Multifunctional Benefits of Willow Crops

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Exploring the Benefits of SRC Willow Planting for Water Quality Protection & Waste Water Management

4th March 2020

Crops for Energy

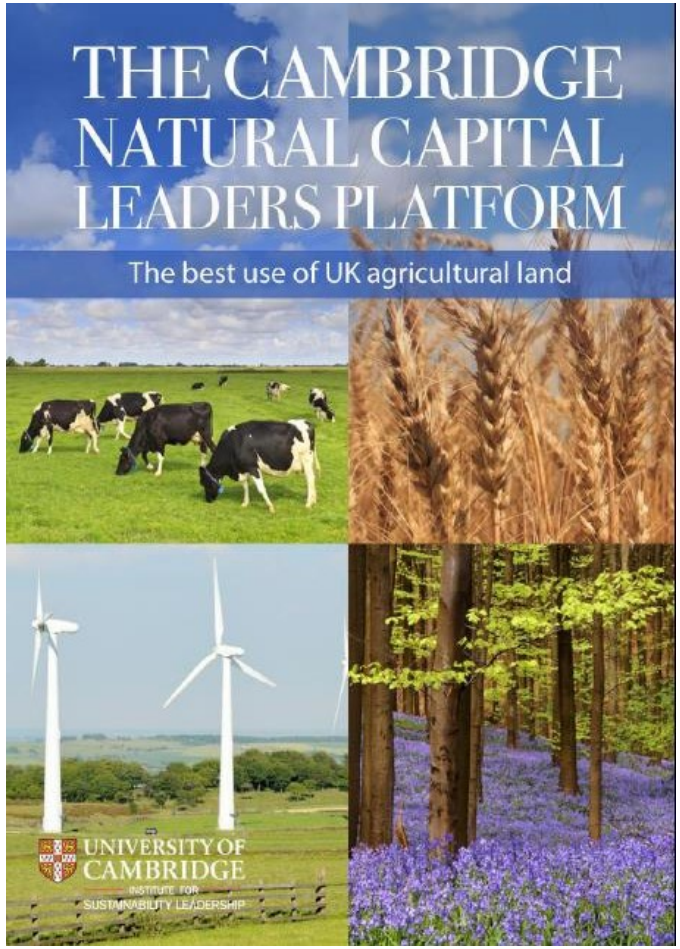
A bit about me

- Involved with energy crops since 1994
- Willow breeder at Long Ashton Research Station 1996-2003
- Set up C4E in 2004
  - Consultancy
  - Project management
  - Sales of cuttings, rods, rhizomes and plugs
  - Grant proposals and RHI hand holding
  - Communications
- Set up the Sustainable Fuel Register (SFR) in 2014 with NFU Energy
- Director of the Wood Heat Association from 2015-18

The best use of UK agricultural land

Crops for Energy

"Where land can deliver multiple benefits – such as forestry or perennial crops providing both a source of timber and energy as well as water management, carbon storage and wildlife benefits – all of these should be understood, valued and their multiple delivery actively encouraged and rewarded".



Ref: The Best use of UK Agricultural Land
http://www.cisl.cam.ac.uk/business-platforms/natural-capital-leaders-platform.aspx

Multifunctional uses

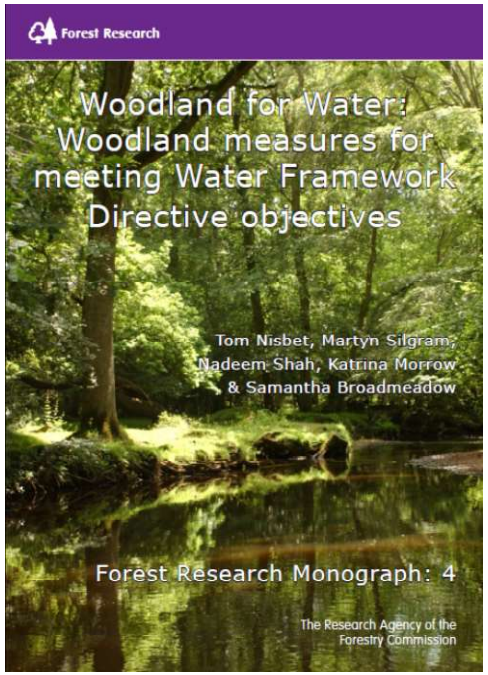
Crops for Energy

- Other water management benefits – flood mitigation
- Biodiversity
- Bioremediation
- Noise pollution
- Air quality
- Food and fuel

Water quality / Flood mitigation

Crops for Energy

- *"Energy woodland crops such as SRC could be a particularly attractive option for **mitigating nitrate leaching in NVZs** by maximising nitrogen uptake and providing a **high yielding crop for farmers**."*
- *"….the rapid growth and multi-stemmed nature of these crops makes them **ideally suited to flood risk management**."*
- *"……energy crops can offer additional advantages for water protection, flood risk management and climate change mitigation by enhancing pollutant uptake and **sediment retention**, more rapid establishment of vegetation roughness (especially for SRC) and **increased carbon sequestration**, as well as a more attractive and faster economic return for landowners."*



BUT….

"……there is no incentive to plant (energy) crops where they could benefit water most."

Ref: Woodland for Water: Woodland measures for meeting Water Framework Directive objectives. Forest Research July 2011
http://www.forestry.gov.uk/pdf/FRMG004_Woodland4Water.pdf/$FILE/FRMG004_Woodland4Water.pdf

Flood mitigation

Crops for Energy

- Significant water use (willow coppice can use up to 0.4 million litres per tonne of dry matter produced per year)
- Greater hydraulic roughness
  - Enhances sediment retention (less need for dredging)
  - Slows down the flow of flood water by acting as green leaky dams
  - Increasing the time available for issuing flood warnings
  - Stops dangerous large objects and debris travelling downstream
- Willow species can tolerate up to 13 weeks immersion without affecting growth and 1-3 weeks submersion

Refs: Drought resistance of willow short rotation coppice genotypes - Ph.D Thesis Luc Bonneau 2004
Species & clonal variation in growth responses to waterlogging & submersion in the genus Salix – Good et al 1992.

