What can Agroforestry achieve? – The evidence base

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TRANSFORMING LIVES AND LANDSCAPES

Agroforestry – ‘where trees interact with agriculture’

…the deliberate combination of trees (including shrubs) and agricultural crops and/or animals on the same land management unit in some form of spatial arrangement or temporal sequence such that there are significant **ecological and economic interactions** between tree and agricultural components.

Not just Alley cropping!

Agroforestry Research

- New name for an old (and common) practice
- Globally 43% of agricultural land has at least 10% tree cover
  - 30% of the global rural population
  - Not niche!
- Research on agroforestry dates back ~50 years
  - Relatively young science
  - Increasingly high profile

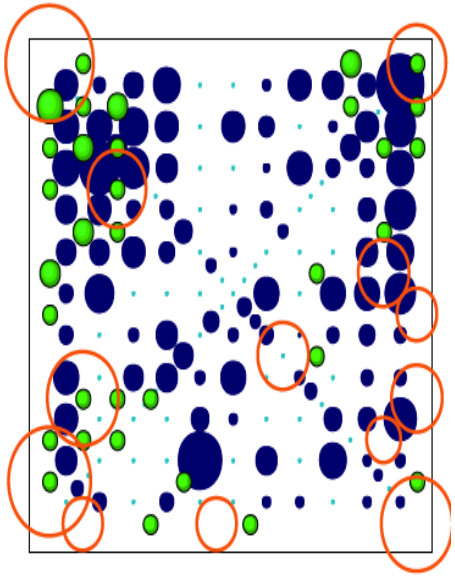
”Electric’ sheep being used for the MULTILAND project to test shelter properties of hedgerows

What are the main research questions?

- Research effort primarily aimed around **sustainable intensification of agriculture**.
  - Increasing agricultural production whilst reducing environmental risk
- Potential benefits are perceived differently by different groups but all related to the MULTIFUNCTIONALITY associated with agroforestry systems
  - Fundamental research (hedgerows)
  - Opportunities (tree fodder)
  - Technical advice
  - Exploring barriers to adoption (policy, cultural values, knowledge gaps)
- Benefits of scaling agroforestry systems

Agroforestry - Benefits to the soil

- Nutrient cycling and utilisation is more efficient in agroforestry systems
- Trees ameliorate soil compaction and increase infiltration
- Trees improve the soil holding capacity for water and nutrients
- Increase in fungi/bacteria ratio and the number of earthworms near trees
- Under elevated CO_2 conditions trees invest in their mycorrhizal associations (scavenge deep nutrients – including P)
- Temperate agroforestry systems store more than 2 T/ha/year of C.



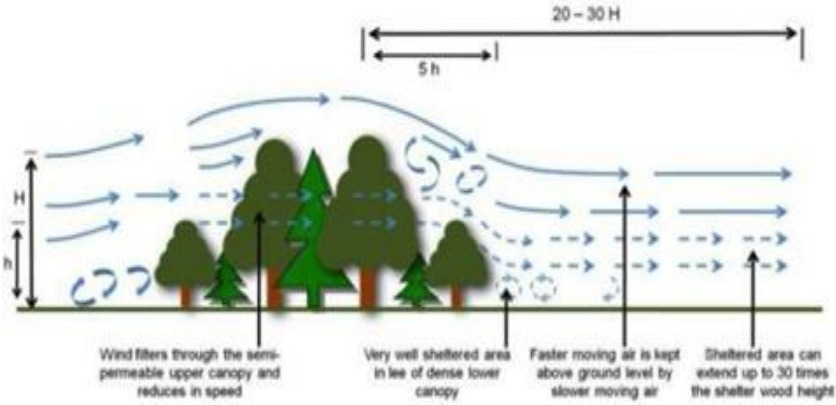
Agroforestry and Erosion

- Annually, 75bn tonnes of soil, this lost to erosion, waterlogging and salination;
- 20m hectares arable land is abandoned because soil quality has degraded.
- The presence of the trees limits the effects of wind and rain erosion
- Buffer strips can significantly decrease pollution run-off, with reductions of 70-90% reported for suspended solids, 60-98% for phosphorus and 70-95% for nitrogen

