Carbon sinks in a changing environment

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Soil carbon sinks from ***wheat*** plants in a changing environment

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Plan

1. Why will carbon in soil change with a changing environment?

2. What is the carbon doing there anyway?

3. Is wheat–cropped soil a sink for carbon or a source?

4. What can we do about it with wheat?

How do plants affect soil C?

- Root exudation
- Moderate or exacerbate global environmental change
- Reduce erosion
- Stabilise soil carbon

Root input of carbon

Root turnover is estimated at 2 – 10 g C kg^{-1} soil $month^{-1}$
Root exudation is estimated at 0.1 – 5 g C kg^{-1} $month^{-1}$

The soil microbial biomass typically contains at most 1 g C kg^{-1} soil

The monthly inputs from roots are at least one order of magnitude greater than the size of the notoriously slow-growing, living component of soil

Total root C input has been estimated in excess of 2 t ha^{-1} yr^{-1}

Grassland Jones 2009; Swinnen 1994

Why do plants put C in soil?

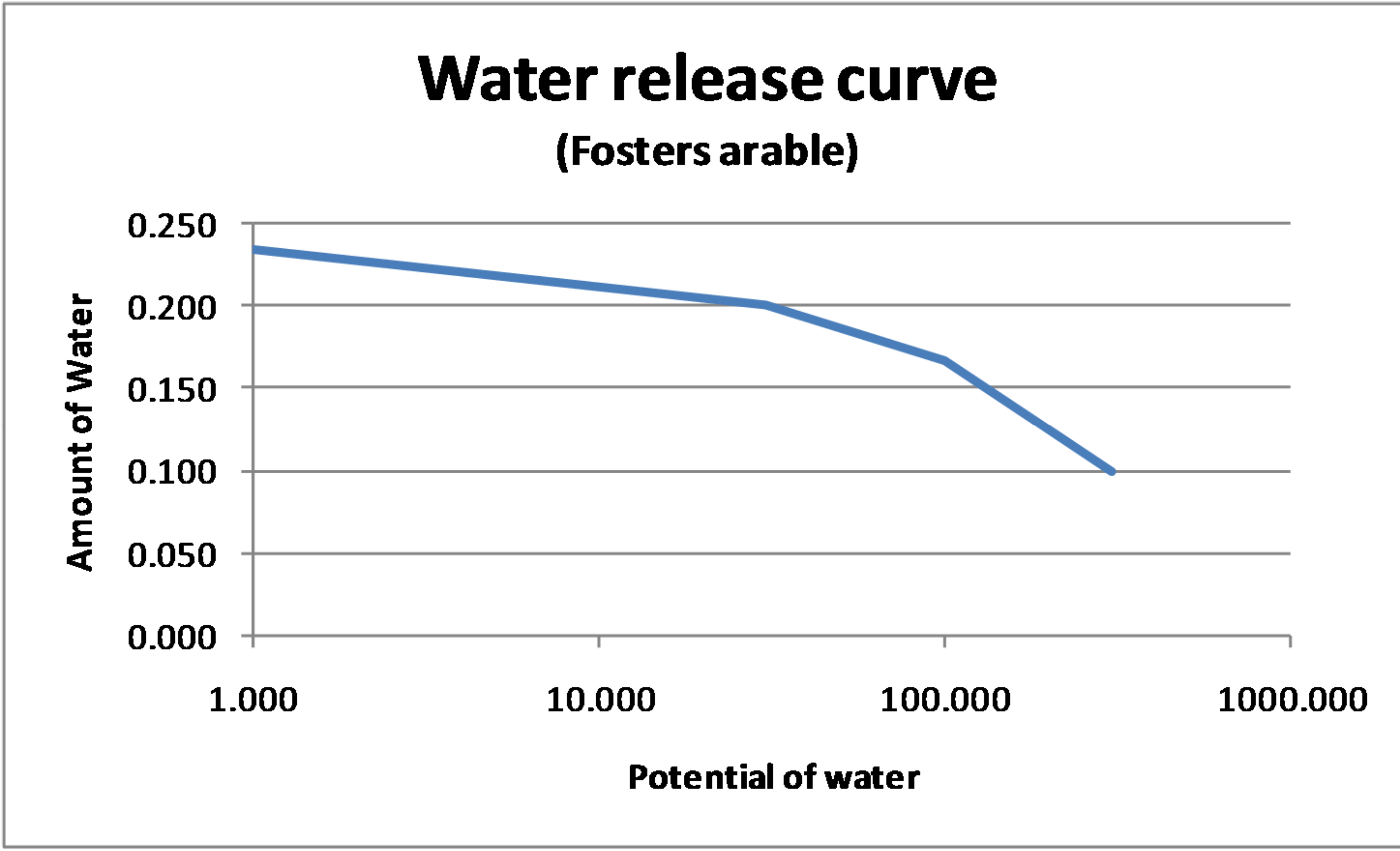
- Phosphorus capture
- Nitrogen capture by feeding the microbes
- Water capture?
- Engineer their physical environment
- All of the above?
- None of the above?

Phosphorus

Some plants (but not especially wheat) exude large amounts of organic acids to solubilise P