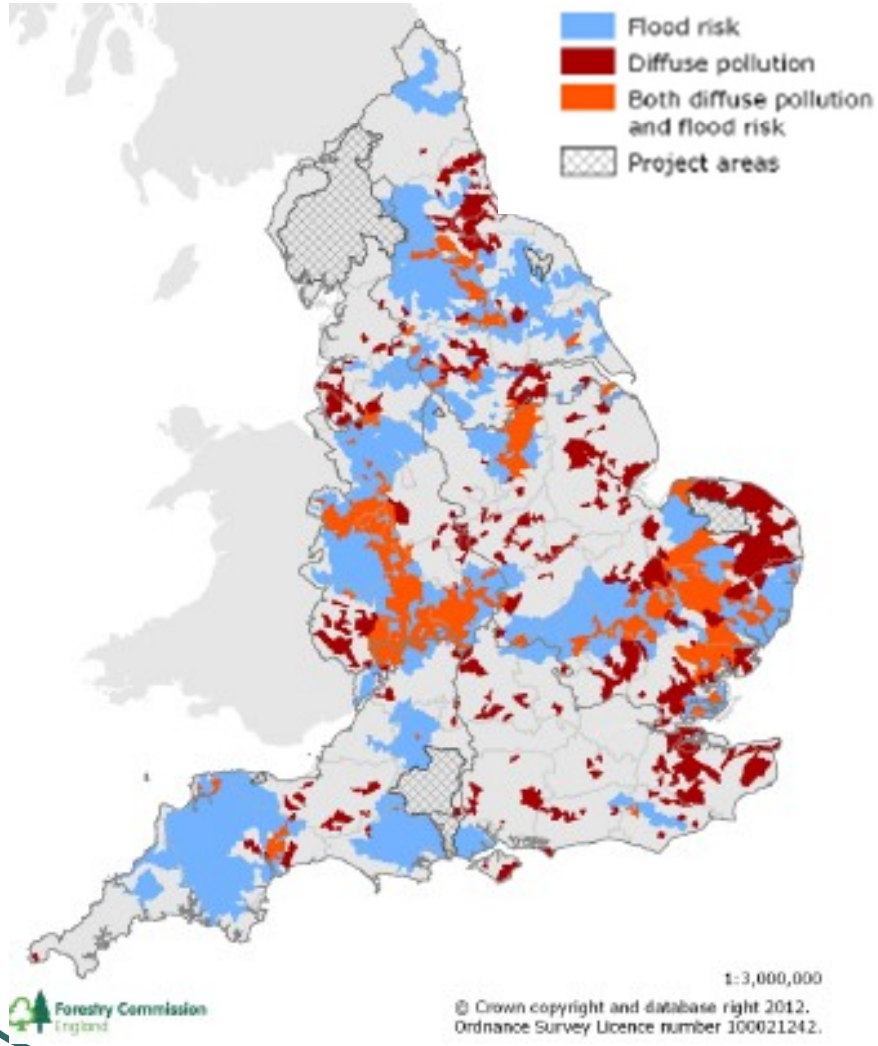
Flood mitigation

Crops for Energy

Vegetation option	SRC	Woodland
Time to maturity	4-5 years	> 20 years
Stocking rate (plants per hectare)	15,000	Typically 2,250
Management	Cut every 3 years	Thinned after 15 years
Hydraulic roughness (Manning's n coefficients)	0.1-0.34	0.1 when mature
Potential of reducing flood risk in < 10 years	Medium - High	Low

Ref: Typical Manning's n values for Floodplains. After Chow (1959)

Flood mitigation



Ref: Forestry Commissions Woodland for Water – National EWGS Targeting Map 2012/2013
http://www.forestry.gov.uk/pdf/NationalMapping_report.pdf/$FILE/NationalMapping_report.pdf

Biodiversity on farms

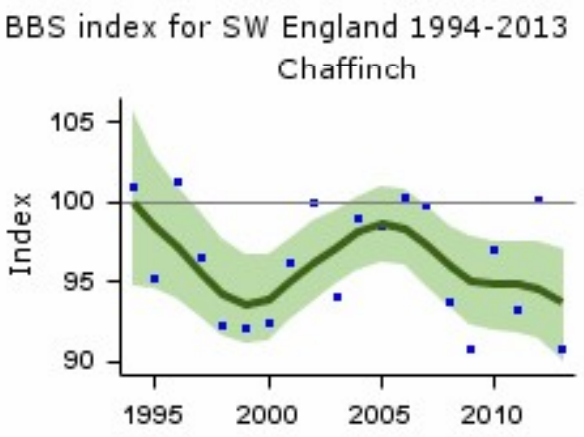
- Wild bird populations have fallen significantly since 1970
- 59 species of birds have Biodiversity Action Plans

But

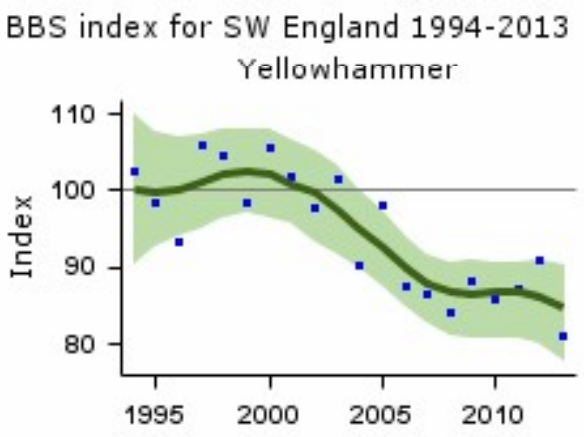
- Significantly more birds in SRC compared to the improved grassland and arable controls
- 12 bird species that reside in SRC with Biodiversity Actions Plans (BAPs)
  - Bullfinch, Corn Bunting, Dunnock, Lapwing, Linnet, Reed Bunting, Skylark, Song Thrush, Tree Sparrow, Willow Tit, Willow Warbler, Yellow Hammer

Ref: The Effects on Flora and Fauna of Converting Grassland to Short Rotation Coppice. http://webarchive.nationalarchives.gov.uk/+/http://www.berr.gov.uk/files/file30621.pdf

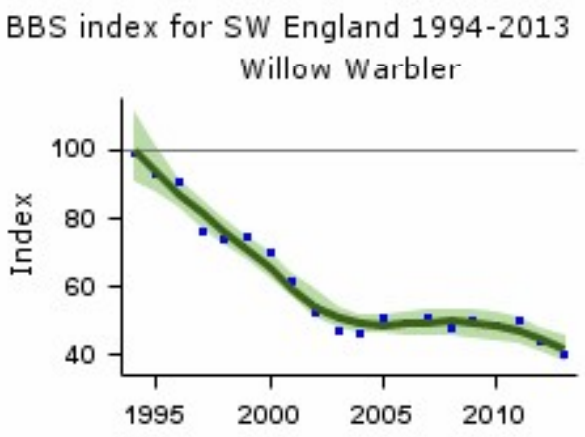
Bird populations



"The most commonly recorded bird in the SRC…"