Trees - Benefits to livestock

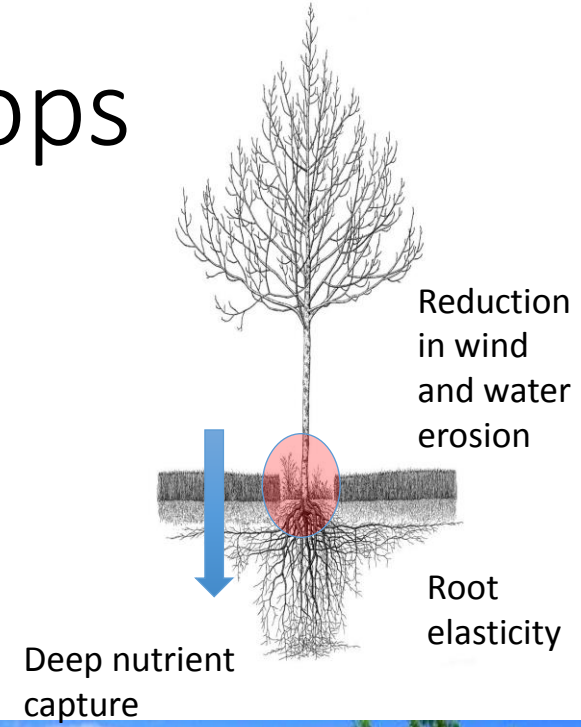
- Shelter benefits (wind, snow and heat). Initial evidence suggests:
  - 10% Live weight gains recorded in Australia
  - Provision of shelter reduces lamb mortality by 50%
- Trees improve drainage & ground conditions
  - Conditions less favourable for foot rot or liver fluke
  - BUT trees can provide habitat for flies; increased risk of head flies & blow flies
- Biosecurity benefits at landscape scales

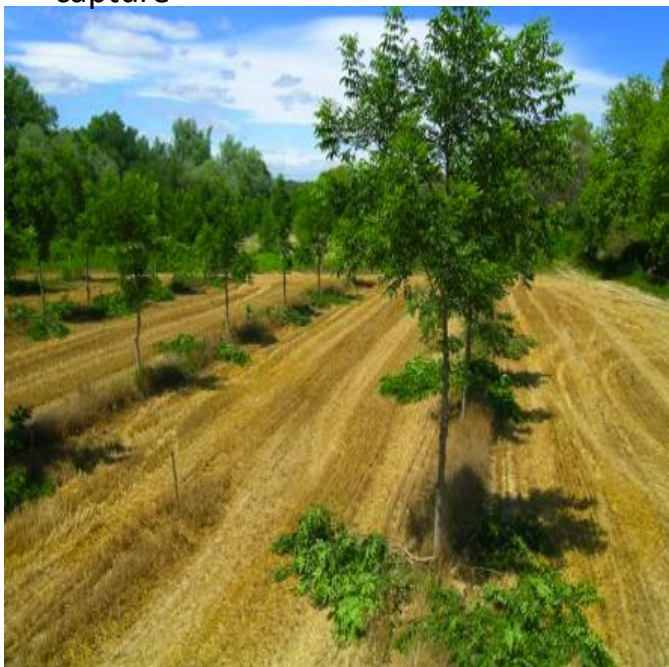
Shelterbelt systems at the Pontbren farms in Mid Wales (Benefits: provision of shelter, Timber and reduced flood risk)



Trees - Benefits to the crops

- Niche differentiation reduces completion and increases efficiency
  - Tree roots may compete with crop roots for water and nutrients
- INRA (France): Production from one hectare of a walnut/wheat mix is the same as for 1.4 hectares with trees and crops separated (40% increase in productivity)
- Tree crops - long term investment. High Value Timber trees/Fruit trees
- Boundary planting can reduce nutrient losses





Farm and Landscape scales: water regulation

THE TIMES | Monday January 25 2016 1GM

Plant more trees to reduce flood danger

Ben Webster Environment Editor

Hundreds of thousands of trees will be planted in upland areas to help slow the flow of rainwater and reduce the risk of flooding, under a government plan to protect homes from extreme weather.

