Phytoremediation of metal-contaminated soils with willows

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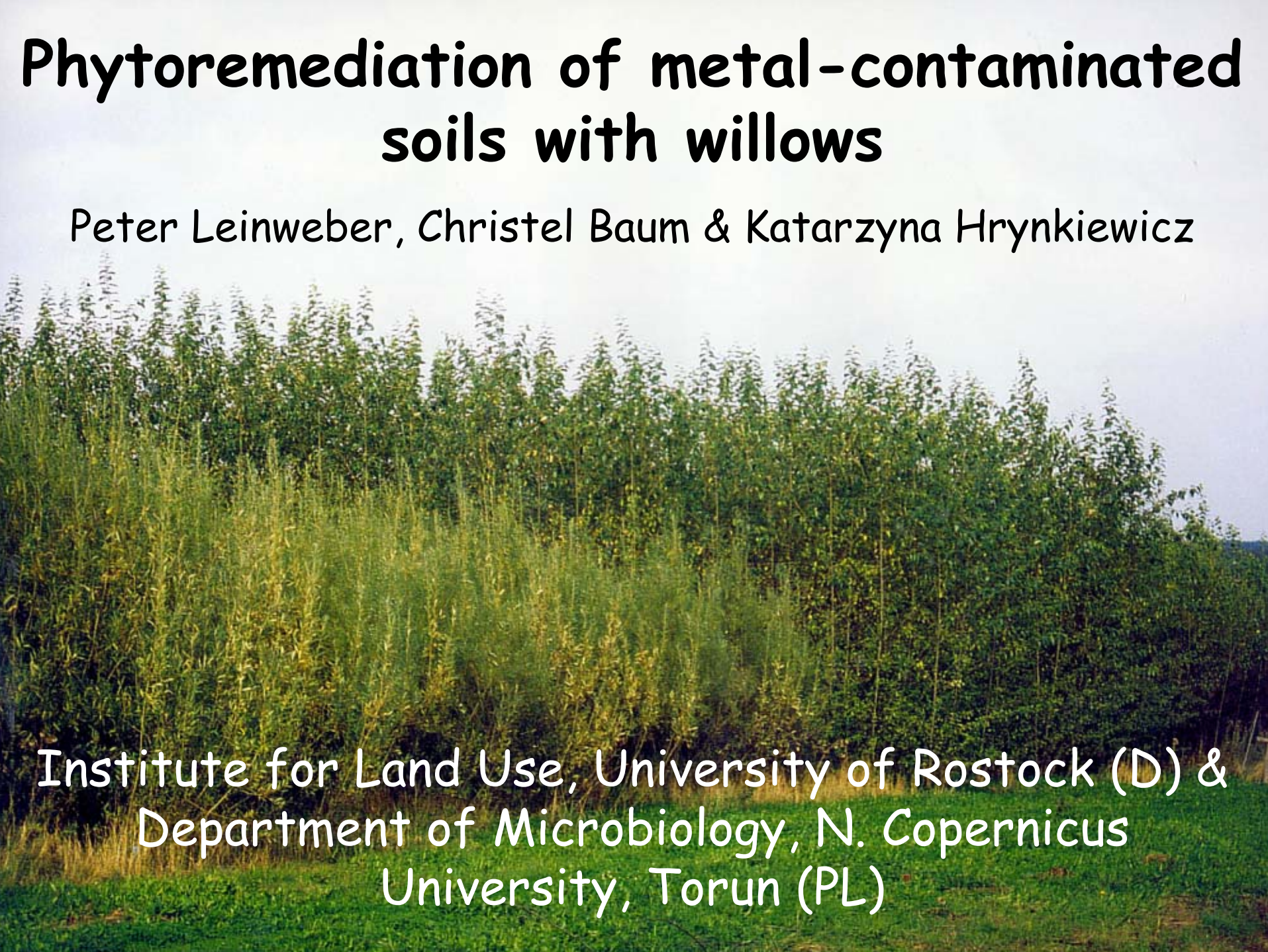

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Rationale for the research

- In Germany, about 10^5 sites in rural and urban areas are contaminated with inorganic and organic pollutants (Thoenes, 2001)
- Traditional chemical and physical remediation techniques such as soil excavation, washing ... are to much expensive, and therefore will not be applied on the large scale
- Phytoremediation ... as well currently not applied on large scale as the success hardly can be fore-casted; efficiency is insecure (amount of metals removed, time required for clean-up, cost / benefit ratio) ⌫ <u>research</u> required to improve technique

