Habitats and carbon, storage and sequestration

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Urgency for action

- ❖ Committee on Climate Change recommend tree planting, peatland restoration and green infrastructure to meet latest 2050 net zero C target

- ❖ UK State of Nature 2019 –decline of abundance & distribution of UK's species continues. Some progress, but not meeting most of CBD's Aichi targets

- ❖ Climate change impacts on biodiversity likely to be significant requiring enhanced resilience of habitats & species

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Opportunities

- ❖Integrate responses to these challenges with other ecosystem services, eg
  - ❖flood control
  - ❖water quality
  - ❖health and wellbeing
- ❖Focus here on carbon and habitats
  - ❖Carbon stock
  - ❖Carbon losses
  - ❖Carbon capture

A leaky dam

- ❖ NB beware many studies use different measures that are hard to translate and compare results. List of conversion factors provided.

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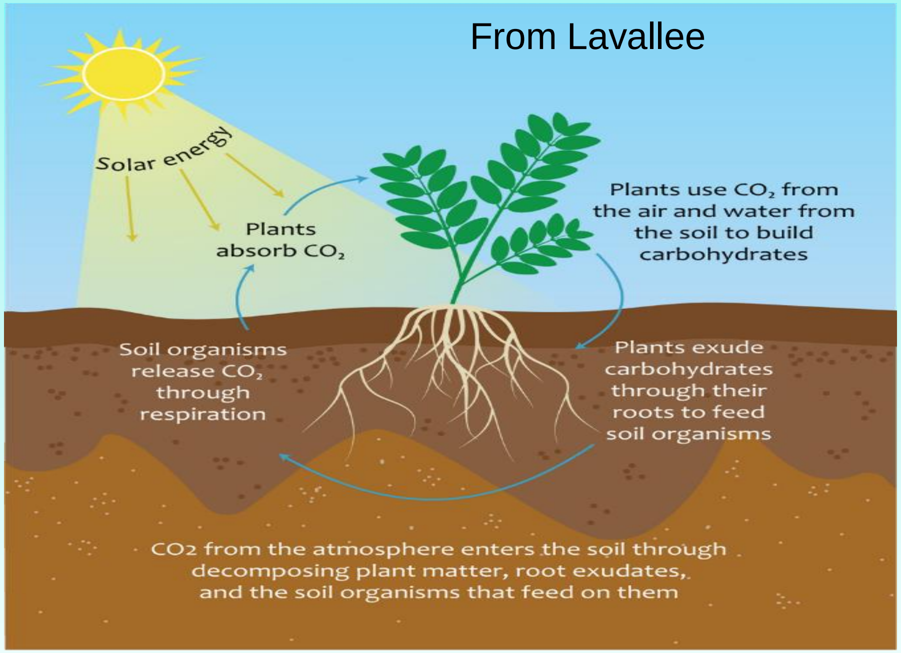
Where is carbon?

❖ Carbon cycle basis for life on earth.



❖ About ½ of emissions from human activity absorbed by land and oceans, rest in atmosphere

❖ Easier to measure carbon stock - very few complete carbon balance measurements.

Carbon stock – soils

- Globally 3-5x more C in soils than vegetation, 2-3x more than in atmosphere
- Soils can continue to capture & store C
- Amounts vary with climate, soil type, vegetation and soil microbes
- Most studies have used soil to 15 or 30cm, but 50% + can be below this – varies with vegetation
- More C in soils:
  - With >30% clay content
  - In wet soils
  - Acidic soils - slow breakdown of OM
  - Where ectomycorrhiza and ericoid mycorrhiza dominate