Red listed / Biodiversity Action Plan
"These important species should benefit substantially from SRC cropping"



Amber listed
"…should also benefit"

Refs: BTO/JNCC/RSPB Breeding Bird Survey South West England graphs
http://www.bto.org/volunteer-surveys/bbs/latest-results/trend-graphs/south-west-england-graphs

Sage et al 2006. IBIS. Birds in willow short-rotation coppice compared to other arable crops in central England and a review of bird census data from energy crops in the UK.
http://onlinelibrary.wiley.com/doi/10.1111/j.1474-919X.2006.00522.x/full

Biodiversity in SRC

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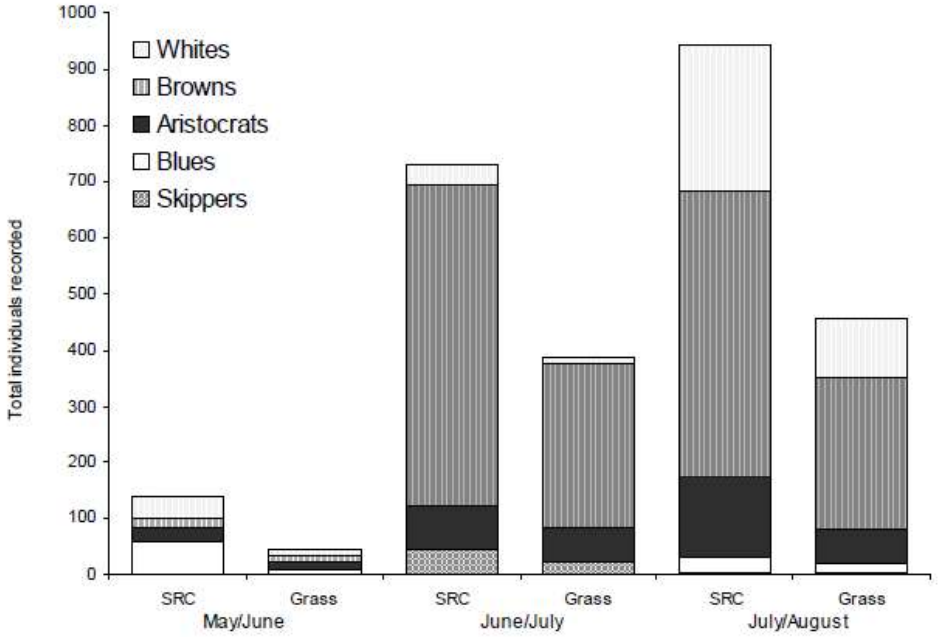
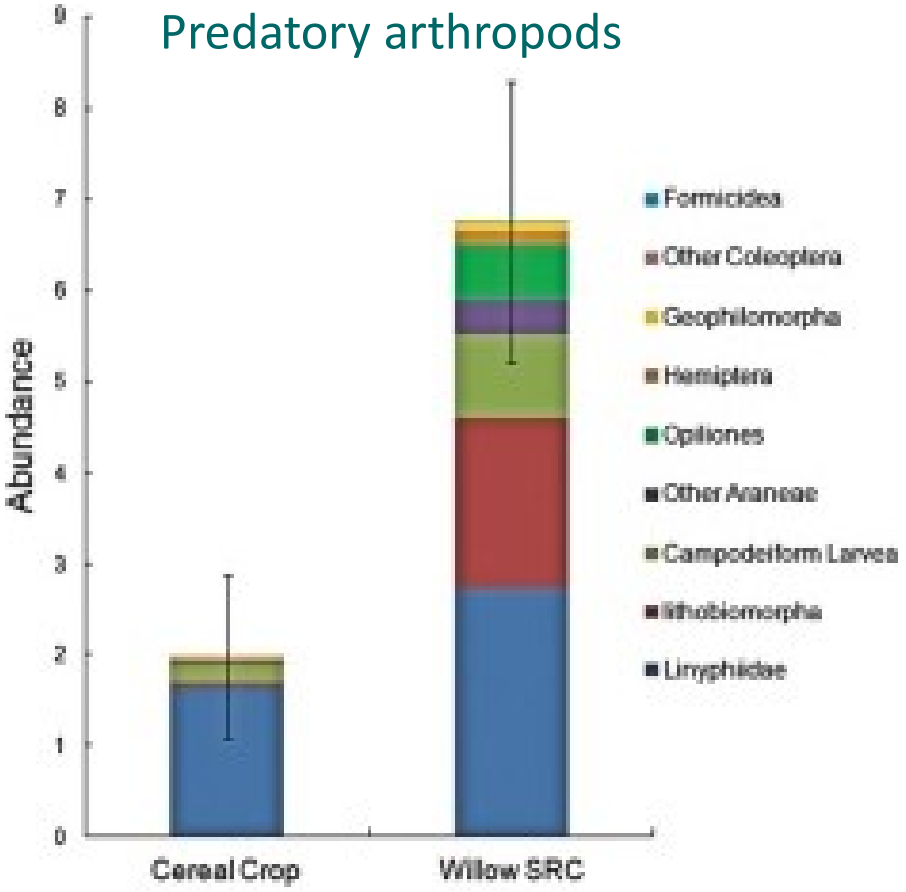
Butterflies



The Effects on Flora and Fauna of Converting Grassland to Short Rotation Coppice. Cunningham et al 2006.

http://webarchive.nationalarchives.gov.uk/+/http://www.berr.gov.uk/files/file30621.pdf

