Cadmium Phytoextraction by Woody Plants

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- Clean-up using trees: does it work?

Phytoremediation

phytoextraction

phytostabilization

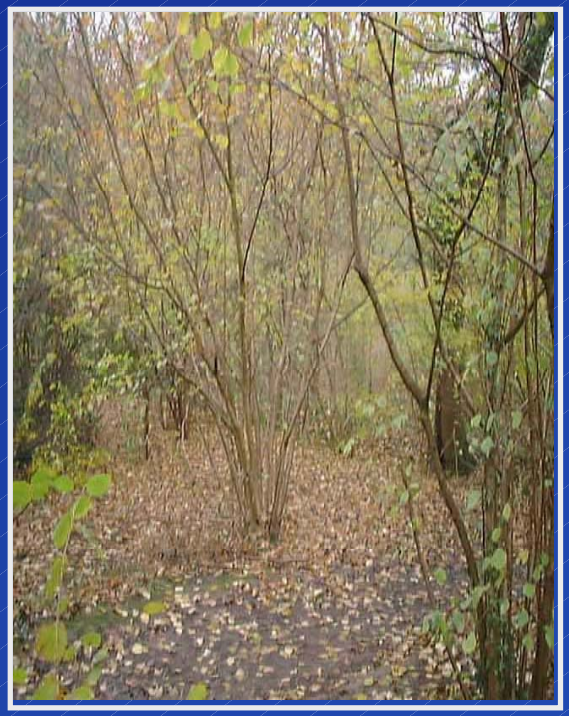
Cadmium in soil

Cadmium

- One of the heavy metals of most concern due to:
  - high solubility – high mobility – high toxicity
  - ubiquitous in urban environments
  - Soluble low-molecular weight chelates formed in soil solution
  - Absorbed and translocated freely. Accumulates in plants with little discernible effect

Woody plants

- May be a useful application for phytotechnology
  - few hyperaccumulator options
  - may be suitable in urban situations



Salix (willows and osiers)

- High potential for phytoremediation
  - *S. viminalis* and other biomass clones
  - *S. caprea* / *S. cineria* naturally colonise contaminated soils
  - Many hybrids exist naturally
  - Agronomy and harvesting are well established

Short-Rotation Coppice

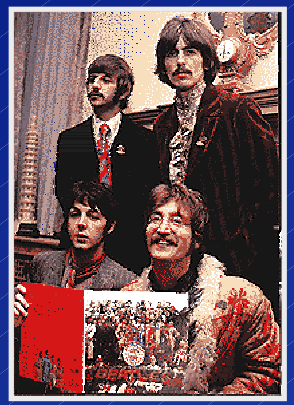
Propagation

Year 1

Short-Rotation Coppice

Short-Rotation Coppice

Merseyside

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y-Coed
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0
30km

North-West England

"… arguably the first region to pollute the environment on a structured, grand, even imperial scale in the desire for economic growth and development"

Lord Thomas of Macclesfield

Brownfield Land

- 1.4 M sites in W. Europe
- 300,000 sites in UK

60% of UK's brownfield sites are in N.W. England

Urban Renaissance

Former landfill and industrial waste site

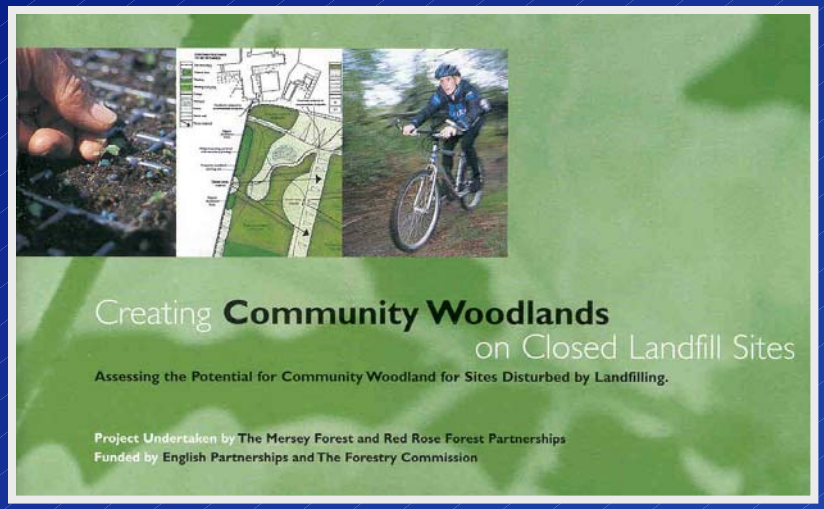
Cromdale Grove, St. Helens, Merseyside

Community Forestry

Environmentally- friendly

Ecologically-sound

Low- cost



- Clean-up using trees: does it work?