Oliver Letwin, the cabinet office minister who is leading a review of flood protection after 16,000 homes were flooded last month, favours paying farmers to store water on their land.

He and Liz Truss, the environment secretary, have agreed that more trees should be planted and are considering increasing the grants available under the Countryside Stewardship scheme.

Tree roots create channels in the ground, allowing it to absorb more water than bare fields compacted by livestock or machinery. Undergrowth beneath tree canopies also soaks up more water than grazed land.

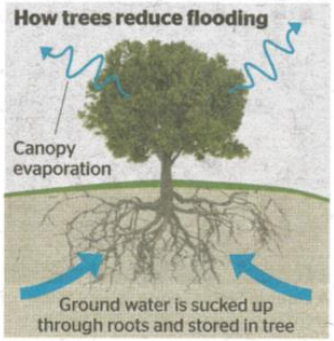
Mr Letwin is planning to publish interim proposals this spring that will include much better flood defences for key infrastructure, such as electricity substations and telephone exchanges.

He is persuaded that man-made climate change has made a repeat of last month's storms more likely and is considering a big increase in spending on defences. The existing plan to spend £2.3 billion over six years will be extended, with an investment programme covering at least 12 to 18 years.

Mr Letwin strongly supports a "catchment-based approach" to reducing flood risk, which means looking at slowing the flow across the entire landscape that drains into a river .

Three rivers had the largest flow recorded in England after Storm Desmond last month, according to the Centre for Ecology and Hydrology.

The Eden and Lune in northwest England and the Tyne in the northeast all recorded flows of about 1,700 cubic metres per second (cumecs) — the equivalent of 41 Olympic swimming pools of water going past the measuring gauge every minute. That rate would fill the Royal Albert Hall in less than a minute. The average flows are 53 cumecs for the Eden, 45 for the Tyne and 36 for Lune. The previous English record was for the Eden, with 1,516 cumecs in 2005.



Ms Truss also wants landowners to be paid for allowing new reservoirs to be built on their land to reduce the flow into rivers. She wants more defences to be built based on the worst case scenario for flooding.

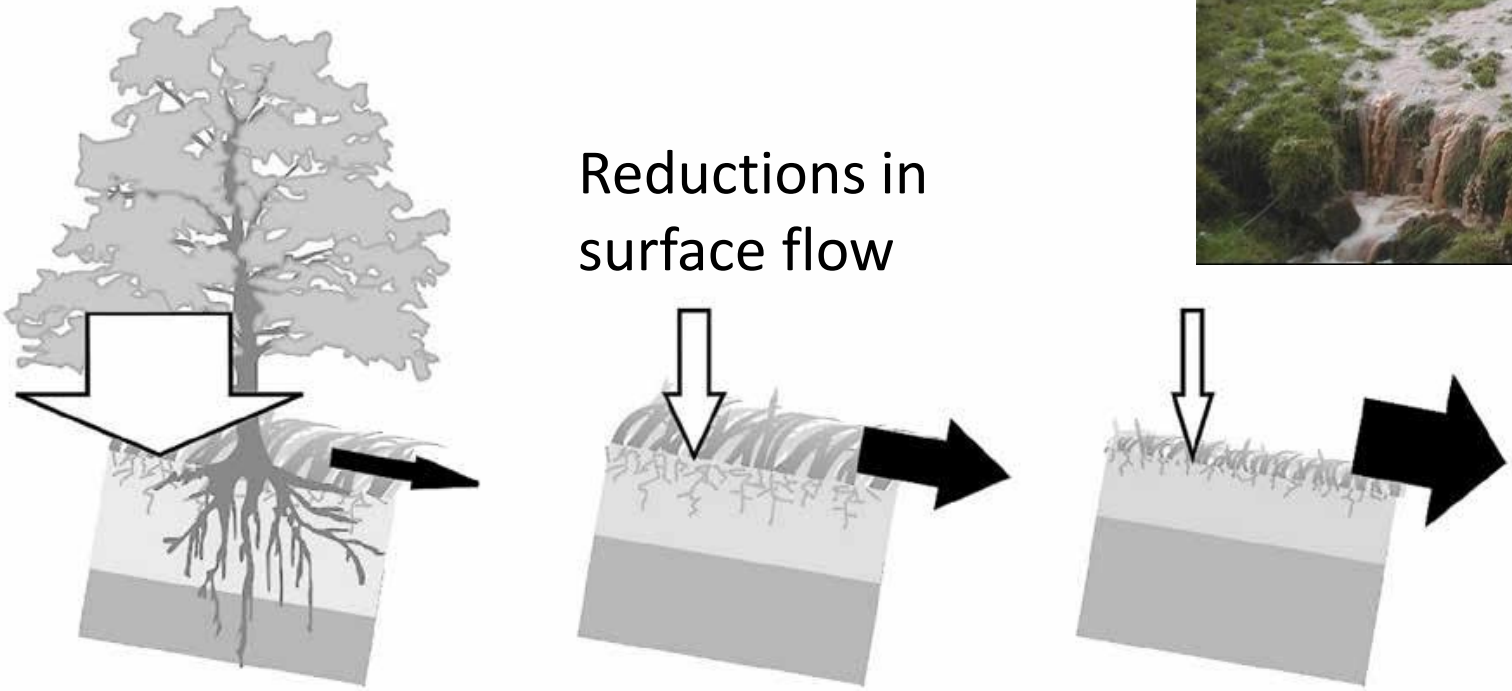
She plans to make Natural England, which handles stewardship payments to farmers, and the Environment Agency, which is responsible for flood defences, work together much more closely. A Conservative proposal to merge the two agencies was blocked by the Liberal Democrats in the previous parliament but could be revived.