Predatory arthropods

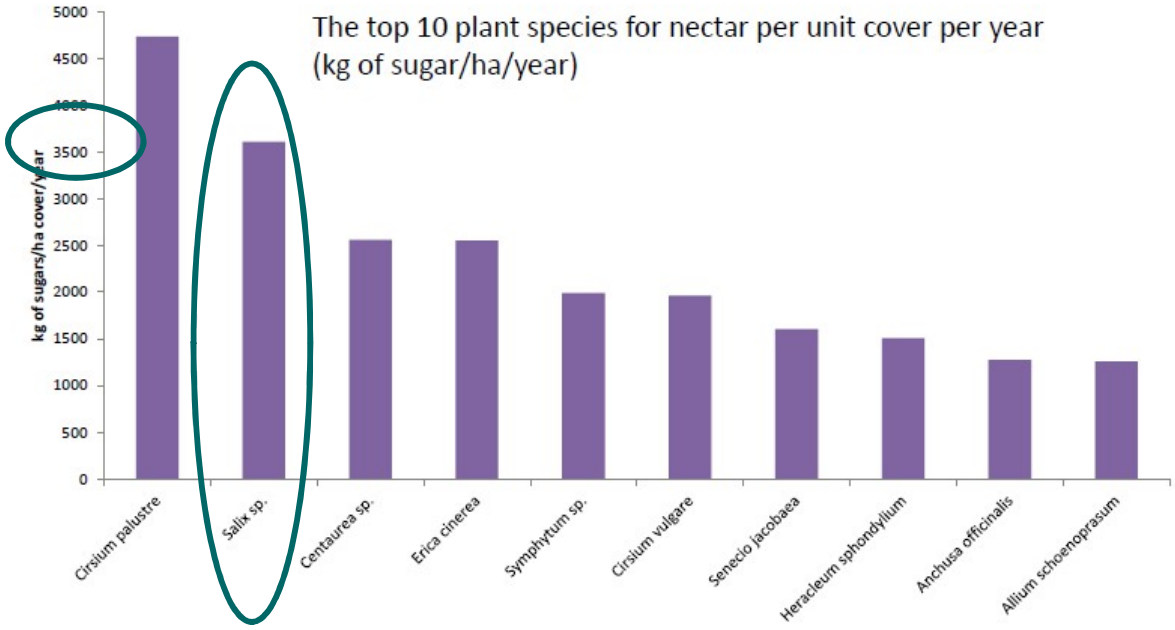


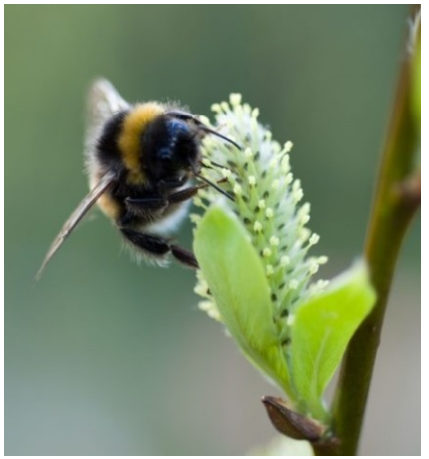
Evaluating ecosystem processes in willow short rotation coppice bioenergy plantations. Rowe et al, 2013

https://onlinelibrary.wiley.com/doi/full/10.1111/gcbb.12040

Pollination services

- 20% of UK cropland is covered by insect pollinated crops
- Value of pollination to UK agriculture = estimated £430 m



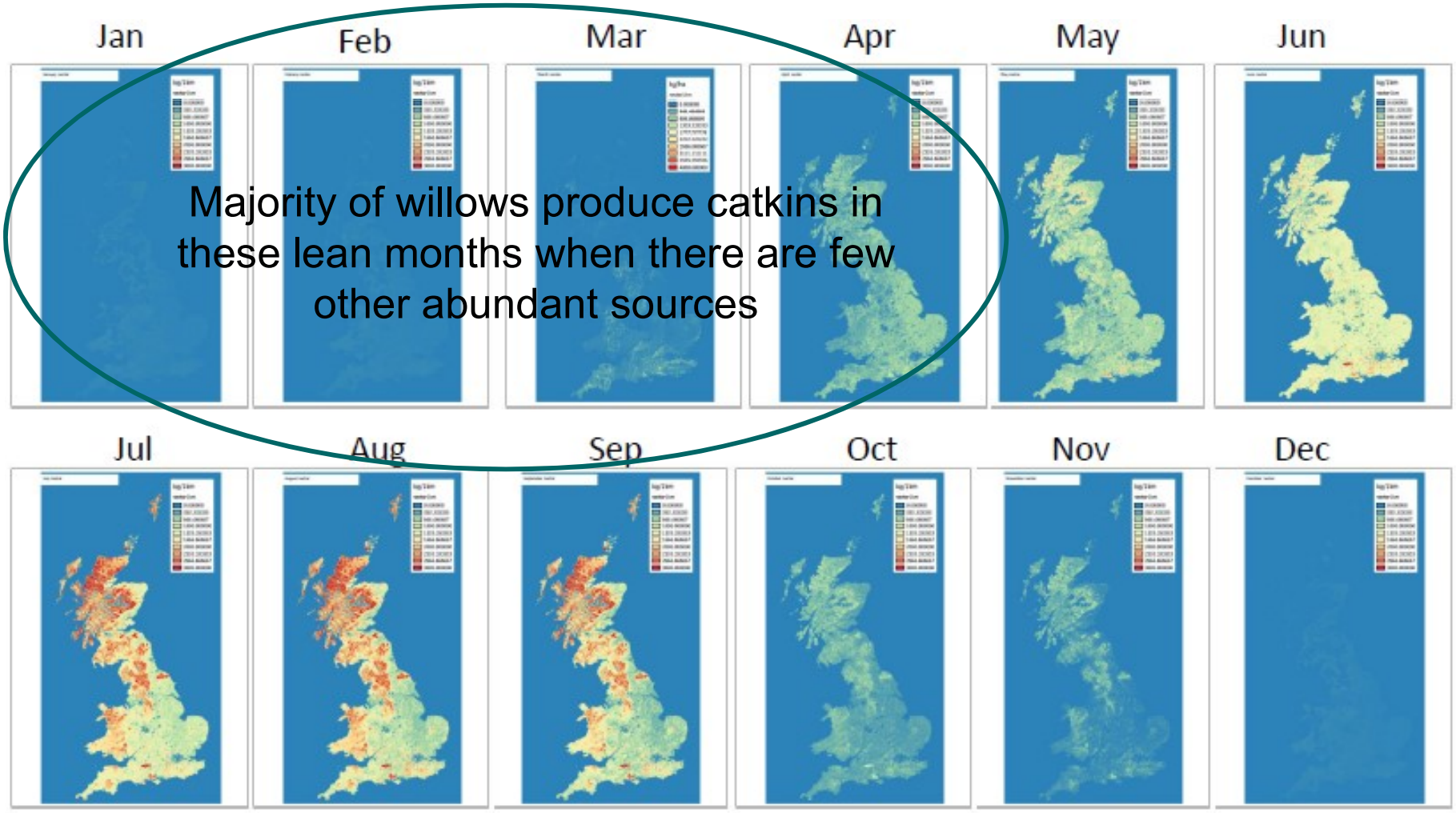


Picture credit: Jason Ingram
http://www.jasoningram.co.uk/

Ref: Quantifying nectar resources from the flower to the national scale. Prof. Jane Memmott, Uni of Bristol . Agriland Project
http://www.agriland.leeds.ac.uk/news/documents/4_JaneMemmottnectarresources.pdf