Wheat may do so via mycorrhizae

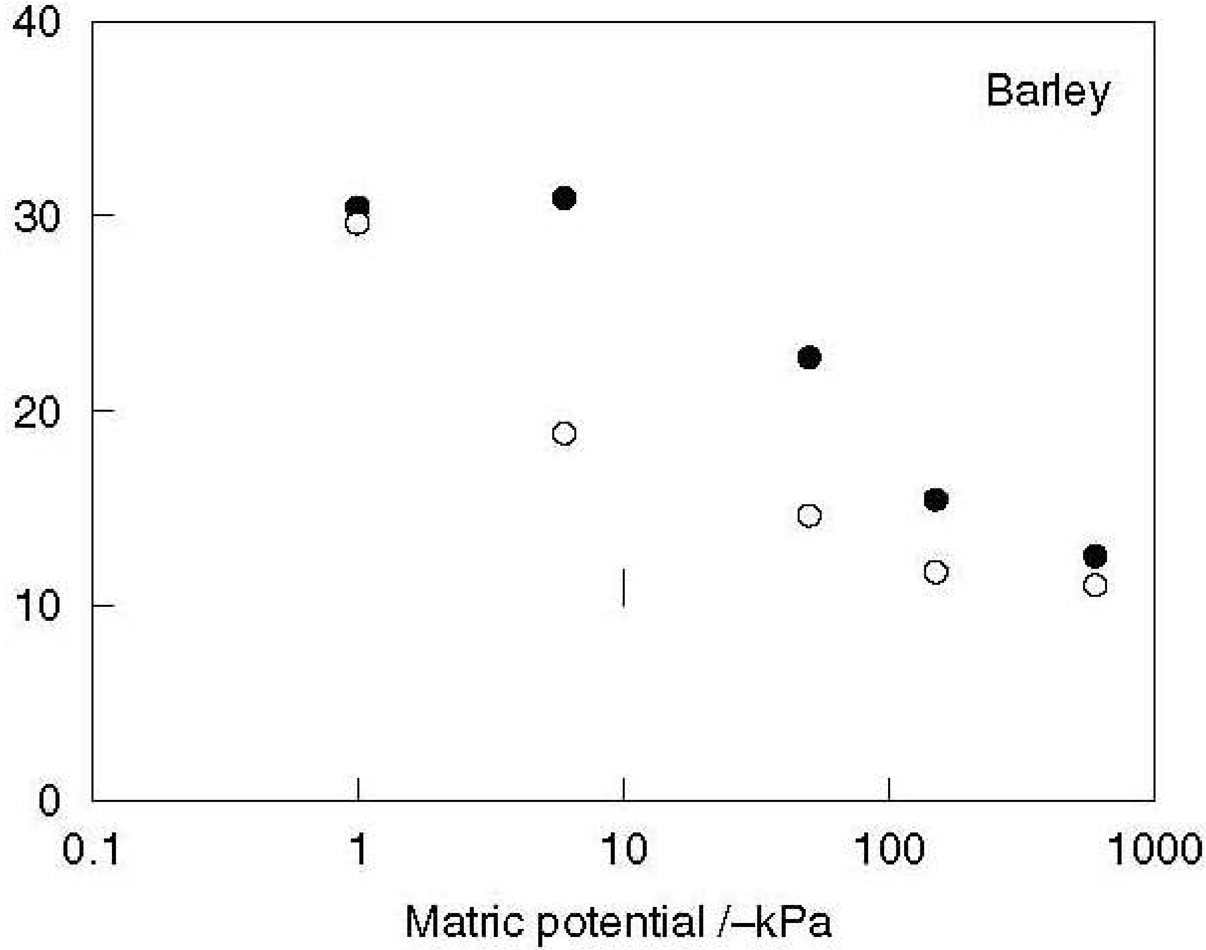
C input to soil represents a considerable investment by the plant: 10% of total productivity



Watts unpublished

Do exudates help plants obtain water?

Moisture release curve in soil growing barley



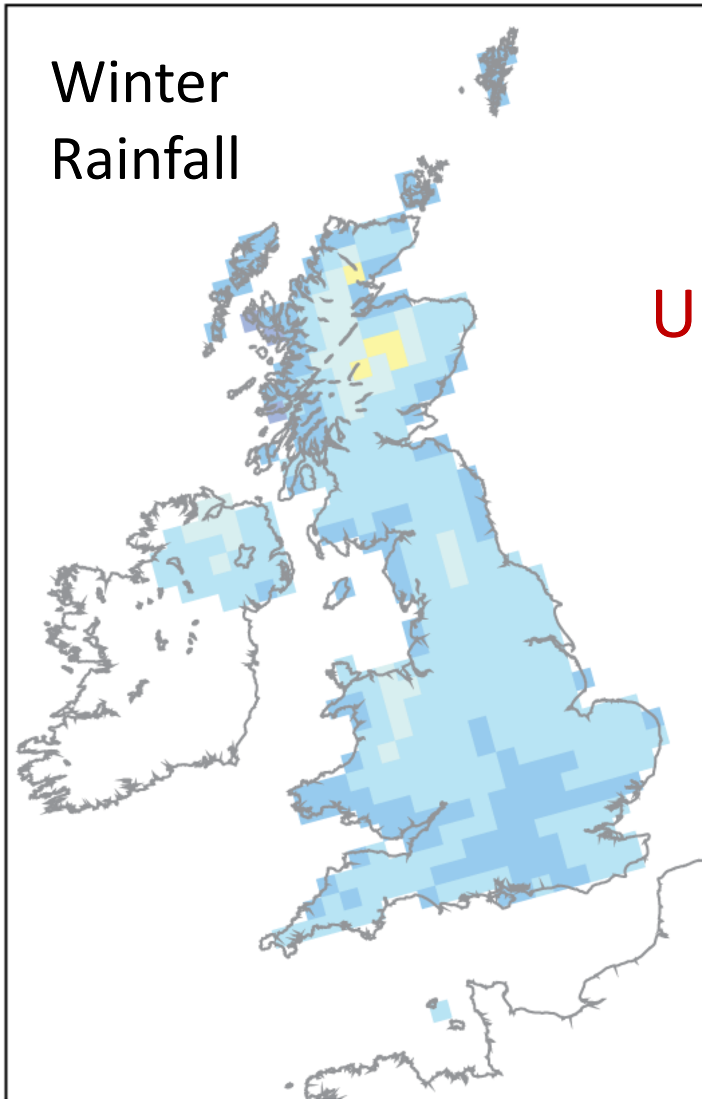
Wet dry

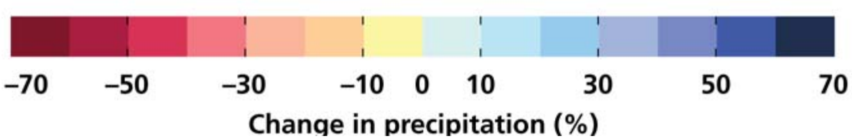
Soil circles, bulk soil; open circles rhizosphere soil

