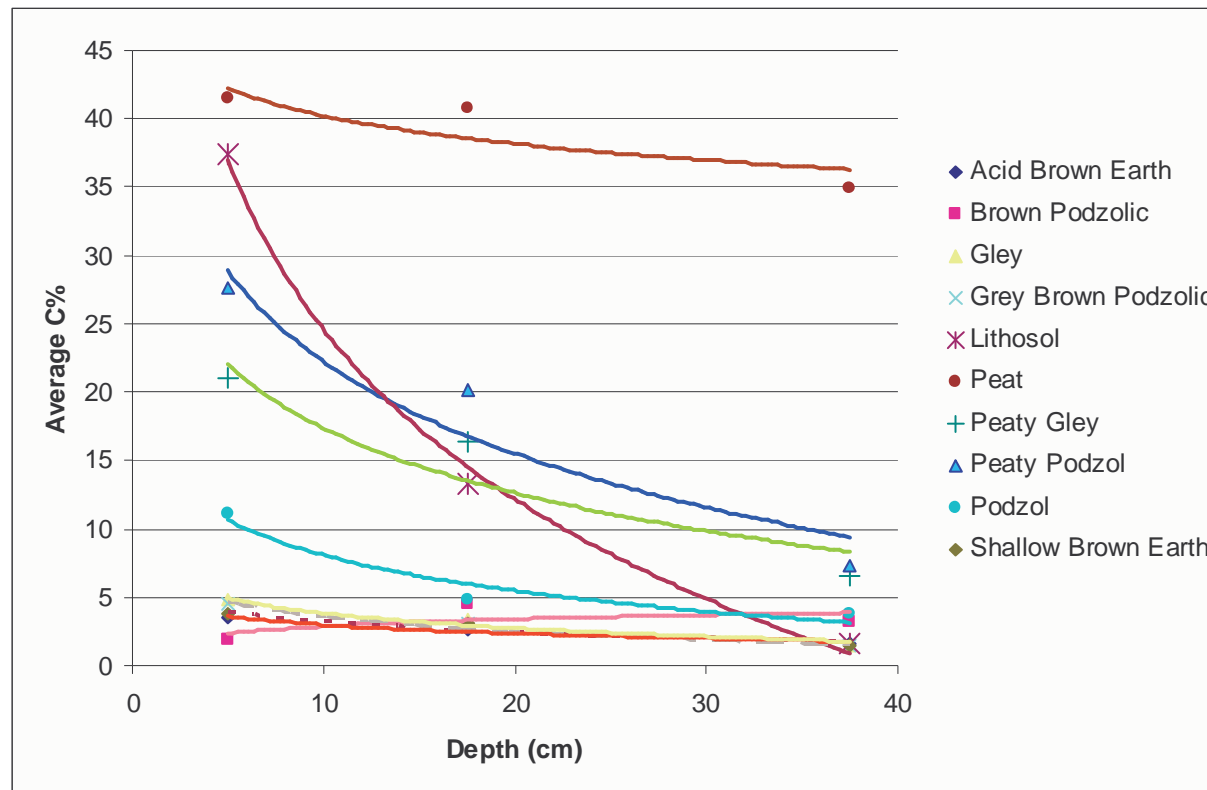Rough and Forest show peaty impact and mineral soil at depth

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Land use and soil organic carbon content are closely related

Rough: important different class. Intermediate of bogs and grasslands in bulk density and %C.

Poorly drained, usually peaty, may be grazed intermittently.