Pollination services

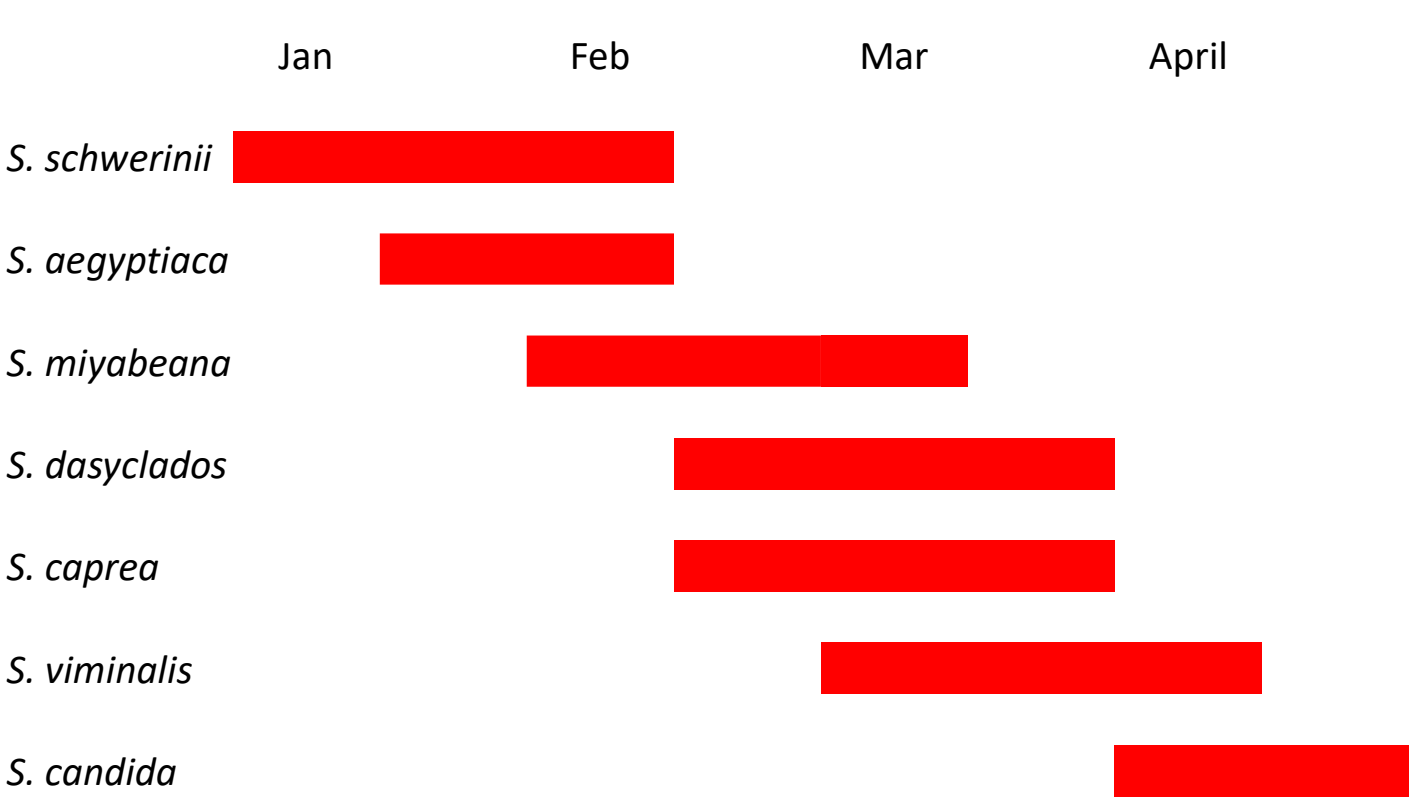
Crops for Energy



Ref: Quantifying nectar resources from the flower to the national scale. Prof. Jane Memmott, Uni of Bristol . Agriland Project http://www.agriland.leeds.ac.uk/news/documents/4_JaneMemmottnectarresources.pdf