Hydroponics screening

Salix

Tolerance Indices

Salix	Cd (1.0 mg l^{-1})
caprea	**265**
x *calodendron*	**140**
fragilis	**128**
pentandra	**212**
nigricans	**137**
phylicifolia	**401**
triandra	**102**
viminalis	**66**
purpurea	**62**
caprea	**61**

Cd uptake

Hydroponics

- Uptake may vary by a factor of 80 after 20 days (in different *Salix* clones)
- Stem concentrations up to 100 μg g^{-1} from 1μM solution

Pot experiments

- Stem concentrations of 76 μg g^{-1}
- 30% of bioavailable Cd removed in 90 days

(Sweden, UK, Switzerland)

Extrapolation to field

Theoretically…

- 15 t ha^{-1} yield
- Tissue concentration of 100 mg Cd kg^{-1}

- Would reduce soil concentration (0-10 cm) from 12 to 3 mg Cd kg^{-1} in about 24 years

Field evidence

- Hydroponics and field data are not correlated for Cd

(Pulford, UK)

- 4 x higher uptake in *Salix* that *Alnus*, *Fraxinus*, *Sorbus*
- Bioconcentration of 1.42 (foliage) and 1.12 (stems) of total soil Cd

(Keller, Switzerland)

Field evidence

In relation to EDTA-extractable Cd:

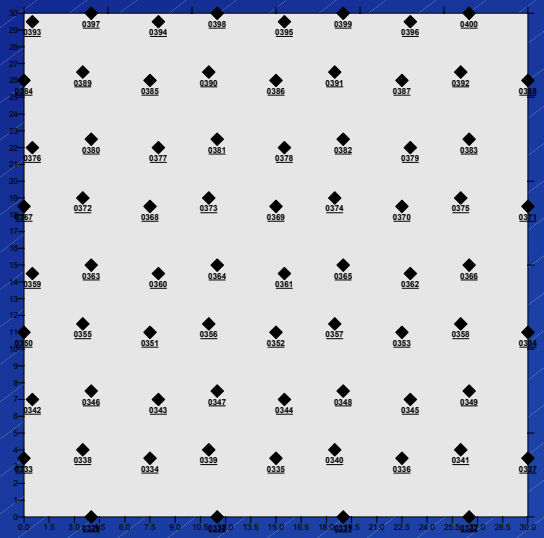
- Stem bioconcentration up to **x** 8 in *S.* x *calodendron*
- Foliar bioconcentration = **x** 20
- Stem yields 8 – 12 t ha^{-1}.