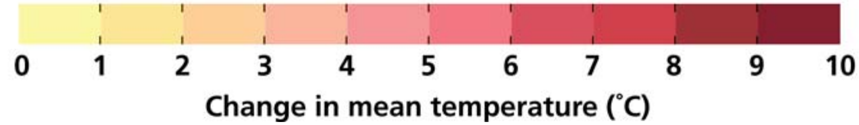
Whalley et al 2005

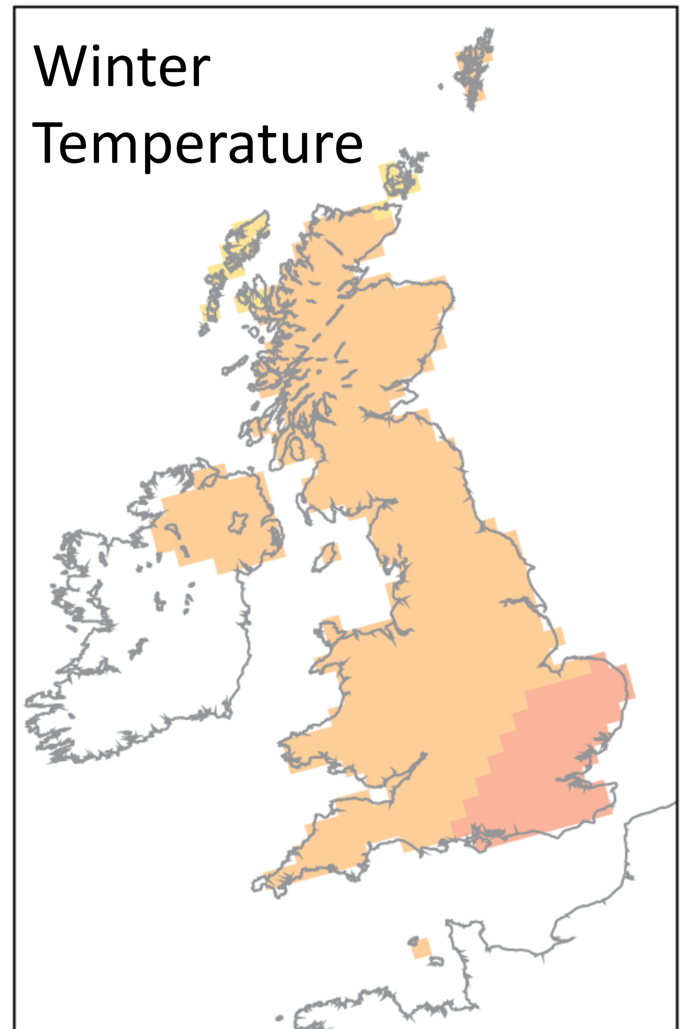
UK CIP 2009

50% probability level
Central estimate



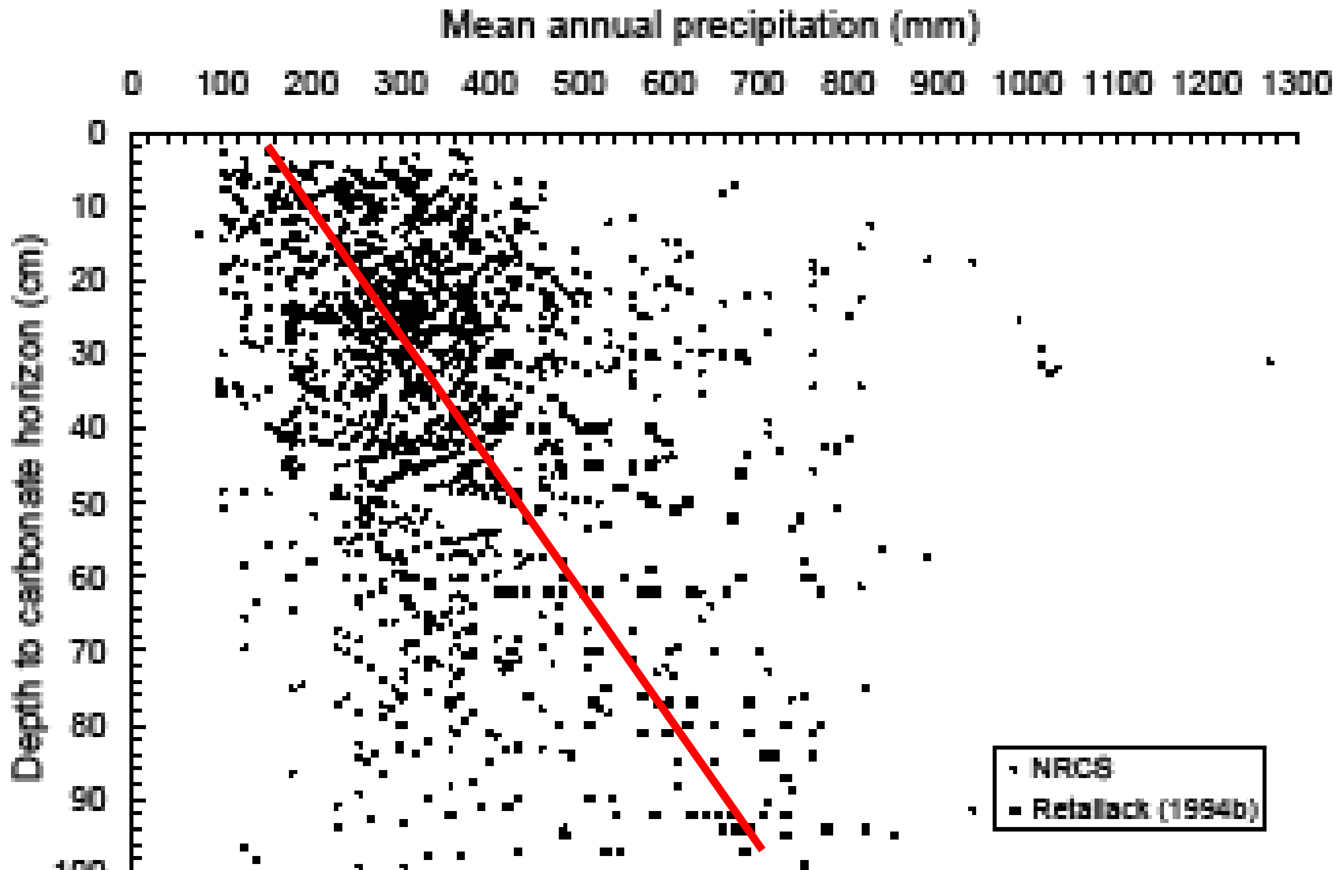




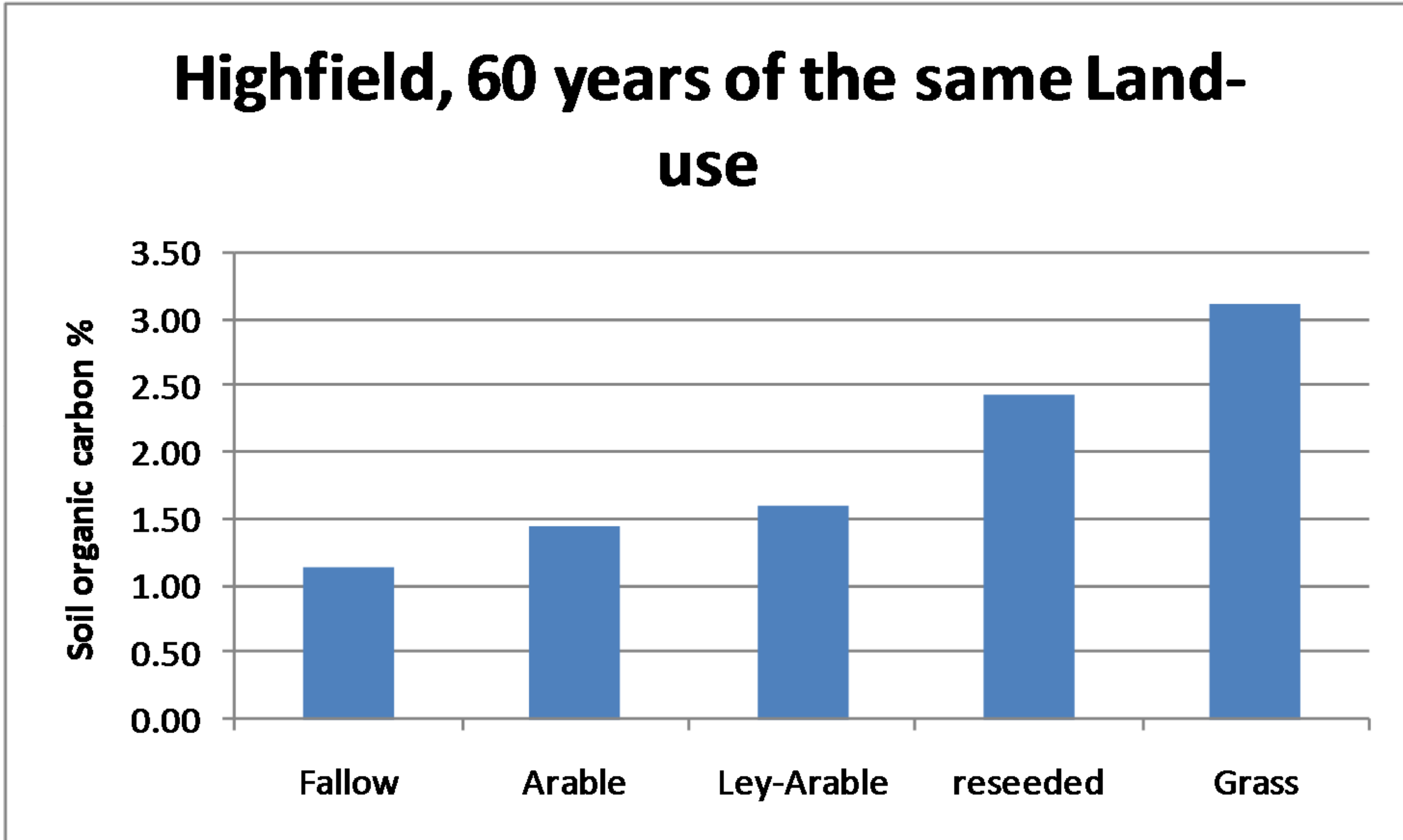


[illegible] computing power, but also an our-
computer adage, "garbage in, garbage out."
d that the most useful paleoclimatic indicator to
es from the observation that 95% of his calcic
ean annual precipitation of less than 760 mm, but
ations for paleosols may only be true for the

a depth to carbonate horizon (D) > 100 cm (n = 35), anchor the regression of Retallack (1994b). Removal of these 35 data points, which decreases his sample size by only 11%, reduces the r^2 of the regression from 0.62 to 0.44 (Royer, 1999). Removal of all D > 100 cm data from the data set of Retallack (1994b) (n = 67) further reduces the r^2 to 0.38. Most studies applying this modern relationship to the geologic past use paleosols with D < 100 cm