Flowering times

Crops for Energy

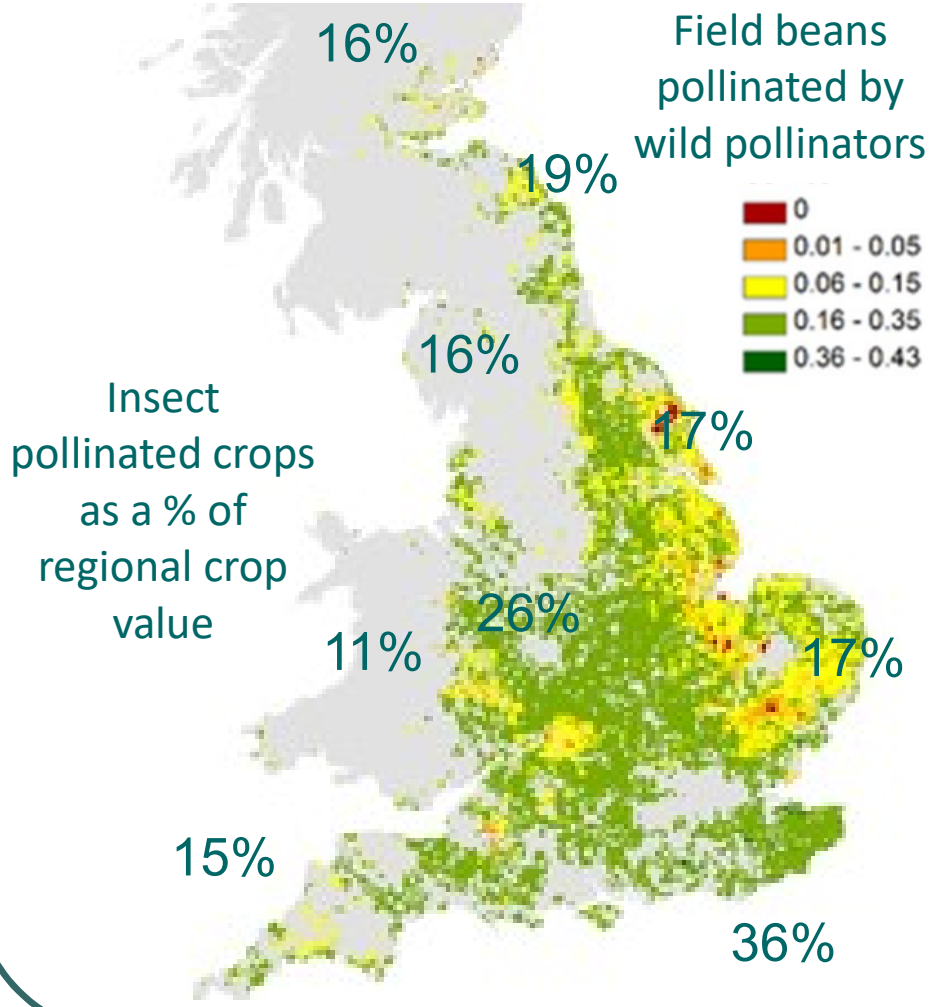


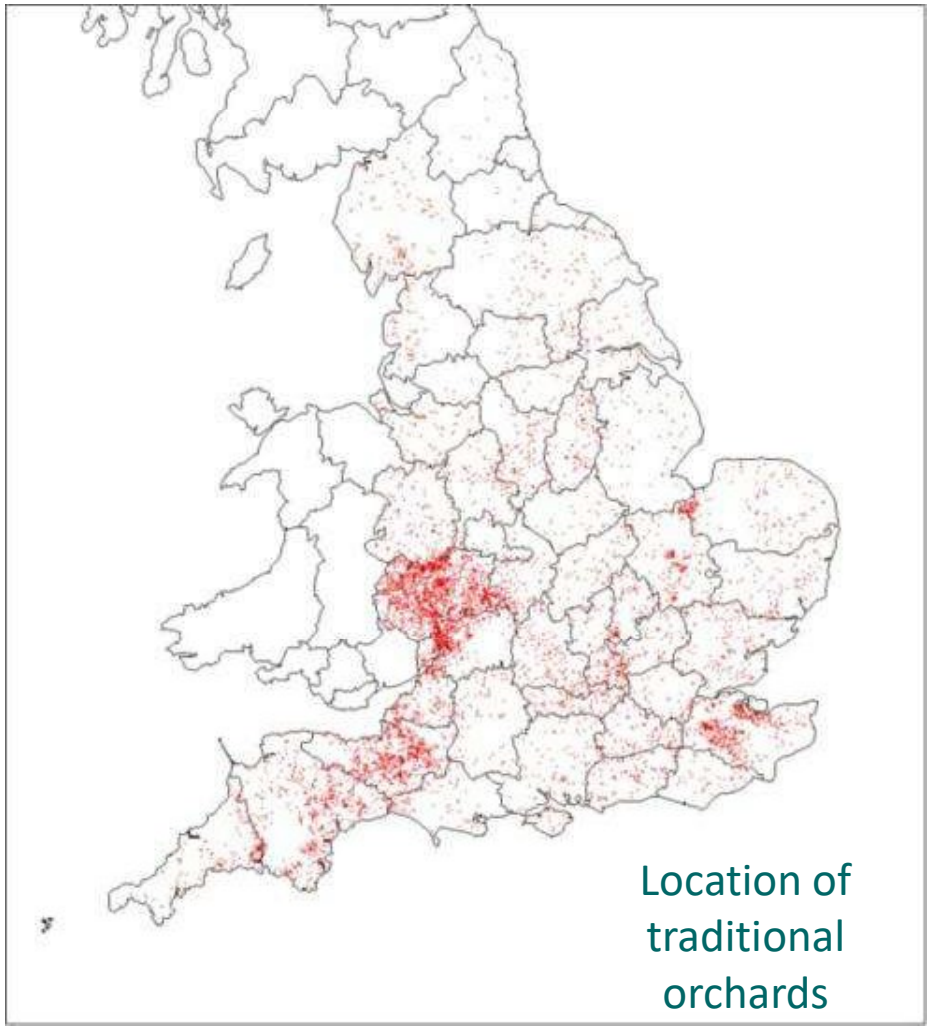
S. dasyclados Loden

(Picture credit: Stig Larsson)

Pollination services

Crops for Energy





Refs: Polce et al 2013. Species Distribution Models for Crop Pollination: A Modelling Framework Applied to Great Britain.
Breeze et al, 2011. Pollination services in the UK: How important are honeybees?
Traditional orchard project in England. May 2011 http://publications.naturalengland.org.uk/publication/47015

Maximising biodiversity benefits

Crops for Energy

- Maximise “edge effect”
- 8 m margins around plantations
- 8 m rides between plantations
- Maximum individual blocks of 3 hectares
- Include lower yielding male varieties e.g. Ulv for pollinators
- 20% open land
- Leave awkward corners unplanted
- Minimal use of herbicide
- No use of insecticide