Rough

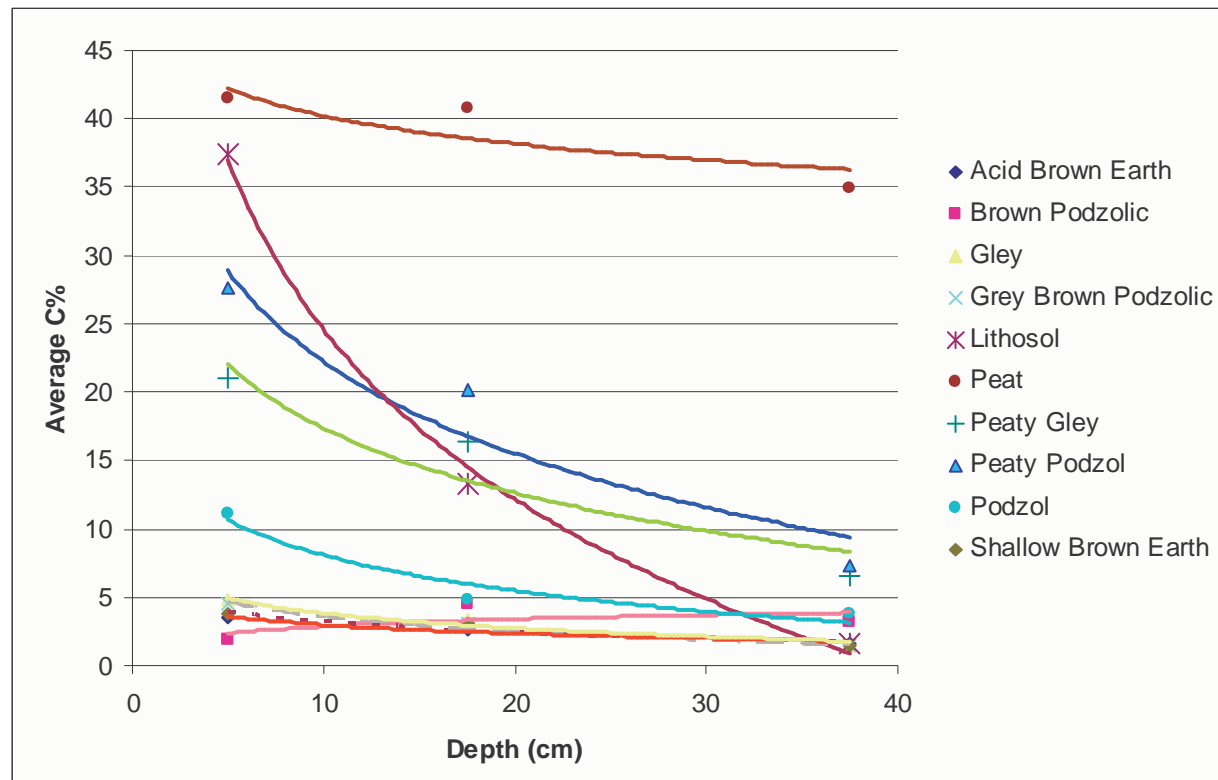| Boglands | Forests | Grasslands | Arable |

decreasing SOC content

Soil organic carbon concentrations by soil type

Soil organic carbon concentrations by soil type
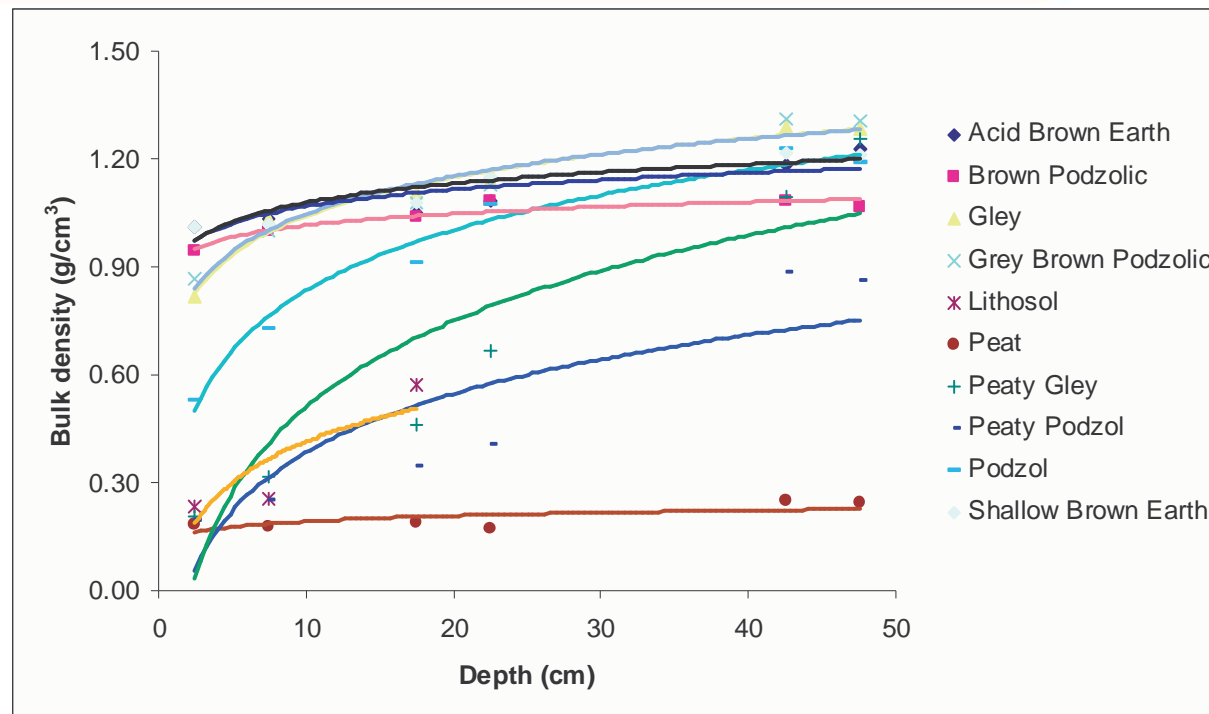