ween depth to carbonate
nual precipitation (P) for
ed data sets (NRCS + Re-
r^2 for Retallack data set


Highfield, 60 years of the same Land-use
Soil organic carbon %
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Fallow
Arable
Ley-Arable
reseeded
Grass

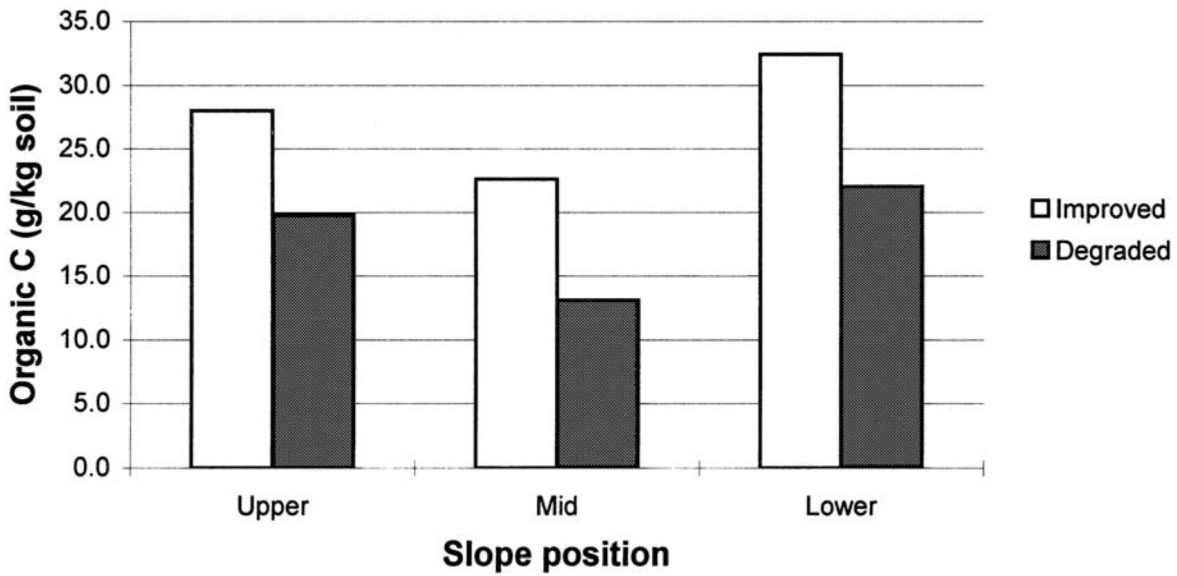
Perennial Wheat

Table 3
Assumptions of grain yield for annual and perennial wheat on each LMU in MIDAS

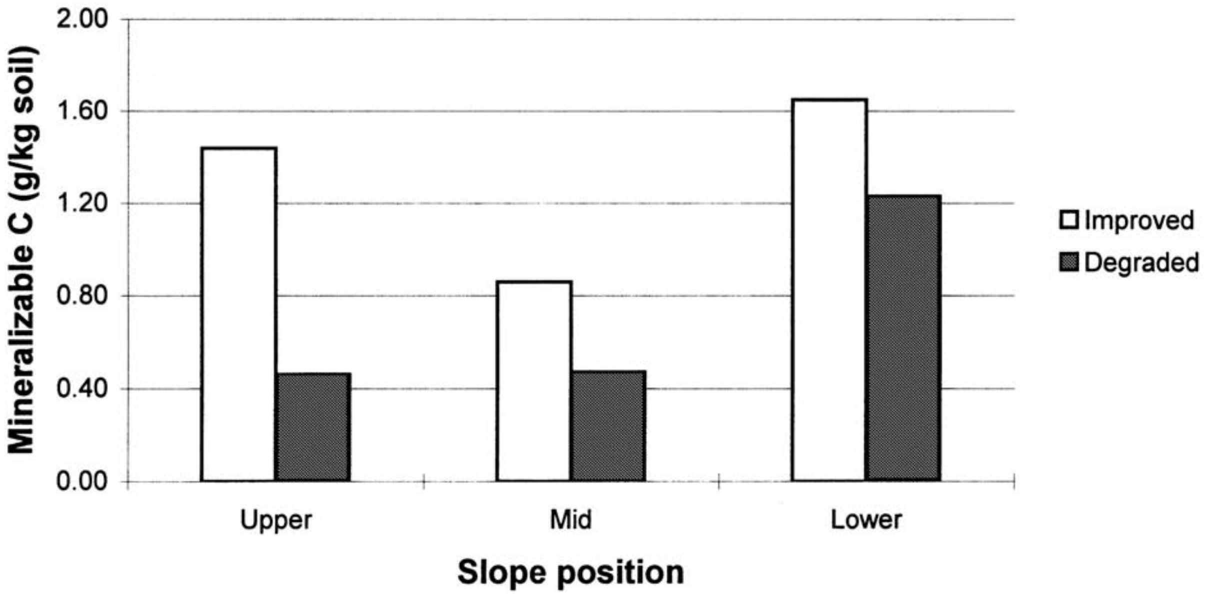
LMU	Grain yield (Mg/ha)	
	Annual wheat	Perennial wheat
(1) Poor sands	1.0	0.6
(2) Average sandplain	1.7	1.0
(3) Good sandplain	2.4	1.4
(4) Shallow duplex soil	2.0	1.2
(5) Medium heavy soil	2.0	1.2
(6) Valley floor soil	2.3	1.4
(7) Sandy surfaced valley soil	2.1	1.2
(8) Deep duplex soil	2.1	1.3

