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Environmental Role of Poplar and Willow

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Environmental roles include

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- Buffer zones
- Riparian zone protection
- Slope stabilisation
- Flooding reduction
- Carbon sequestration
- Phytoremediation

Definition of environmental role

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- The use or application of poplar and willow for environmental protection, repair or benefit during crop growth, rather than once the crop is harvested. Planting may be established solely for an environmental purpose without the specific aim of producing a harvestable crop for an income.

Definitions of phytoremediation

- Use of plants to remove from, or reduce the impact of a contaminant on the environment
- To rehabilitate land such that the range of its potential uses are increased
- To prevent environmental degradation thorough the use of plants

Types of remediation

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- Rhizofiltration
  - removal of contamination from soil solution or groundwater via adsorption or precipitation onto roots.
- Phyto-restoration
  - reinstatement or generation of soil physical conditions: water & nutrient holding capacity, etc.
- Phyto-volatilisation
  - take up and transpiration of contaminant with its subsequent release to the atmosphere

Types of remediation

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- Phyto - extraction
  - contaminants are removed from soil and either metabolised within the plant or exported in harvested plant matter (<20 years)
- Phyto - stabilisation
  - Contaminants immobilised on site, but risk to the wider environment is reduced, on-site risk may also be reduced (>20 years)
- Phyto – degradation (transformation)
  - Presence of plants induces or enhances degradation of contaminants to harmless state (<20 years)

Buffer zones

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Planting located between a source of nuisance and an area or object to be protected.

- Prevention of chemical or soil entry to water course from agricultural or industrial land by planting in close proximity to water course.
- Reduction in noise and dust impact from industrial operations or roads on neighbouring residential or recreational land.

Riparian zone protection

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- Bank-side planting of trees to increase stability or reduce livestock access to water course.
- Construction of living engineered barriers from poplar and willow to provide protection of watercourse bank from damage associated with flood events.

Other roles

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- Flood protection:
  - Aid retention of water in managed flood plains to reduce flood height further down catchment – protection of high value land (typically urban)
- Slope stabilisation:
  - in natural or engineered environment such as road cutting reinforcement

Carbon balances

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- Mitigation - biofuel substitution for fossil fuel
- Soil organic matter
- Sequestration

Carbon sequestration & soil OM

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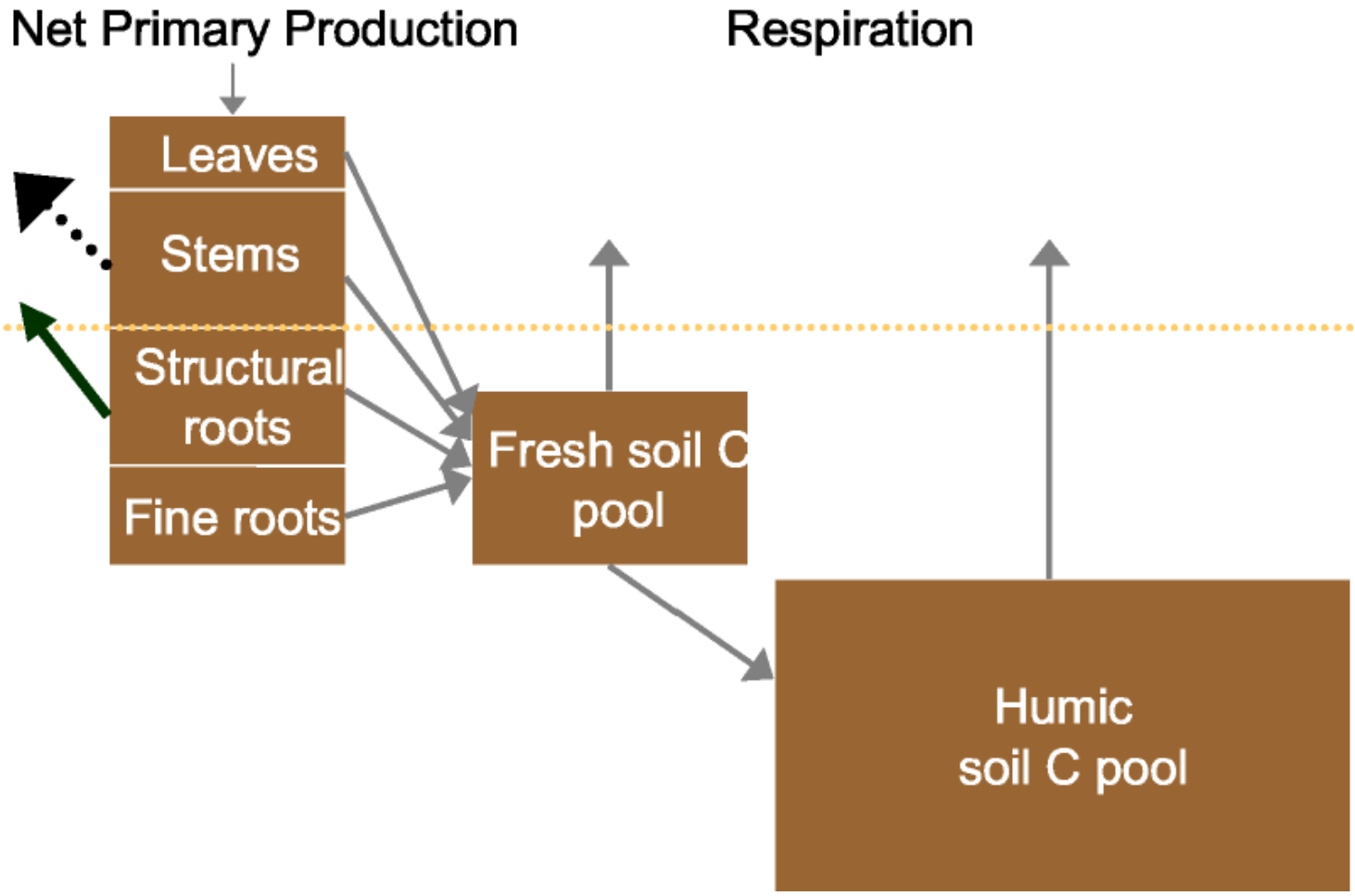