Peat highest C%

Lithosol > peaty podzol > peaty gley: All mid-high range C%

Mineral soil grouping at lower end

16

Bulk densities by soil type

3 groups: Mineral
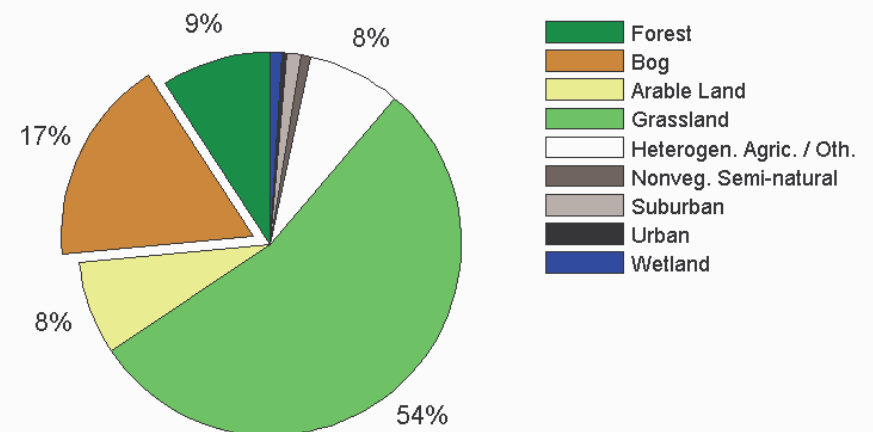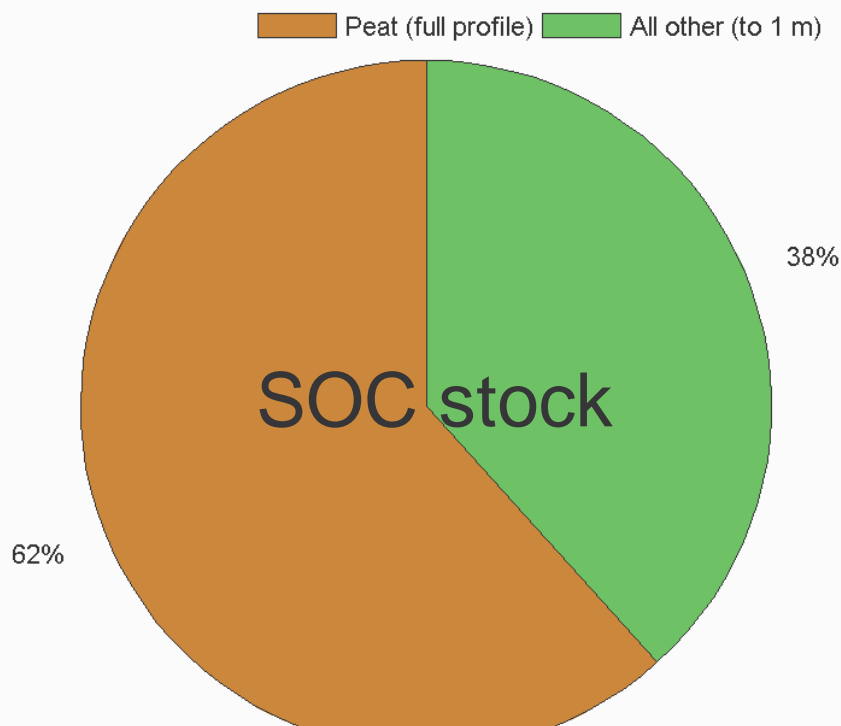
Peat