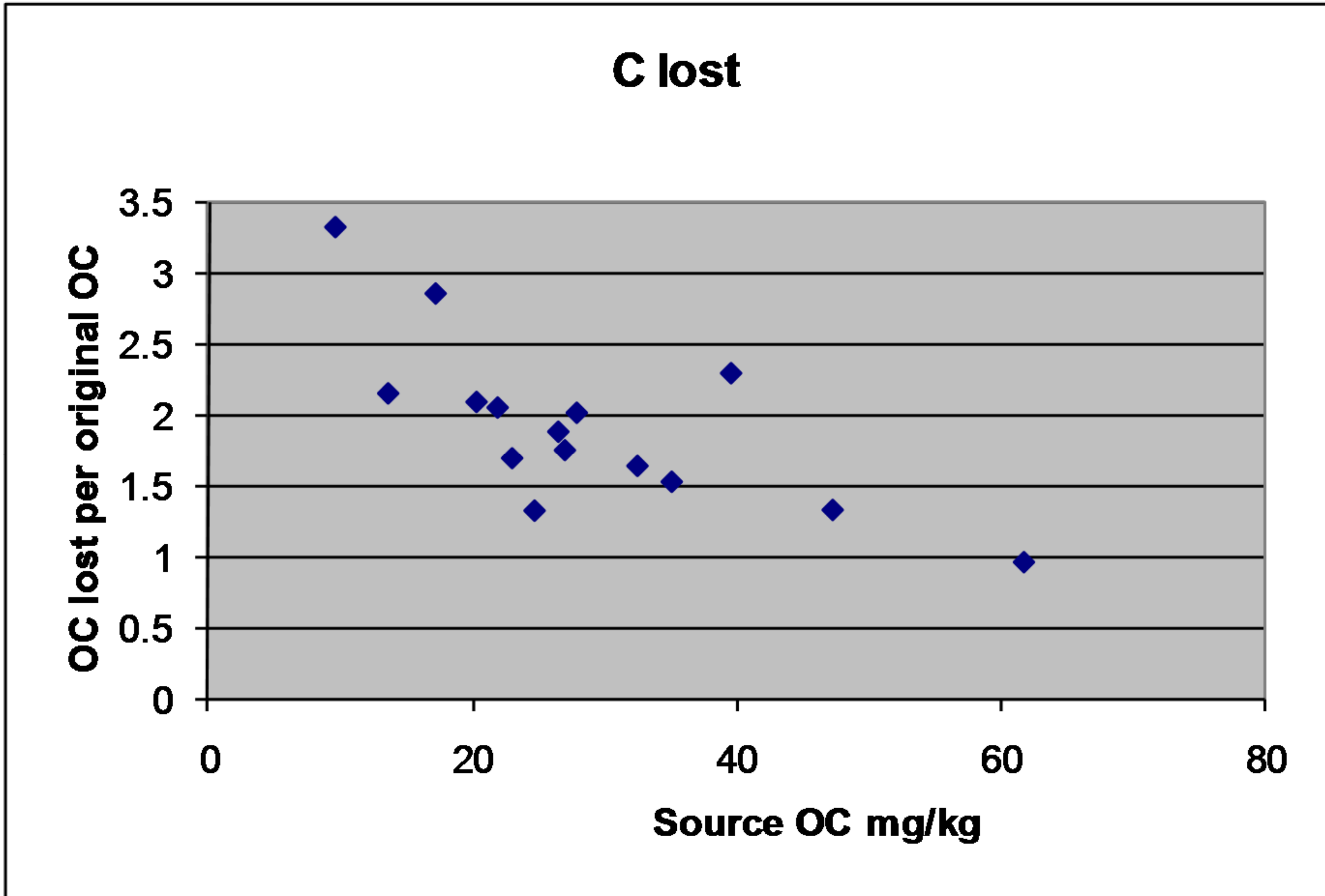
Bell 2008

E.G. Gregorich et al. / Soil & Tillage Research 47 (1998) 291–302

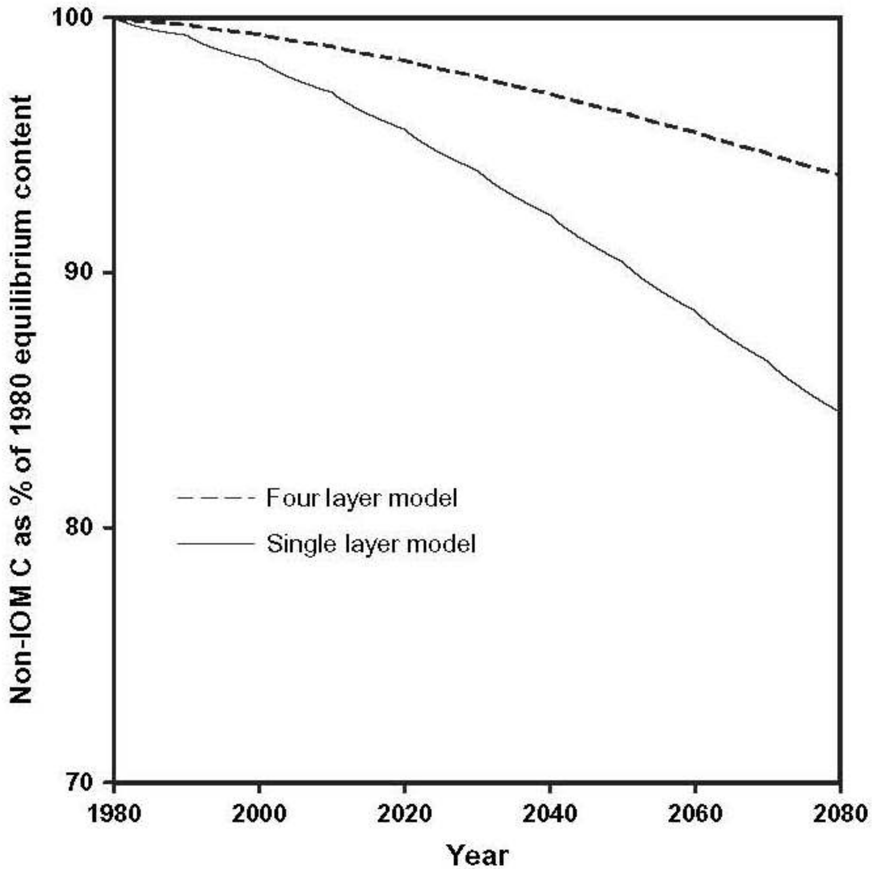


Erosion

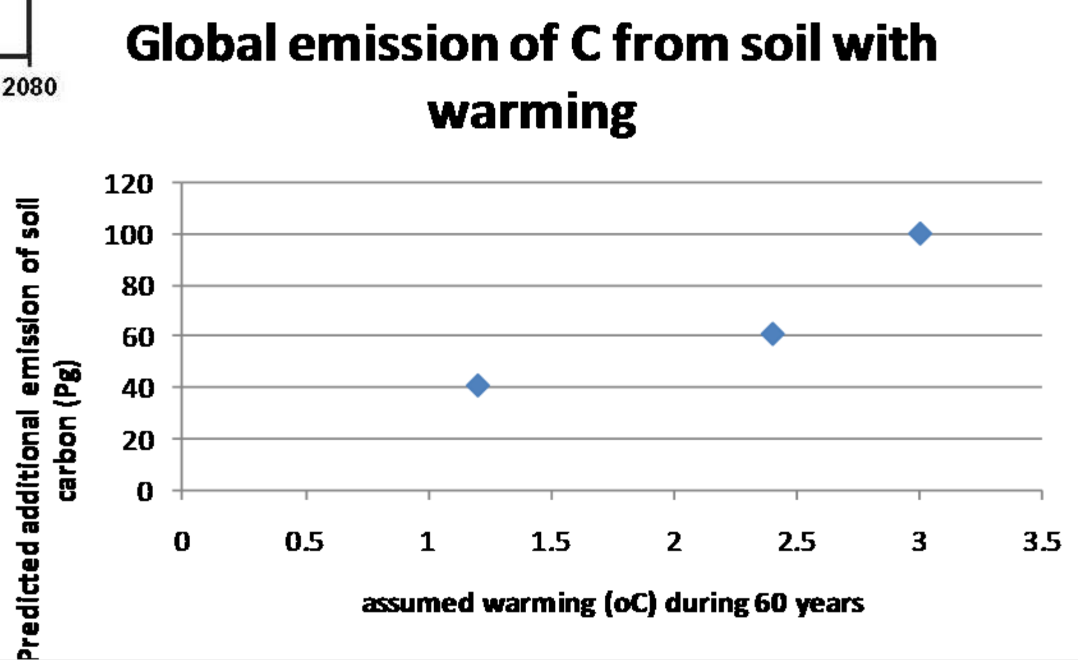