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Site History	Years since establishment	Soil sample depth (cm)	Average rate of soil organic carbon increase (kg C ha^{-1} yr^{-1})	Ref
Agriculture to SRC poplar (USA)	12-18	100	1630	Hansen 1993
Agriculture to SRC poplar (USA)	6-15	0-25 0-100	No change No change	Grigal & Berguson 1998
Grass/shrub to SRC willow (USA)	4	0-60	No change	Ulzen-Appiah, Briggs *et al*
Agric to SRC poplar & willow (Germany)	7-9	0-10 10-30	100-555 gain 0-555 loss	Jug, Makeschin *et al* 1999

Carbon sequestration

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- Reduce carbon losses – similar to no till
- Add organic matter to soil in form of leaves, roots etc
- Net addition to carbon pool in soil of about 0.5 t C ha^{-1} yr^{-1} under SRC

Phytoremediation

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- soil chemistry – metals, hydrocarbons, organics.
- soil physics – structural integrity and organic matter content.
- water - wastewater, landfill leachate, sewage effluent.

Poplars managing farm dirty water

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Landfill leachate management

System efficacy

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	Leachate	Porewater in leachate treated plots	Drainwater from drain 2 draining leachate	Ditchwater at outlet
NH_4-N	85.7	0.62	0.05	0.05
NO_3-N	0.56	11.8	4.2	3.3
Cl	889.1	178.6	194.5	62.1
Na	548.8	202.3	49.2	20.5

Applying phytoremediation

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- Industrially degraded land of little development potential due to site physical & chemical condition and location
  - Large sites of low value due to lack of development potential
  - Brings land back into economic use
  - Reduces the pollutant risk
  - Improve the aesthetic quality and conservation value of a site

Applying phytoremediation

- Agricultural land to which heavy metals have been added in management amendments eg phosphate fertilisers
  - Cd levels limits wheat production
  - integrity of soil unaffected
  - soil cleaning may be achieved in under 10 years while maintaining farm income

Applying phytoremediation

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- Agricultural land which has been contaminated by industrial inputs:
  - ➢ aerial deposition close to point sources
  - ➢ application of waste materials eg river dredgings
  - – soil conditions conducive to plant growth
  - – land use limited by presence of contaminants

Industrial site after initial cultivation

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Willow one year after planting

Willow established on heavy metal contaminated land

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Conclusions of EU funded study on metal uptake

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- Metal uptake is variety specific and hence can be bred for in willow
- Time of harvest for influences metal off take
- Willow are tolerant of high concentrations of heavy metals in their growing media and tissues
- The bioavailable pool of metals in the soil is decreased where willow is grown compared to uncultivated areas reducing environmental risk

Heavy metal removal from agricultural land

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UK example

- Annual Cd inputs range - 1.4 to 6.2 g ha^{-1}
- Typical Cd concentration in willow 2.5mg kg^{-1} dm
- 25 g ha^{-1} Cd annual removal if yield of 10 odt ha^{-1}
- Net annual export of Cd from agricultural 18.8 to 23.6 g ha^{-1}

Regulated environment

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- Discharge consents for wastewater treatment
- Remediation licenses, specified clean-up targets and timescales for contaminated land
- Potential liabilities associated with failure

Competing with engineered alternatives

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- Clear design specification
- Quantified performance from system components
- Performance/reliability guarantees
- Track record

Benefits of one rotation of willow grown as a biofuel (30 years)

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- Carbon offset for fossil fuel (0.6 t C odt^{-1})
- Improved soil physical characteristics and OM content
- Carbon sequestration (0.5t ha^{-1} yr^{-1})
- Removal of accumulated metals eg 750 g ha^{-1} of Cd
- Habitat enhancement

Benefits of one rotation of poplar for timber (30 years)

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- Carbon sequestration (long term storage)
- Improved soil physical condition
- Improved organic matter content

Research institutions

- **Sweden -** Swedish University of Agricultural Sciences, Kalmar University, University of Stockholm
- **USA** - University of Kansas, Iowa, Florida
- **UK** - Cranfield University, Liverpool John Moore University, WRc, ADAS
- **Belgium** – University of Ghent, Institute for Forestry and Game Management, University of Antwerp
- **New Zealand** – HortResearch, FRI, AgResearch
- Australia – CSIRO Forestry

Environmental uses to which poplar & willow are being put

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- Polishing of treated sewage effluent
- Volume reduction of milk processing effluent
- Treatment of landfill leachate
- Land application of sewage biosolids
- Rehabilitation of colliery spoil heaps
- Remediation of industrially contaminated land
- Riparian buffer zones and river engineering

Future

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- Good foundation of research
- Can adopt environmental roles with current level of knowledge
- Need additional work to better quantify benefits & outcomes in a range of situations
- Need to communicate existing data to practitioners in a fashion that can be readily applied