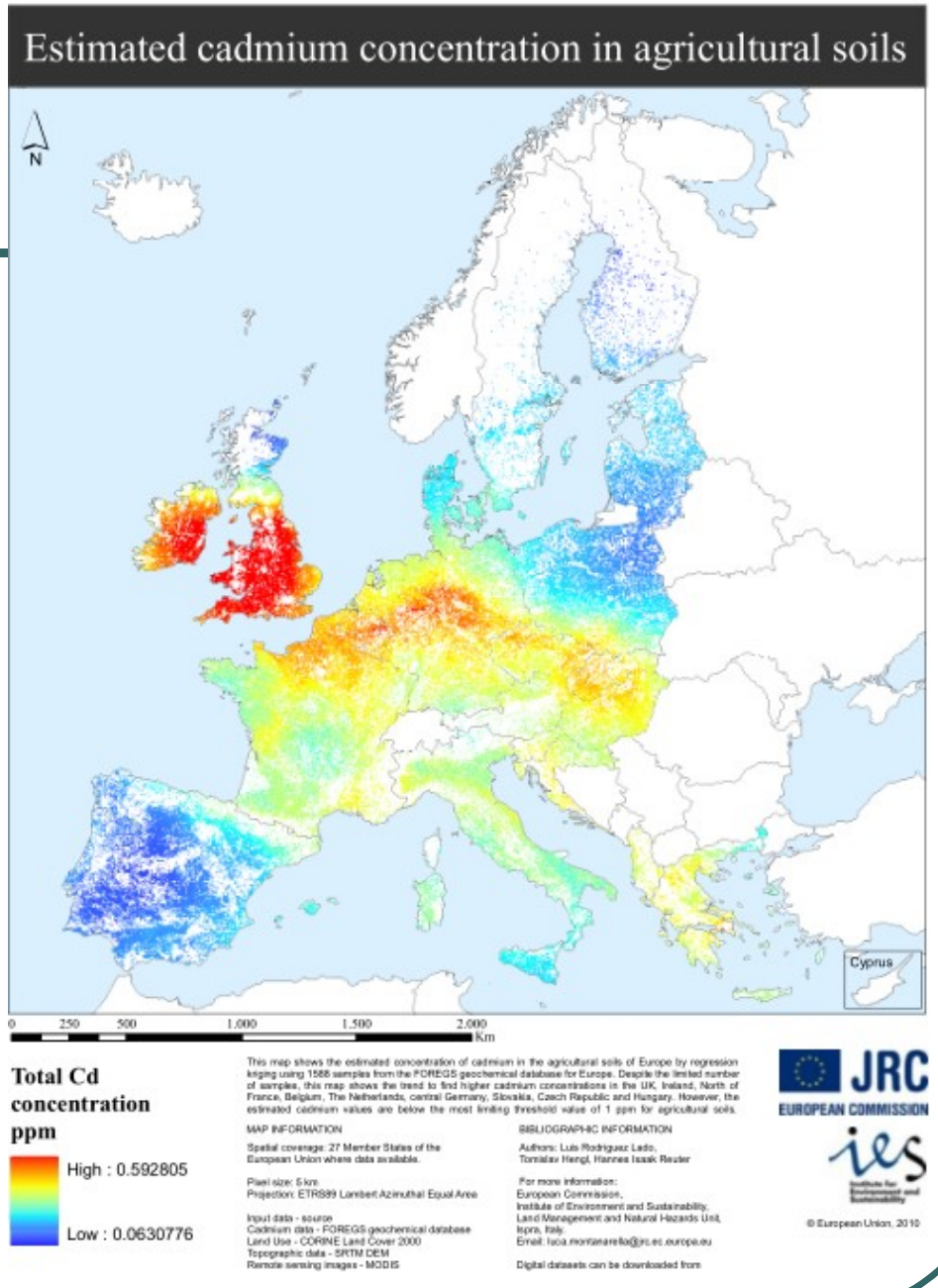
Bioremediation

Crops for Energy

- Greening up vacant and derelict sites e.g.
  - Landfill sites
  - Ex sewage works
  - Former industrial sites
- Removal of heavy metals
  - Cadmium
  - Copper
  - Nickel
  - Zinc

Cadmium

- Heavy metal associated with osteoporosis and increased levels of bone fractures when ingested through food crops
- SRC typical offtake 2 mg/kg of dry matter (but as high as 20 mg/kg)
- SRC 20-50 times more uptake than wheat
- 20 hectare plantation over 22 years could remove 8.4-84 kg Cd



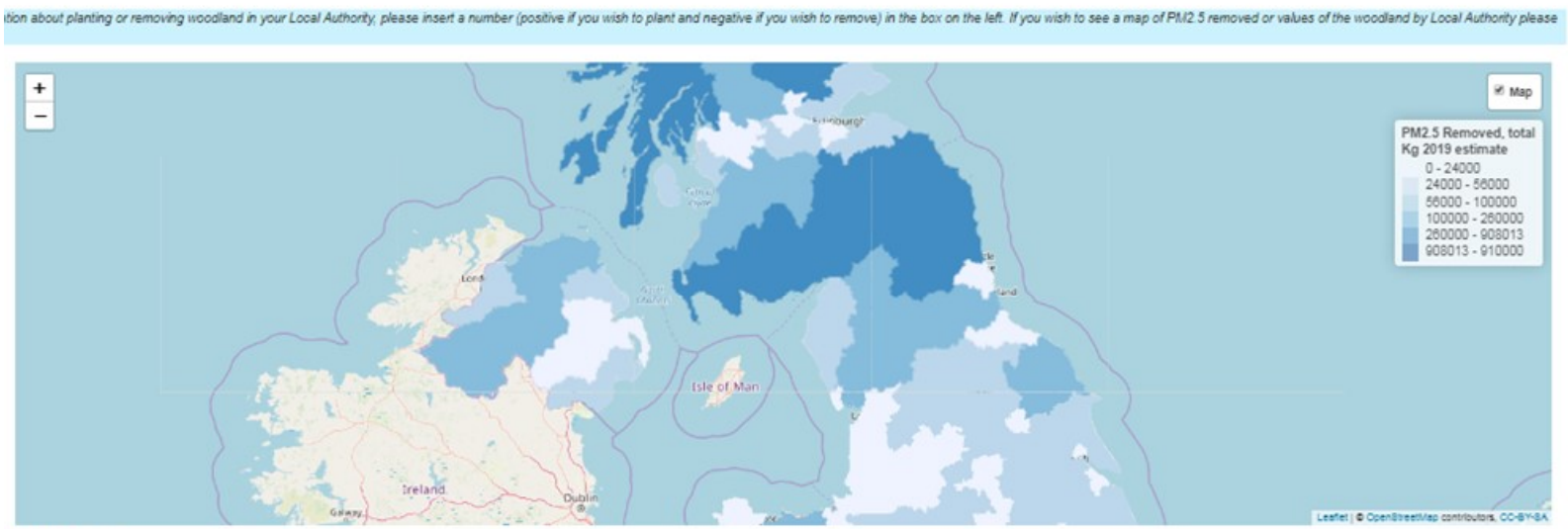
Refs: Solid biofuels — Fuel specifications and classes Part 1: General requirements BS EN 14961-1:2010
Willow as fuel from arable land with high cadmium content – Paulrud et al 2016.
'Sustainable Agriculture and Soil Conservation (SoCo)'. Chap 2: Soil degradation processes across Europe, Pg 29-66.
http://eusoils.jrc.ec.europa.eu/ESDB_Archive/eusoils_docs/other/EUR23767_Final.pdf

Noise reduction

- A 15-30m depth of woodland could reduce noise by 6-15 decibels
- 50% reduction in apparent loudness
- Excellent potential in spring and summer
- More dense varieties with larger leaves e.g. Endurance
- All year round benefit in combination with conifers

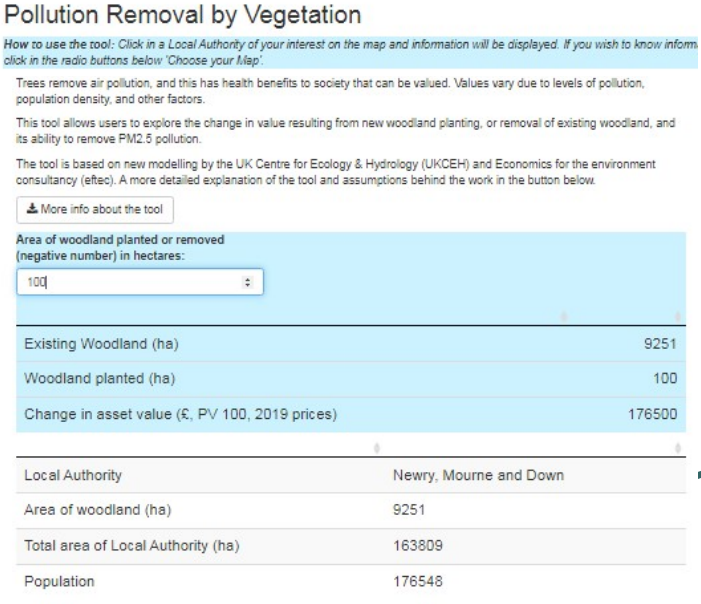
Ref: https://www.greenblue.com/gb/trees-as-sound-barriers/