- <u>But</u> tissue concentrations generally < 15 µg g^{-1}

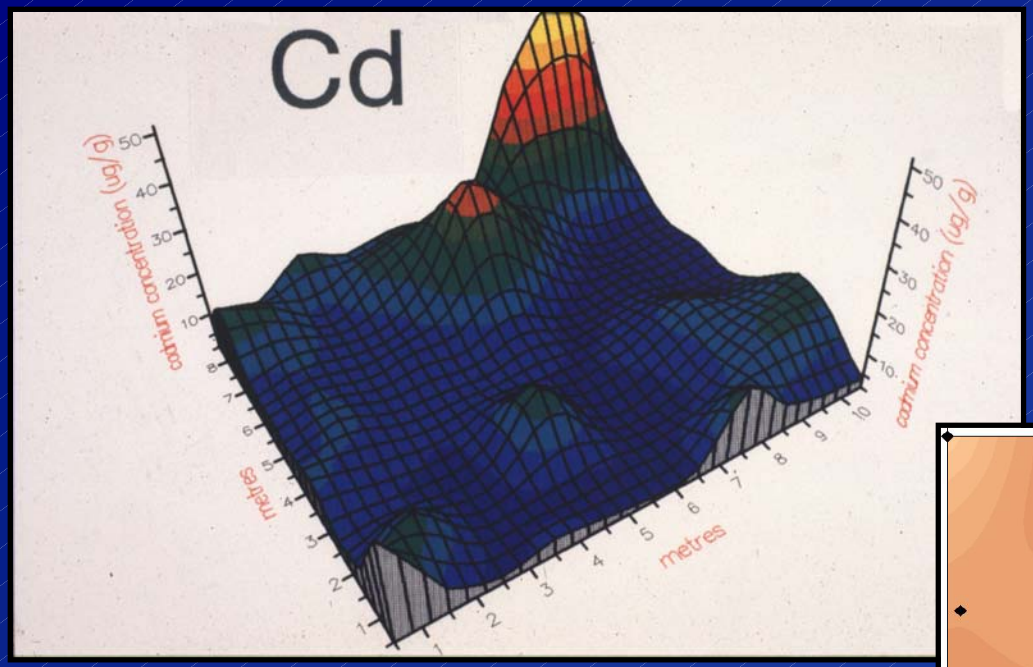
(Liverpool)

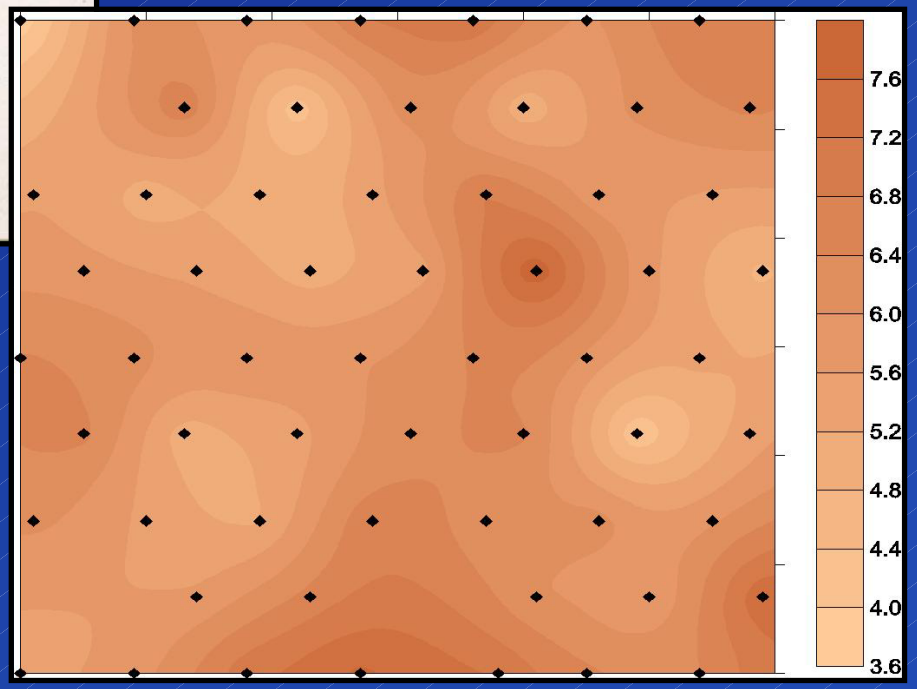
Field Trials

- Tree plots established 1997 and 1999
- Variable sources and ranges of contamination (e.g. landfill, industrial waste, sewage sludge)
- Cd and other contaminants mapped