Our general approach

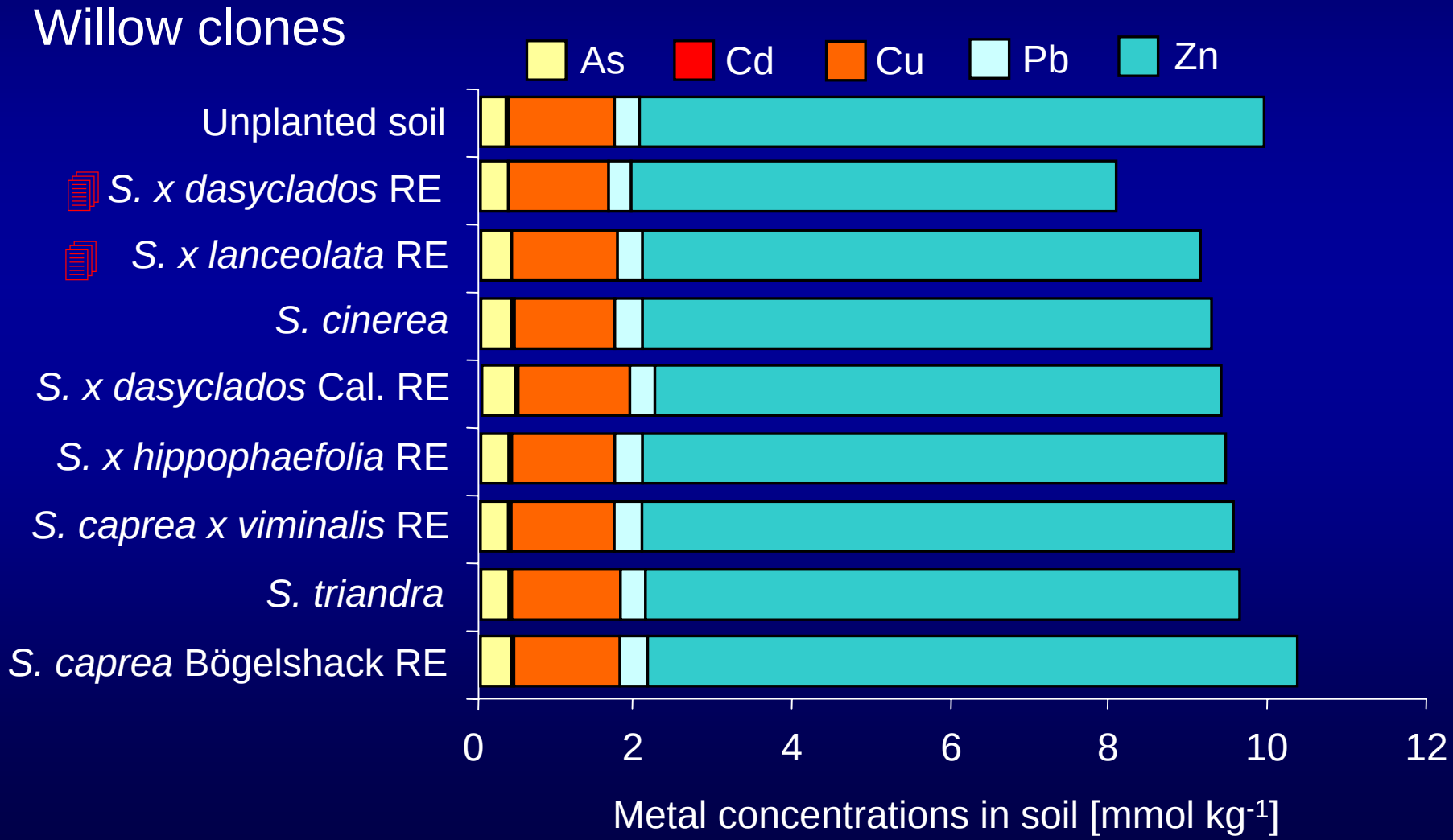
Pot experiments to

(1) test willow clones for changes in metal contents and binding forms in soil and for metal distribution in plants