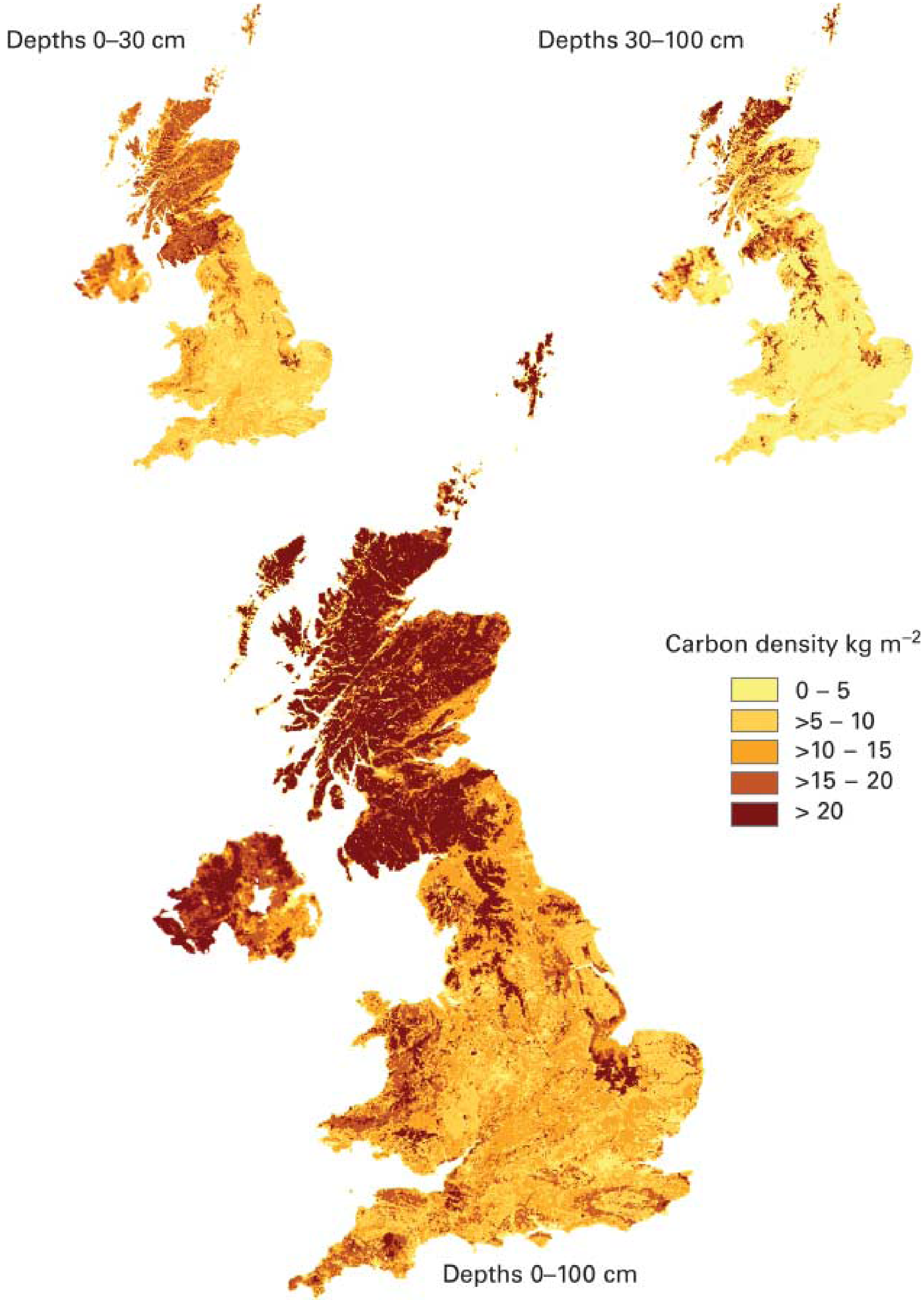
Watts et al unpublished



Models, soil carbon and global warming



Jenkinson, 1991 &
Jenkinson & Coleman 2008



There is carbon in the subsoil as well as the topsoil

Bradley 2005