Ms Truss also wants the Environment Agency to stop referring to "one-in-a-100-year" floods and find a less confusing way of explaining flood risk to the public. Several towns and villages in Cumbria have had two "one-in-a-100-year floods in less than a decade.

Professor Alan Jenkins, of the Centre for Ecology and Hydrology, said that measures in the uplands to slow the flow such as planting trees were "very likely" to mitigate flooding but that there was a lack of research to prove this. He said that even if such measures did not make much difference to flood risk they would have other environmental benefits. He added: "We believe there is nothing that can be done to prevent flooding everywhere at all times."

December was the wettest month in the UK since records began. Thousands of homes were left without power last month after heavy rain and high winds battered parts of Britain. Gales and torrential downpours struck flood-affected parts of Cumbria and Croston, in Lancashire, forcing residents to leave their homes.

Farm and Landscape scales: water regulation

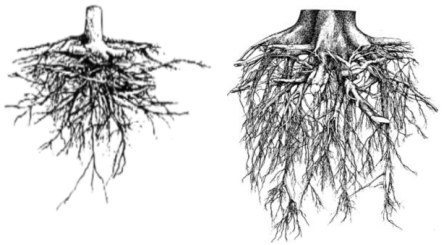


Reductions in surface flow

Increased Infiltration

Ecosystem Services and impacts on wellbeing both on and off farm

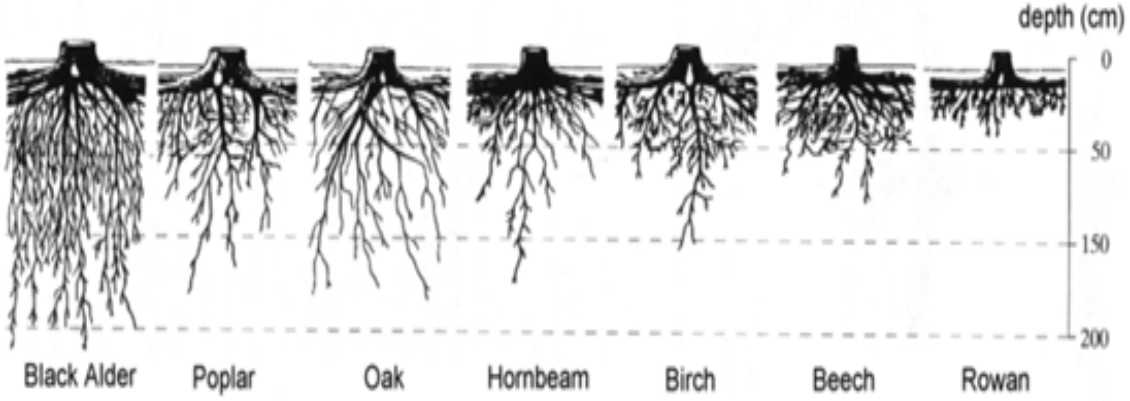
(Infiltration) Root morphology



Shape of birch root systems – 10 years & mature, not to scale.