Organo-mineral

http://soilcarbon.ucc.ie/ website

SOC stock calculations based on existing data

- Total SOC stock to 1 m depth (2000): 1.5 Pg C
- Total SOC stock (1 m mineral + full peat): 2.4 Pg C

Peat (full profile)   All other (to 1 m)

SOC stock

38%

62%

Land use by area

■	Forest
■	Bog
■	Arable Land
■	Grassland
□	Heterogen. Agric. / Oth.
■	Nonveg. Semi-natural
■	Suburban
■	Urban
■	Wetland

9%

8%

17%

8%

54%

- How has the soil organic carbon stock changed in the past?

National land cover and soils data
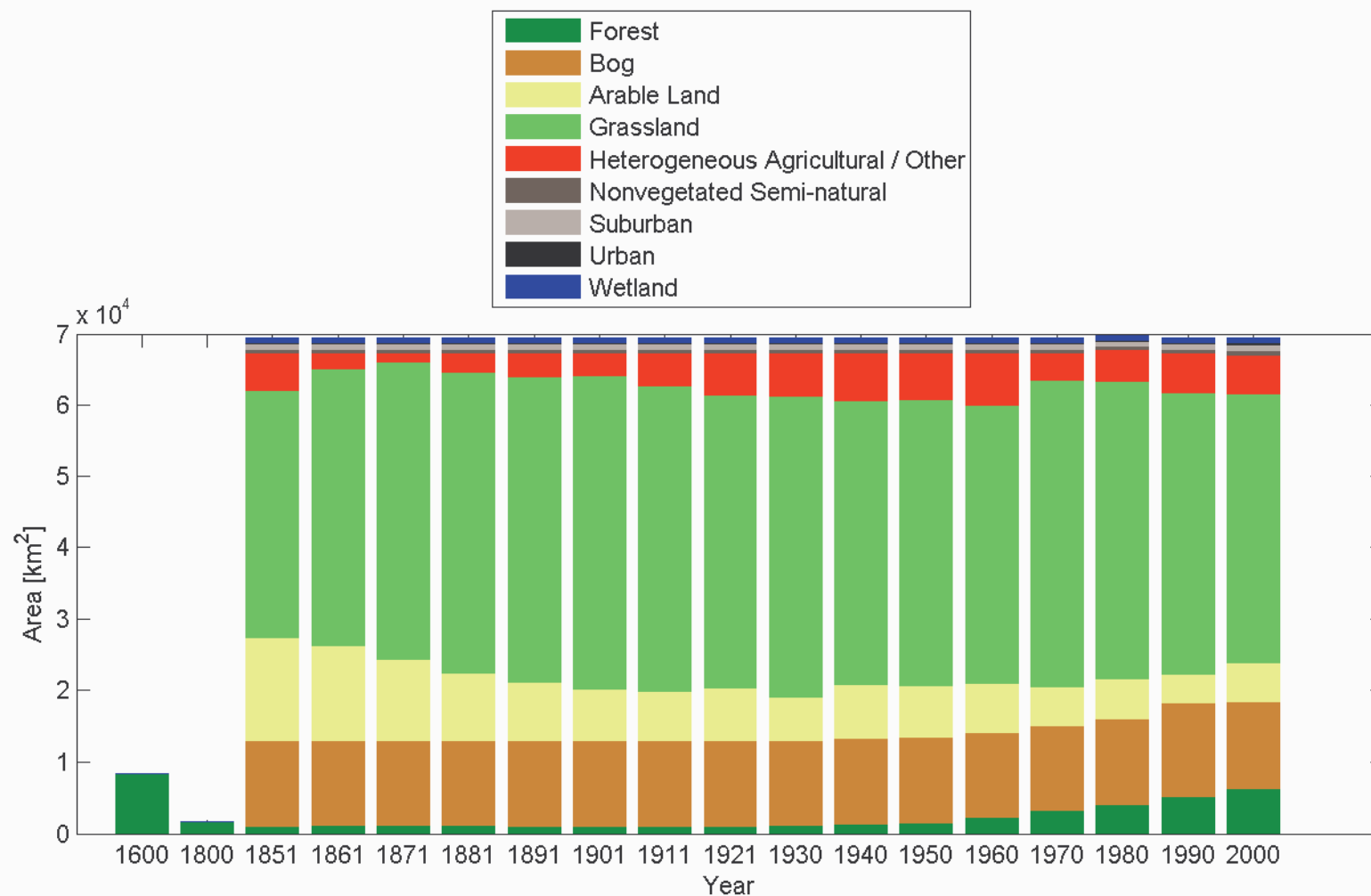
- **Historic**
  - Agricultural censuses (CSO)
  - Bog Commissioners' reports (1811-1814)