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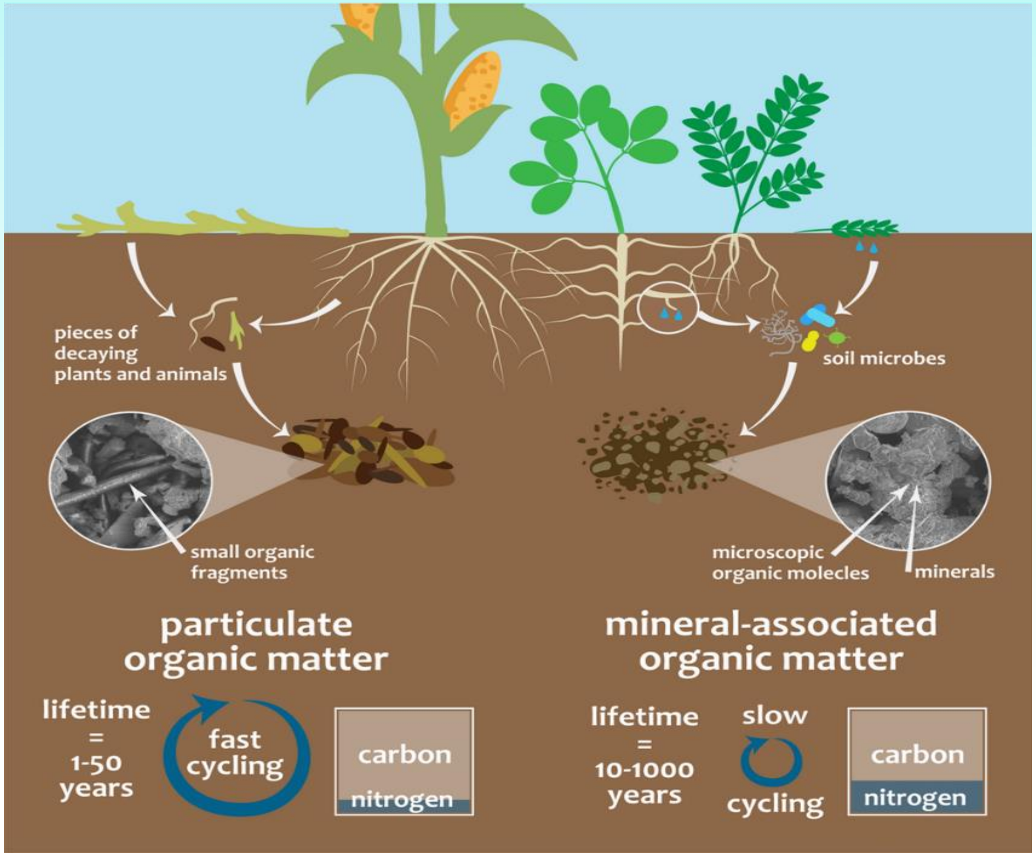
- **C in soils**
  - dissolved in water,
  - as particulates in soil particles,
  - bonded to minerals.

Have different life cycles

Ideal – increase mineral-associated organic matter



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Some soil carbon data

Soils under different habitats	Carbon tC/ha to 0.3m unless shown otherwise
Acid grassland	87
Neutral grassland	60
Flood plain grasslands	**286 (to 3m)**
Agriculturally improved grassland	59-61
Arable	43-64
heath lowland and upland	81-103
Podsols under heath	**175-211**
Bracken	77
Broadleaved mixed wood, soil dependent	**133-320 to 0.5cm,**
Conifer plantation	**73-120 to 0.3m**
Peatland	**259 to 0.5m, 576 to 1m**
Fen, marsh, swamp	76
Salt marsh	**143**

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Carbon store in vegetation

Soils under different habitats	Carbon in vegetation tC/ha
Grasslands	1
heath lowland and upland	2-7.11
Unmanaged forest reserve/Broadleaved mixed wood	**218/70-111**
Conifer plantation	**59-94**
National average all wood types	**57**
Peatland	2
Salt marsh	**8.32**

Woodlands

- 50% of total tree C in trunk – varies with species – BL higher than conifers
- 20-35% in roots - >BL than conifers
- C lost in harvesting & ground preparation
- Most data from plantations

Total amount of carbon in soils and vegetation depends on area of habitat – so in high value habitats more in heathland and bog than woodland

Carbon losses

- ❖ Habitat loss
- ❖ Soil disturbance – ploughing, drainage,
- ❖ Soil loss – sediment, erosion
- ❖ Wildfire
- ❖ Overgrazing