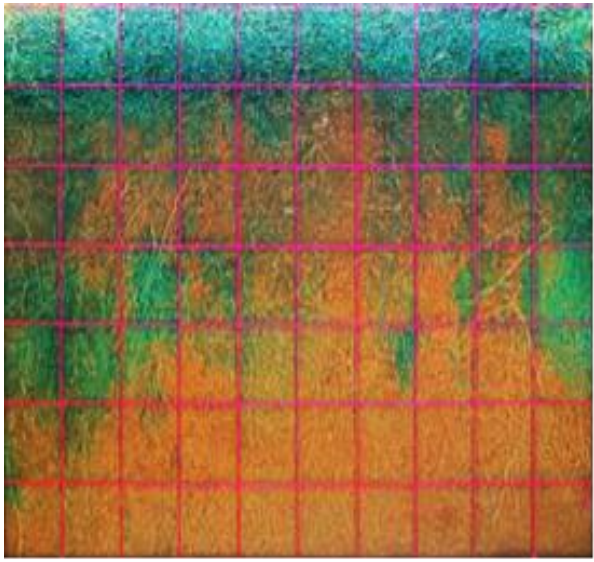
shape of ash root systems – 10 years & mature, not to scale.

From Koestler, Brueckner & Bibelriether (1968)

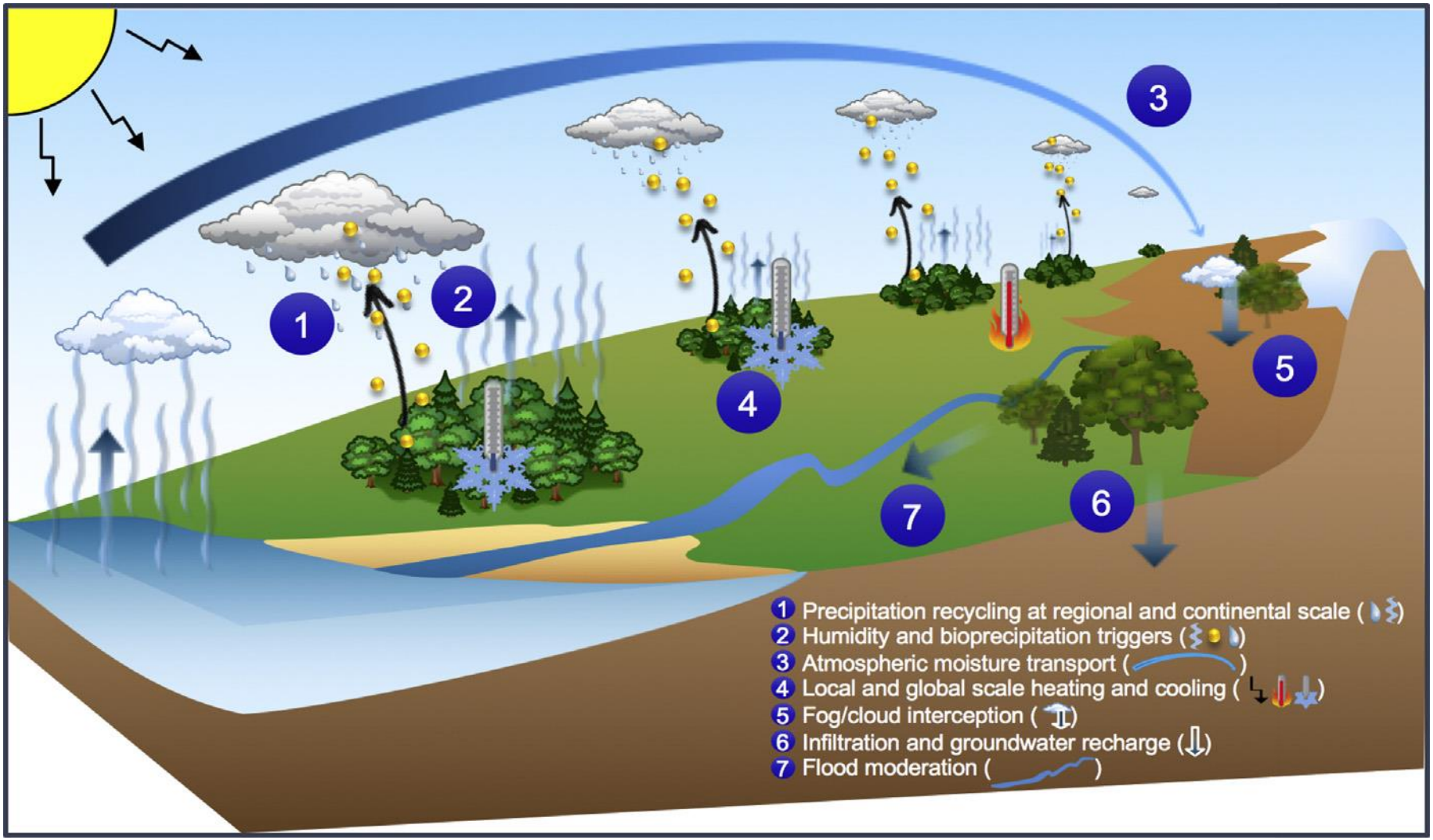


Rooting depths of different species in a clay soil with distinctly seasonal water regime.

After Polomski & Kuhn (1998), translated from German.



Soil pits showing infiltration pathways in two year old ash and birch shelterbelts