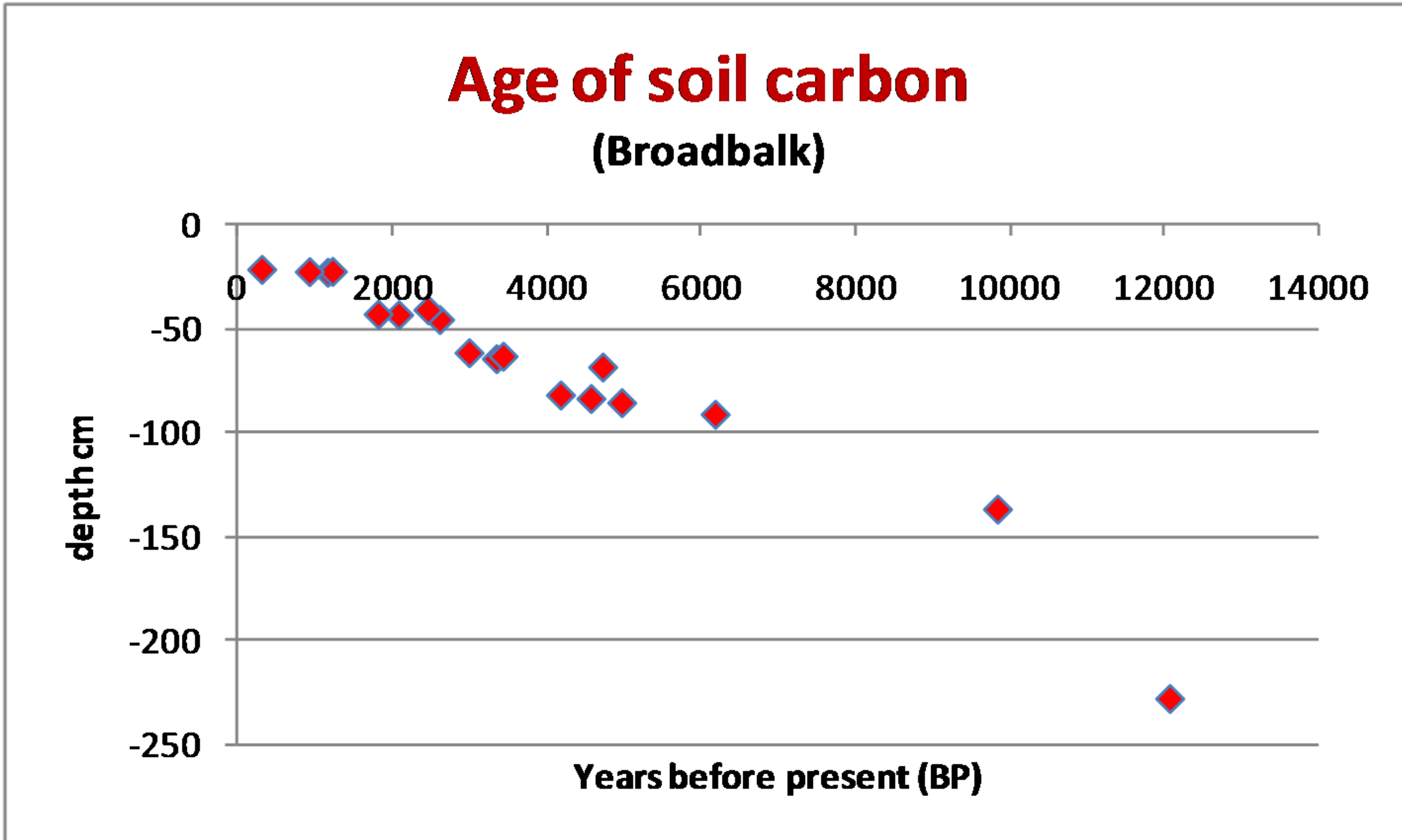
How does carbon get to the subsoil?

Direct input from roots

Downward movement

- leaching (DOC)
- bioturbation (earthworms)
- slow burial (was formed there)
- rapid burial (trees uprooting, ploughing)