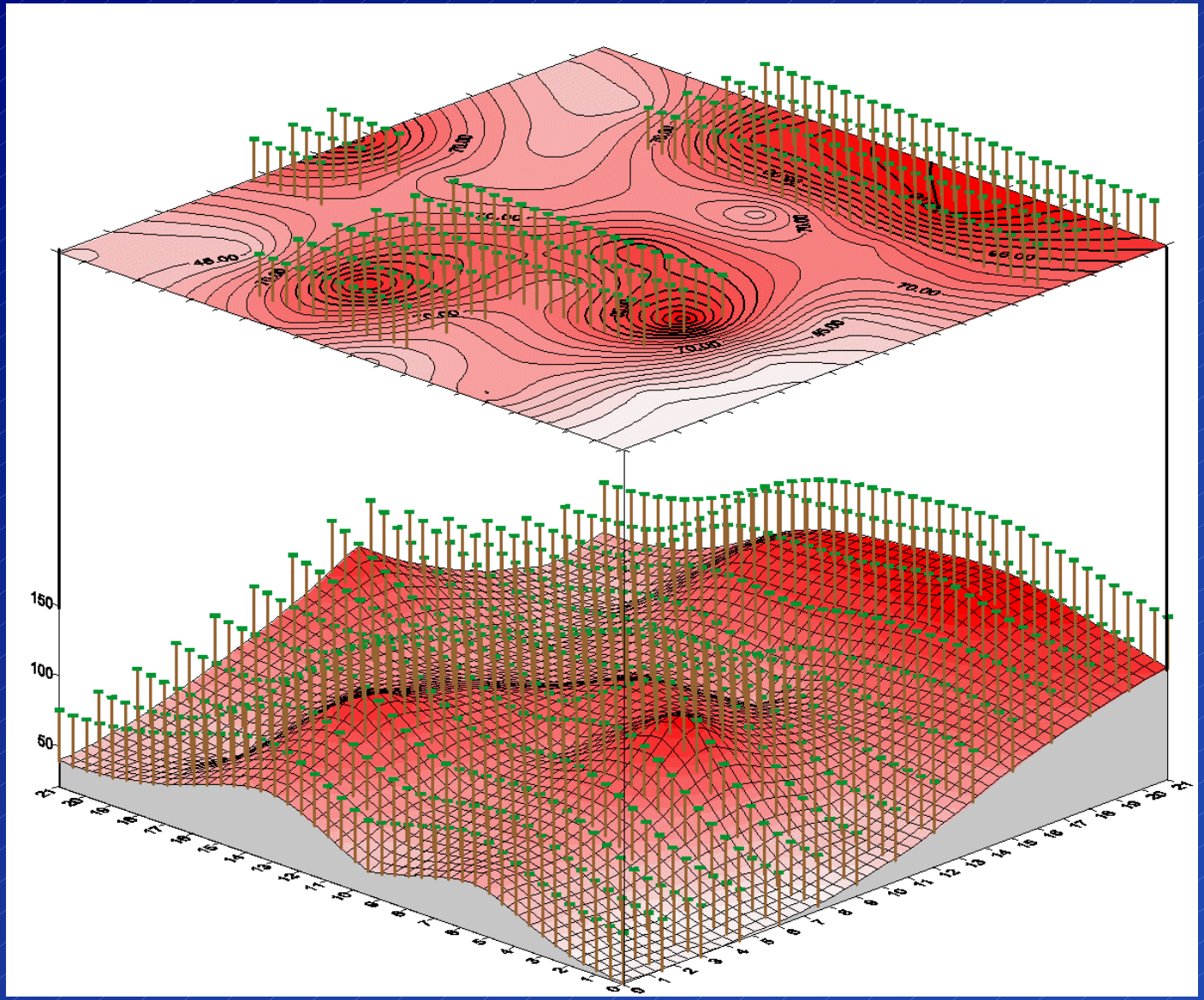


Hotspots


Cd
cadmium concentration (ug/g)
50
40
30
20
10
8
7
6
5
4
3
2
1
metres
1
2
3
4
5
6
7
8
9
10
cadmium concentration (ug/g)
50
40
30
20
10


7.6
7.2
6.8
6.4
6.0
5.6
5.2
4.8
4.4
4.0
3.6

Hotspots



Problem 1

- Spatial dispersion of metal is seldom well defined at brownfield sites.
- Need for better targeting of hotspots.