D. Ellison et al. / Global Environmental Change 43 (2017) 51–61

Biodiversity Benefits

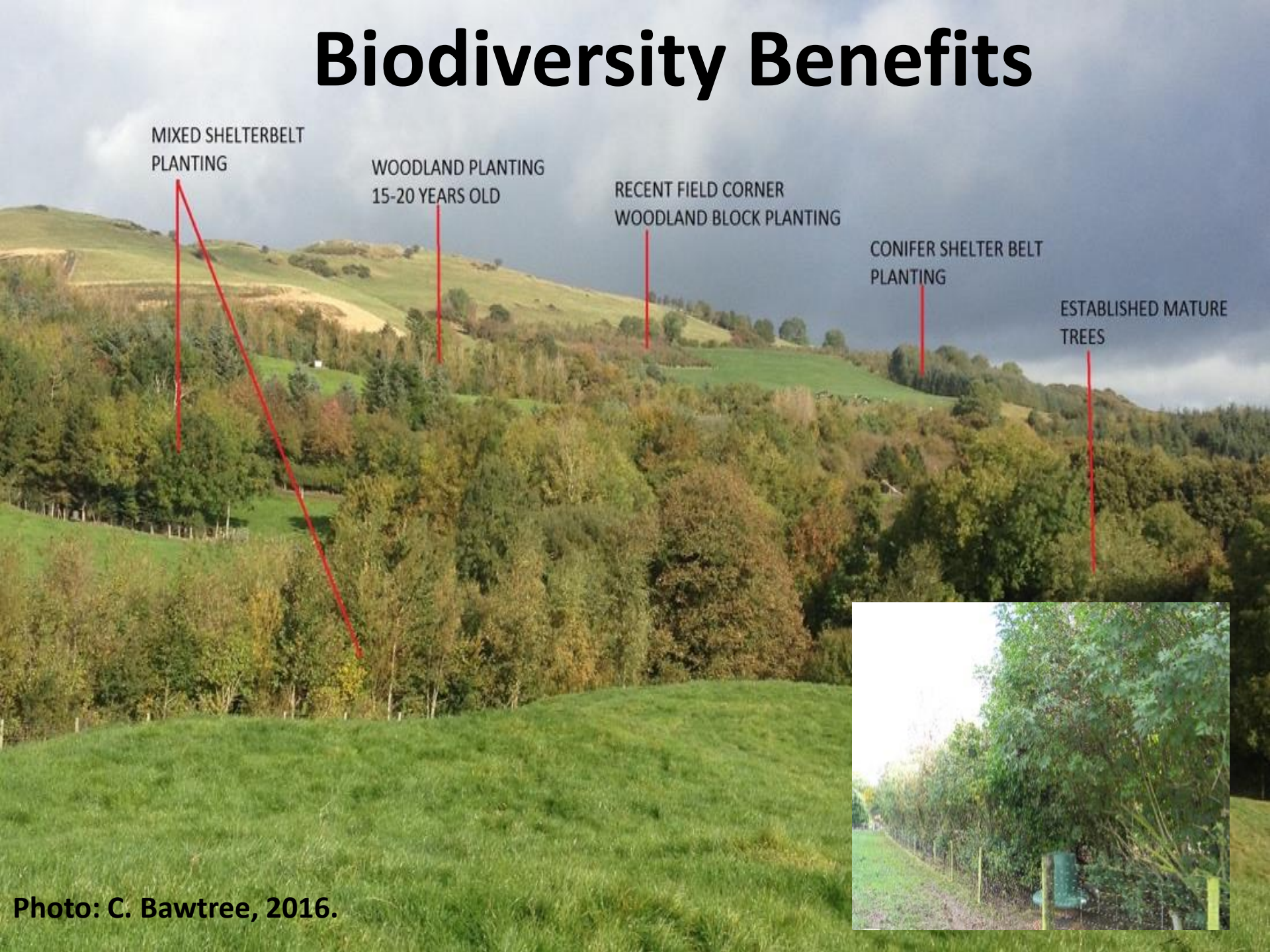
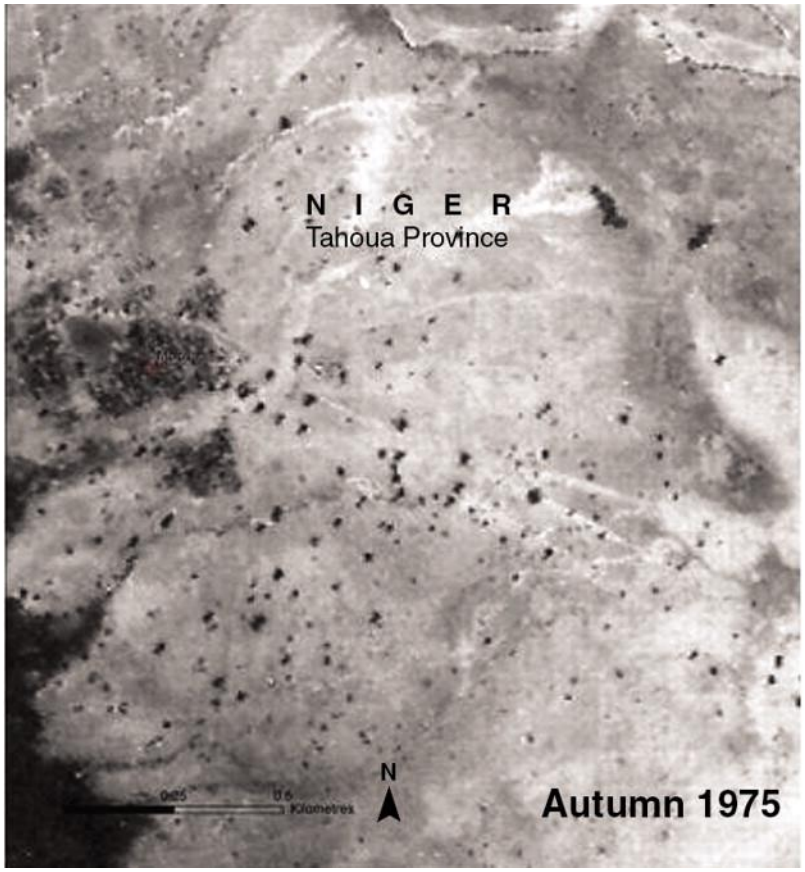