New Farm drainage in wet clay soils 2018

Saddleworth Moor wildfire damage 2018

How to maximise C capture

- Maximum effect:
  - protect remaining habitats
  - minimise losses in soils whilst undertaking habitat restoration or creation
  - large scale, maximising area capturing C – small amounts over large areas & high amounts over small areas?
  - Optimising management to capture C usually also benefits biodiversity

- NB maximising CO_2 uptake is very different from maximising C stocks

- Can take 1-5 years to start overall C capture after disturbance

- First priority – **restore peatland hydrology and vegetation cover** – remove forestry, block drains/gullies, raise water table, revegetate bare peat - reduces loss of stored C, can capture more carbon if wet enough as well. Variable amount = 0.24 - 2tC/ha/yr of new carbon, but can be large scale.
- Create **permanent ponds, marshes, other wetlands, restore diverse flood plain meadows -** connect to rivers –potential for 22tC/ha/yr or more in some constructed wetlands, 1.42tC/ha/year accumulation for well vegetated small ponds
- **Arable to wetland** potential gain 2.2-4.6tC/ha/yr

Gully blocking on blanket bog Peak District

Drained raised bog for extraction *Sphagnum* after hydrological restoration, Ireland

- **Create woodland** – native BL with structural diversity + dead wood for large, long-term forest C stocks and soil C.
- BL woodland can capture 2.5tC/ha/yr, conifers 2tC/ha/yr – depends on age and density (eg. c.0.6 in shrub stage)
- Intensive even-aged forestry captures more/yr – 4-10tC/ha/yr for short period but store not long-term, biodiversity poorer
- Greatest benefit creating woodland from arable
- Variations on this theme – **create orchards, scrub, hedges, wood pasture**, all trap more carbon than grasslands or arable, not as much as woodlands, but wood pasture could be greater area
- Restore and create **heathland** on more acidic soils, c0.9 to 3.45tC/ha/yr
- **Restore marine habitats** – maximum benefit = from arable in managed retreat. Tidal saltmarshes, estuaries & sea grass all good at trapping carbon in sediments (no methane lost) eg 0.16-2.1tC/ha/yr. Larger areas more effective.

- **Create and restore flower-rich grassland**
  - Add legumes, especially red clover - 3.17tC/ha/yr captured
  - High diversity grassland can store 5x more C than monocultures through higher rhizosphere C inputs into microbial community

- **Agricultural land**:
  - Reduce grazing
  - Restore heathland
  - Minimise lime additions
  - Only one hay/silage cut/year
  - Add organic matter
  - No tillage, reduce compaction
  - No drainage/other soil disturbances
  - Remove drainage
  - Reduce inorganic fertiliser use
  - Create wood pasture in pastures
  - Add hedges/scrub
  - Restore flower-rich meadows
  - Control invasive rushes
  - Create wetlands (as part of NFM) – marshes, flood plains, ponds, buffer zones to water

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Conclusions

- All semi-natural ecosystems hold & can trap more C than arable or improved grassland
- These are all better for biodiversity and other ecosystem services
- The key is to create/restore diverse range of habitats that fit the soils, climate and link to remaining habitats in networks
- Scale is vital – what can be done at the largest scale?
- Study in SW England showed creating & restoring habitats to add C on 824,244ha of mixed land would trap more than 16,000ha new woods
- Don't just think trees:
  - think big
  - think diversity of habitats
  - think biodiversity and soils
  - think wider ecosystem services

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Conversions

- 1 tonne = 1,000,000gm
- Mg = megagram = million gm = 1 tonne
- Terragram = 10^{12} = 10,000,000,000,000gm = 10,000,000tonnes or 10,000,000,000kg
- Gigatonne = 10^{9} or 1,000million tonnes = billion tonnes
- P = Peta Pg = petragram = 10^{15} = 1 billion tonnes
- 1 Tonne of C is equivalent to 3.67 tonnes CO_2. Convert C to CO_2 = x3.667.
- Convert CO_{2e} (which includes other GHG) to tC = x12/44 (relates to atomic weight of C and O)