- **Examine past changes in land use**
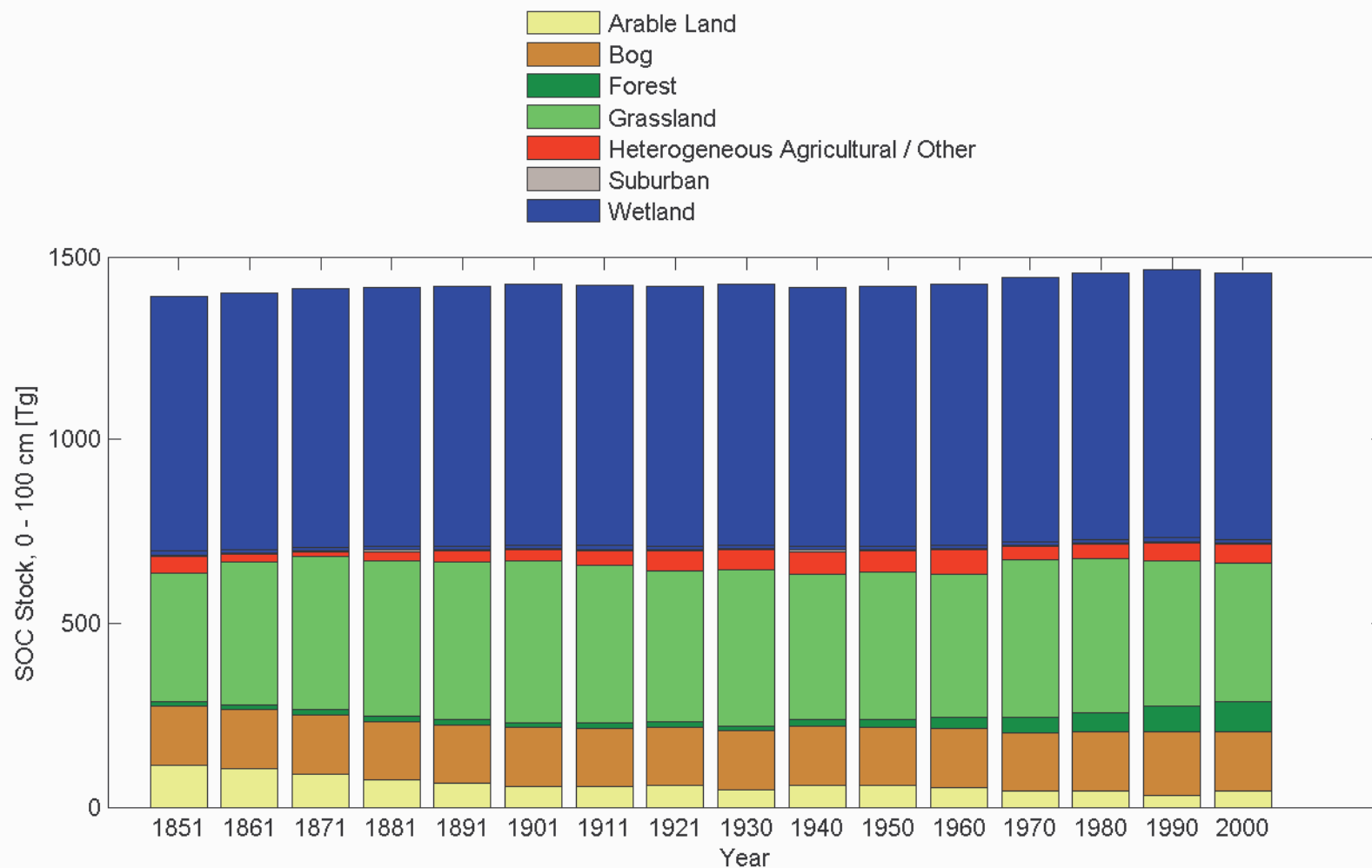 - Assign fixed SOC stocks to each land use