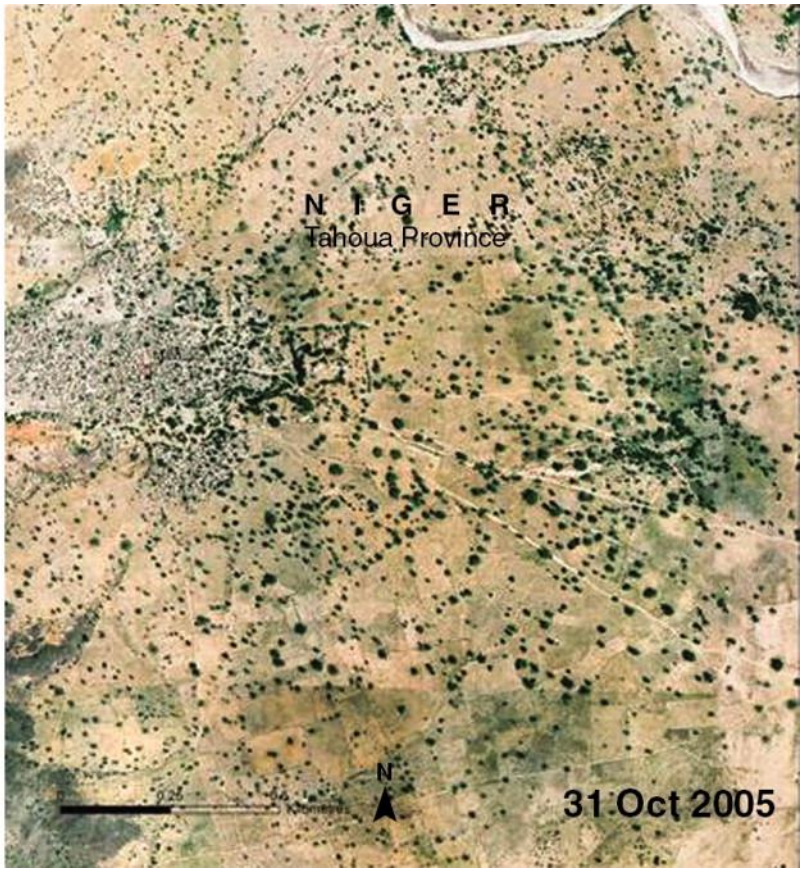
Photo: C. Bawtree, 2016.

Not all agroforestry is good agroforestry!

- Right tree in the right place
- Experiments
  - Old shelterbelt and new shelterbelt systems
- Land sparing vs land sharing
  - Removal of trees from landscapes historically seen as a sign of intensification and progress
- Design agroforestry systems that suit the local context (Coed Cymru, Farming Connect in Wales)
- Get the economics right

An example of a major successful sustainable agriculture project.





Early 1980s, donors invested substantially in soil and water conservation

More than 300,000 ha have been rehabilitated, and crop yields have increased and become more stable from year to year. Tree cover has increased, as shown in the photographs.

H C J Godfray et al. Science 2010;327:812-818

Conclusions – What do we know about what agroforestry can achieve?

- Quite a lot!
- Well designed agroforestry systems make more efficient use of natural resources: sun, air, soil, water (by operating in three dimensions, niche differentiation)
  - Context (right tree, In the right place)
- This allows agroforestry to deliver higher overall productivity from mixtures of trees and crops or/and livestock (but with increased complexity)
- Agroforestry also contributes to greater environmental integrity (decreased erosion, increased biodiversity, reduced flood risk)

But

- Lots more to do!

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Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

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Thank you

COED CYMRU

National Trust

WOODLAND TRUST

PARC CENEDLAETHOL ERYRI
SNOWDONIA NATIONAL PARK

Cyfoeth Naturiol Cymru
Natural Resources Wales

LOW CARBON, ENERGY & ENVIRONMENT RESEARCH NETWORK WALES RHWYDWAITH YMCHWIL CARBON ISEL, YNNI A'R AMGYLCHEDD CYMRU