Problem 2

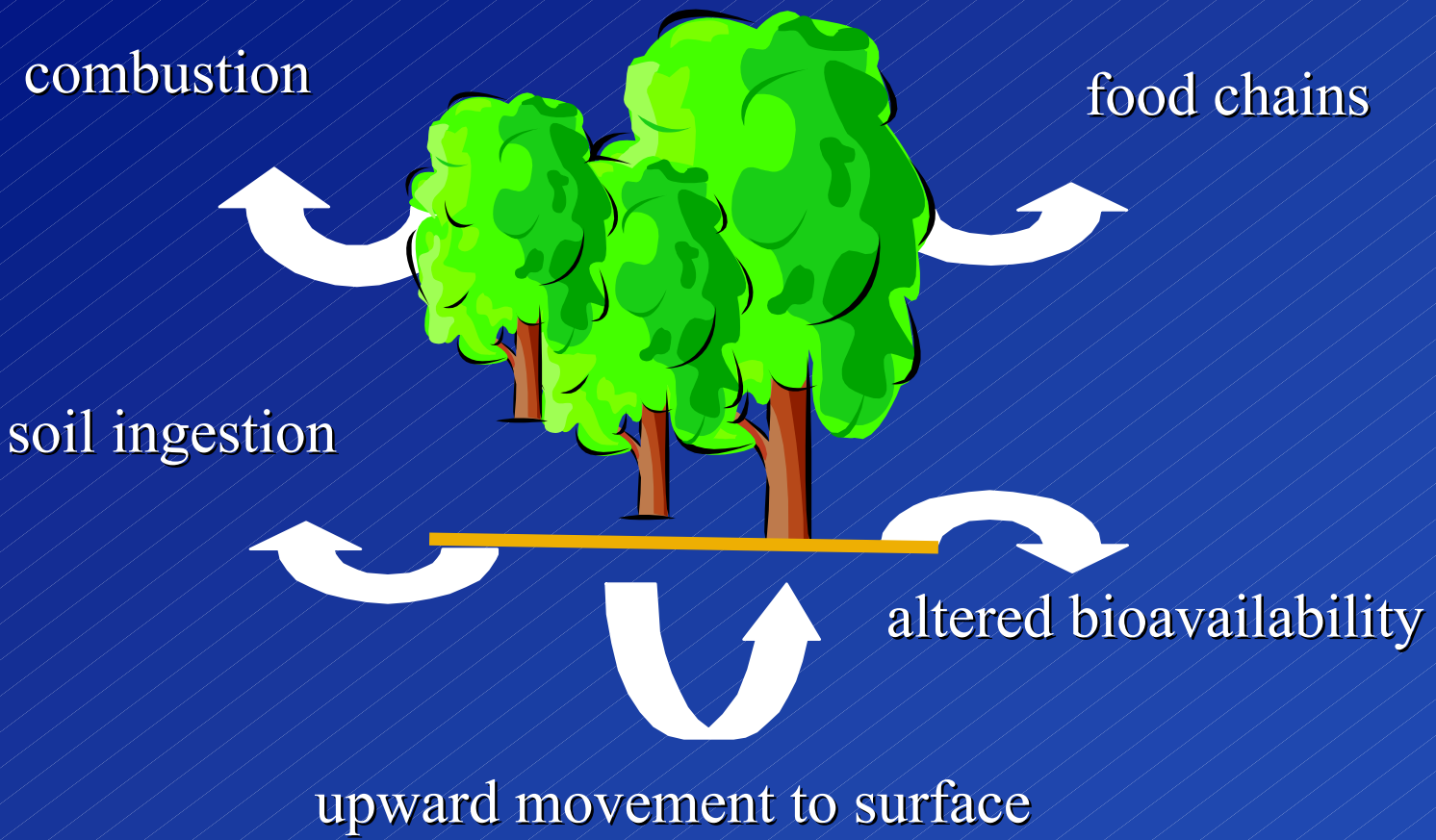
- Identification of stable genetic traits is still at early stage

Problem 3

- Cd availability in soil depends on chemical equilibrium that is affected by:
  - Soils adsorption
  - Root exudates – chelation, reduction
  - Mycorrhizae / earthworms

Problem 4

- Temporal changes are poorly defined



Conclusions

- Clean-up using trees: does it work?

Conclusions

Woody plants may help to clean-up industrially-contaminated sites, but

- this is not yet a proven technology
- field demonstration is required

Acknowledgements

http://www.livjm.ac.uk/brownfield

FORESTS FOR THE COMMUNITY
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