Land cover in Ireland, 1600-2000
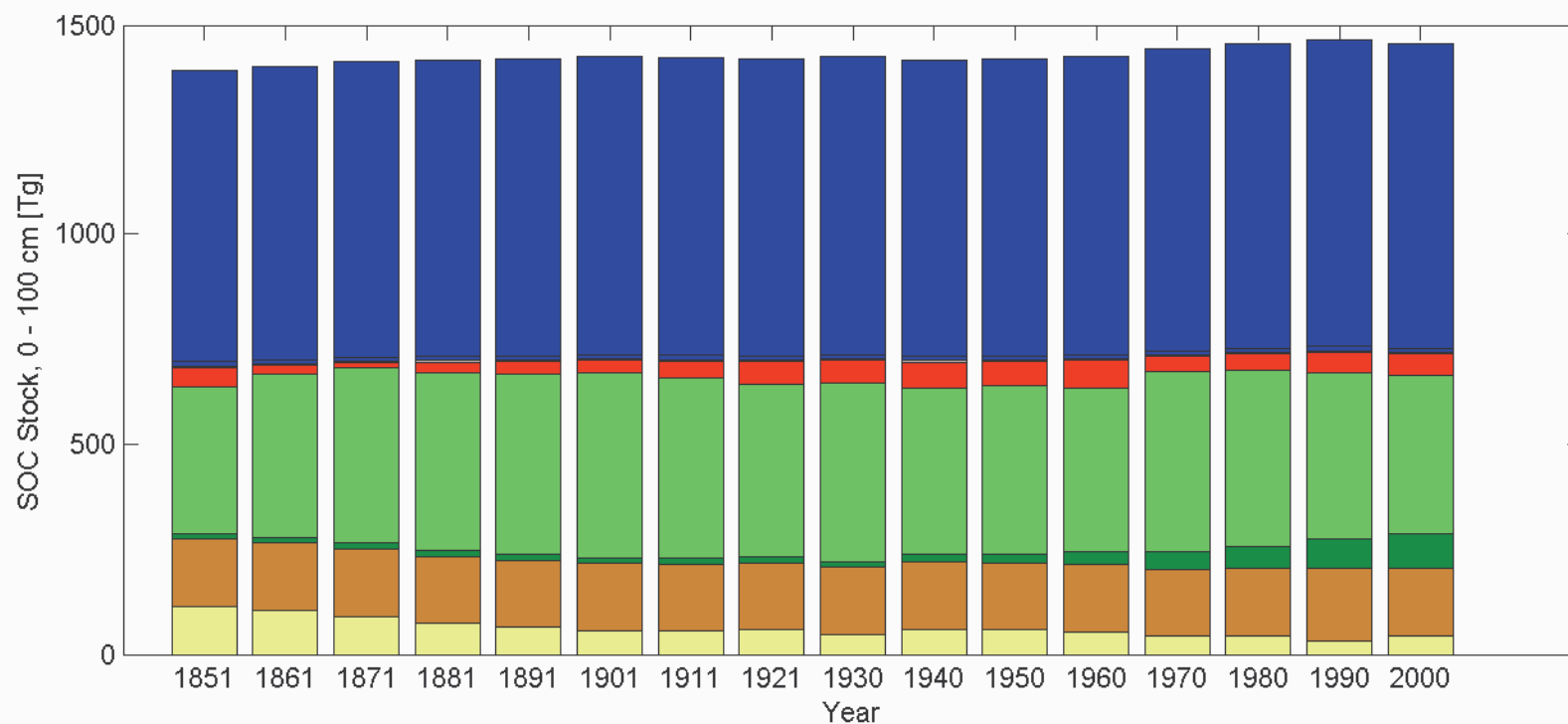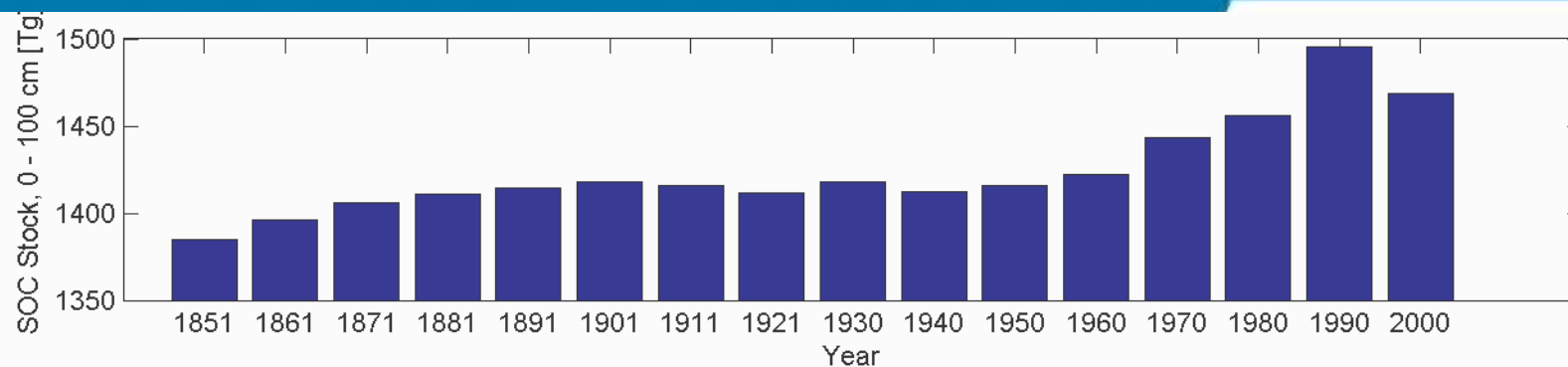
SOC stock in Ireland to 1 m, 1851-2000

SOC stock in Ireland to 1 m, 1851-2000

3: Is the stock vulnerable to depletion in the future?

- Land use change : urbanisation
- Land use change : afforestation on higher SOC soils
- Peat extraction
- Peat & climate change

Main findings

- Year 2000 SOC stock (1 m mineral + full peat): 2.4 Pg C

- From 1851 to 1990 Irish soils (to 1 m) were estimated to have gained a total of 110 Tg SOC, driven mainly by
  - conversion of arable lands to other uses (1851-1900)
  - afforestation of lower SOC lands (1940-)

- Past SOC stock changes have also been driven by:
  - Land use change including peatland reclamation
  - Peat extraction

- However, rapid urbanisation between 1990 and 2000 has resulted in a reduction in SOC stock (-50 Tg)

- Past afforestation of bogs remains a source of uncertainty

Main findings

- Future changes in SOC stock are likely to be driven by
  - Land use change
  - Climate change?

- Management of the SOC stock:
  - Peatland stewardship
  - Targetted, managed afforestation
  - Controls on urban development

- To do: Recalculate the current stock based on field measurements from this study and national soils database

Acknowledgments

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http://soilcarbon.ucc.ie/