Carbon in the subsoil is more stable than surface SOC



Jenkinson et al. 2008

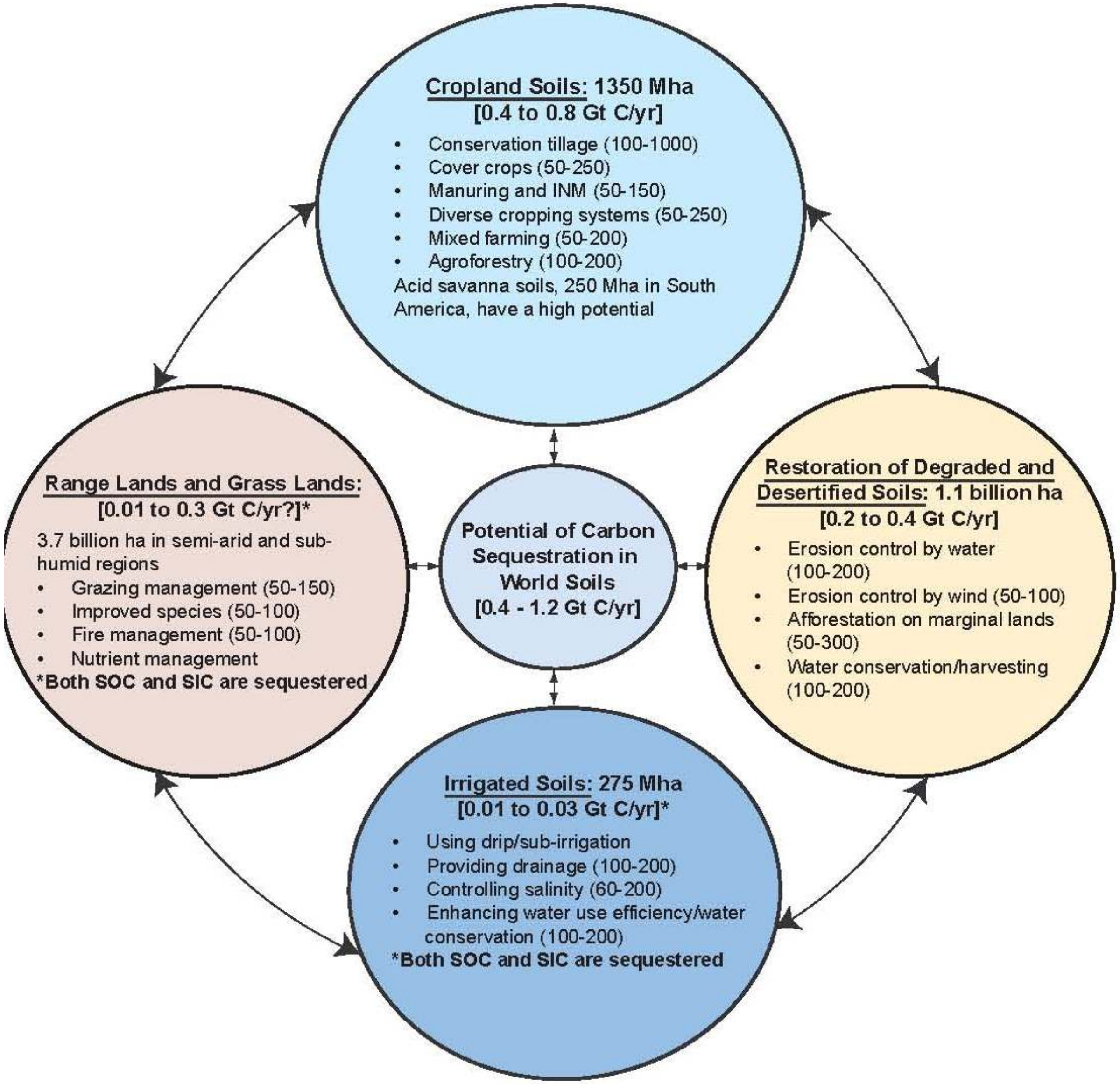
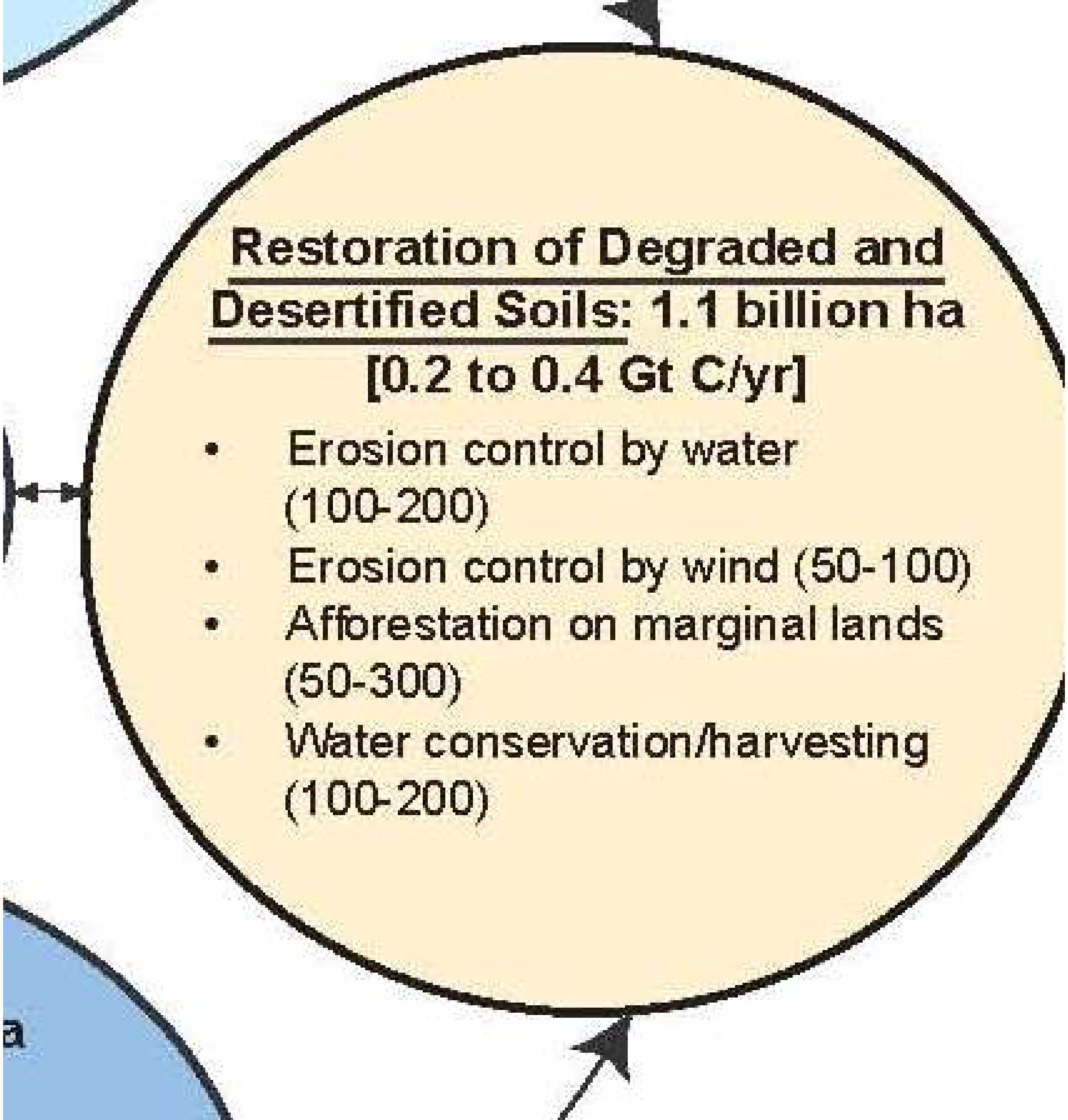


Fig. 2. Ecosystems with a high and attainable soil C sequestration potential are cropland, grazing/range land, degraded/desertified lands, and irrigated soils. Forest soils are included under afforestation of agriculturally marginal and otherwise degraded/desertified soils. Reforestation of previously forested sites have small additional soil C sequestration. The potential of C sequestration of range lands/grassland is not included in the global total because part of it is covered under other ecosystems, and there are large uncertainties. Rates of C sequestration given in parentheses are in kg C/ha per year, are not additive, and are low under on-farm conditions. [Rates are cited from (*2–9*, *15*, *25*, *37–39*) and other references cited in the supporting material.]


Restoration of Degraded and Desertified Soils: 1.1 billion ha
[0.2 to 0.4 Gt C/yr]
• Erosion control by water (100-200)
• Erosion control by wind (50-100)
• Afforestation on marginal lands (50-300)
• Water conservation/harvesting (100-200)
a

Wheat may

Increase soil C while retrieving P
Exude carbon to maintain aeration status of roots
Stabilise soil C especially at depth
Help restore degraded lands or avoid degradation
further increase soil C if grown all year round

Thanks to:
Chris Watts, Richard Whalley, Kevin Coleman,
Tim Davies, Colin Webster, Gordon Dailey, Nigel Bird