Air quality improvements



Local Authority	PM2.5 removed by woodland (kg/year)	PM2.5 removal rate per ha woodland (kg/ha year)	Asset value of PM2.5 removal (£ million, 2019 prices)	Asset value of PM2.5 removal per ha (£/ha, 2019 prices)
Newry, Mourne and Down	56920	6.2	25.5	2761

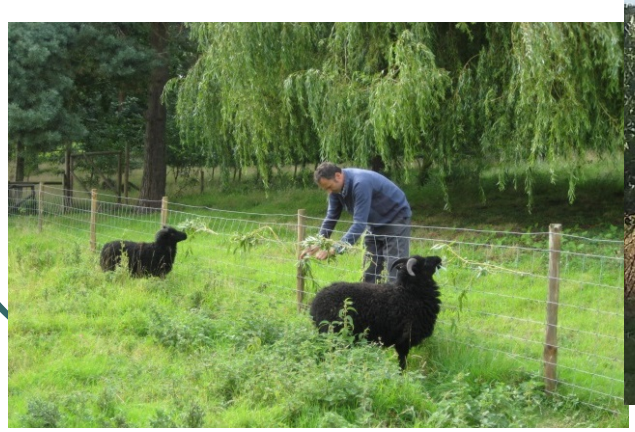
- Trees absorb PM2.5, SO2, NOx & ammoniacal emissions
- Note of caution – willows could potentially worsen air quality in hot weather due to VOCs (e.g. Isoprene) which combine with man made pollutants to form ozone



Ref: https://shiny-apps.ceh.ac.uk/pollutionremoval/
http://www.naturewithin.info/UF/TreeBenefitsUK.pdf

Fodder

- 65–70% dry matter digestibility
- Crude protein ~ 15%
- Valuable compounds - condensed tannins and phenolic glycosides (like aspirin)
- Anthelmintic properties – less need for insecticides
- Beneficial to digestion – better health
- High levels of cobalt and zinc – benefit growth rate of ewes / less need for mineral supplements



Ref: https://www.farminguk.com/news/new-study-shows-willow-trees-could-optimise-lamb-production_54716.html

SRC and livestock

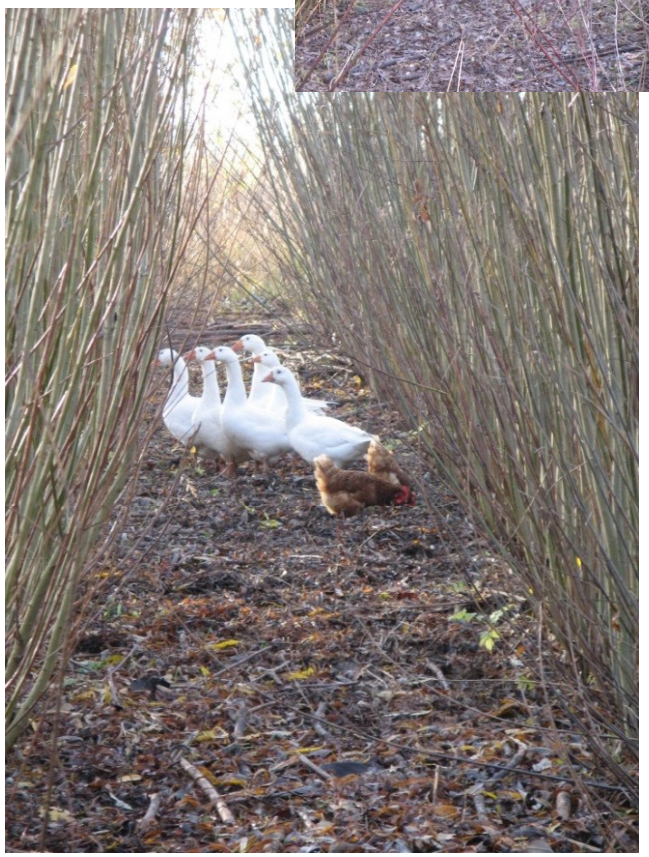
Crops for Energy

- Browse blocks
  - Browsing allowed in autumn or spring (4-5 times per year)
  - 1.6 hectare can sustain 100 ewes for 11 days across 5 breaks (55 days in total)
  - No need for mechanical harvesting
- Coppice blocks (cut and carry)
  - Harvest in late summer and move to where required
- Pollards (cut and drop)
  - Cut every 5 years
  - 30% material edible
  - Mature tree with 5 years growth can feed 30 cows for a day
  - Need to remove stripped branches and use for woodfuel

Refs: http://www.poplarandwillow.org.nz/documents/fact-sheet-3-setting-up-a-willow-coppice-block-for-fodder.pdf
http://www.poplarandwillow.org.nz/documents/fact-sheet-2-poplars-and-willows-as-fodder.pdf

Agroforestry – food and fuel!

- Chicken welfare
  - Shelter and safety
  - More likely to roam = lower stress levels
  - Less likely to injure themselves by feather pecking
  - Lower levels of premature hen mortality
- Tree growth
  - Foraging keeps weed levels down
  - Faeces is high in N - provides nutrition & improves yields
- For the egg producer
  - Increased shell quality & less chance of eggs breaking during collection and transit
  - Estimated that proportion of Grade A eggs is increased by 2%
  - Trees intercept ammonia emissions less chance of complaints from neighbours



Ref: The Agroforestry Handbook - https://www.soilassociation.org/our-campaigns/agroforestry/what-is-agroforestry/

Organic farming - Ramial woodchip

Crops for Energy

- Willow chip mulching in orchards
- Biological control of apple scab
- Induced resistance as a result of Salicylic acid
- Reduce reliance on sprays
- Use willow sticks <7cm diameter

Ref: Using willow woodchip mulch to manage apple scab – Percival et al
https://www.innovativefarmers.org/news/2019/march/06/innovative-new-willow-woodchip-trial-to-tackle-apple-scab-in-orchards-launched/

Contacts

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