(2) test effects of inoculation of willows with ectomycorrhizal fungi on metal mobilization, removal from soil and distribution in plants

1. Effects of willow clones (*Salix* spp.) on metal contents and binding forms in soil

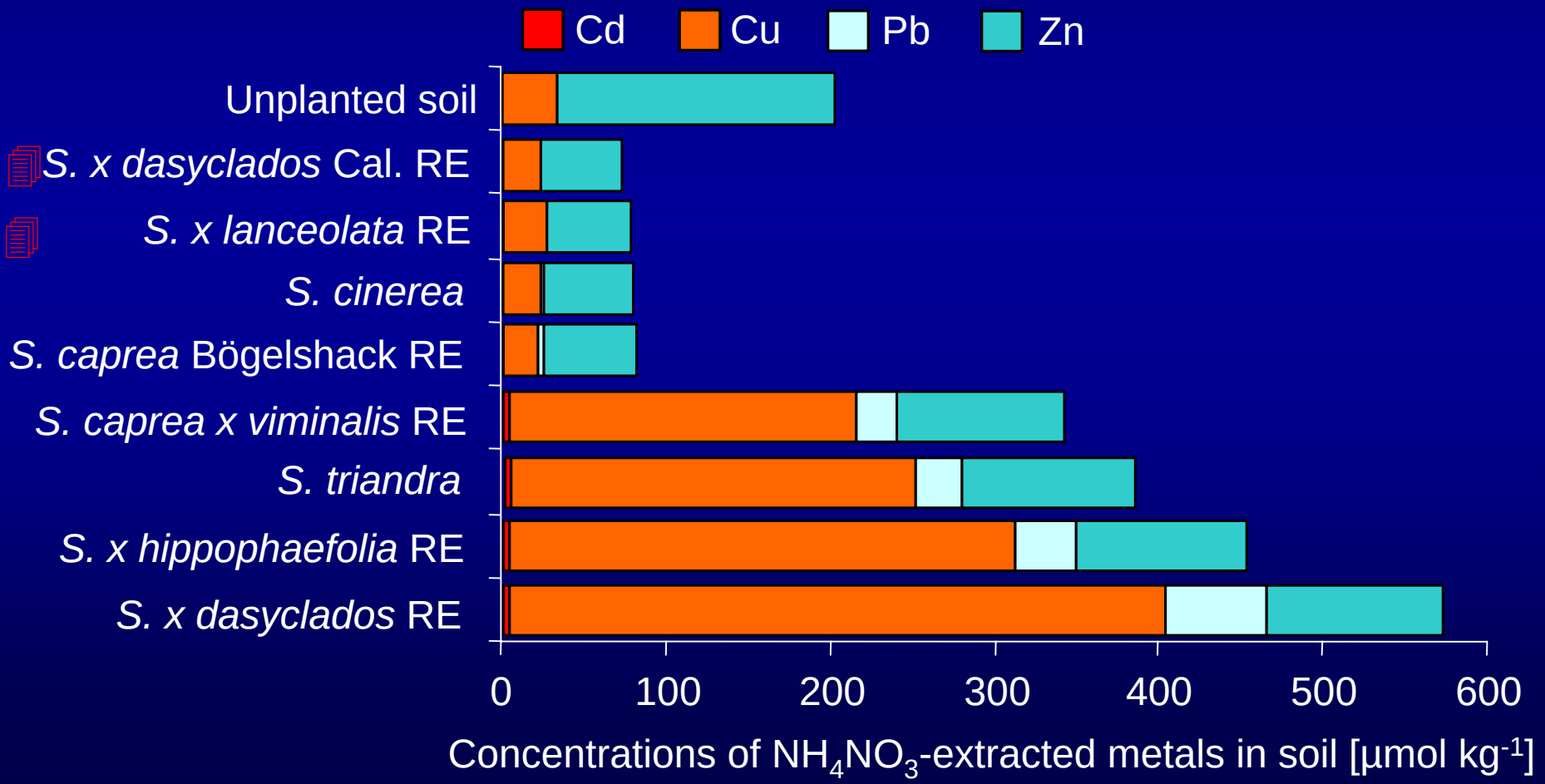
Total concentrations remaining in soil after 3 yrs



1. Effects of willow clones (Salix spp.) on metal contents and binding forms in soil

Mobile fraction remaining in soil after 3 yrs

Willow clones



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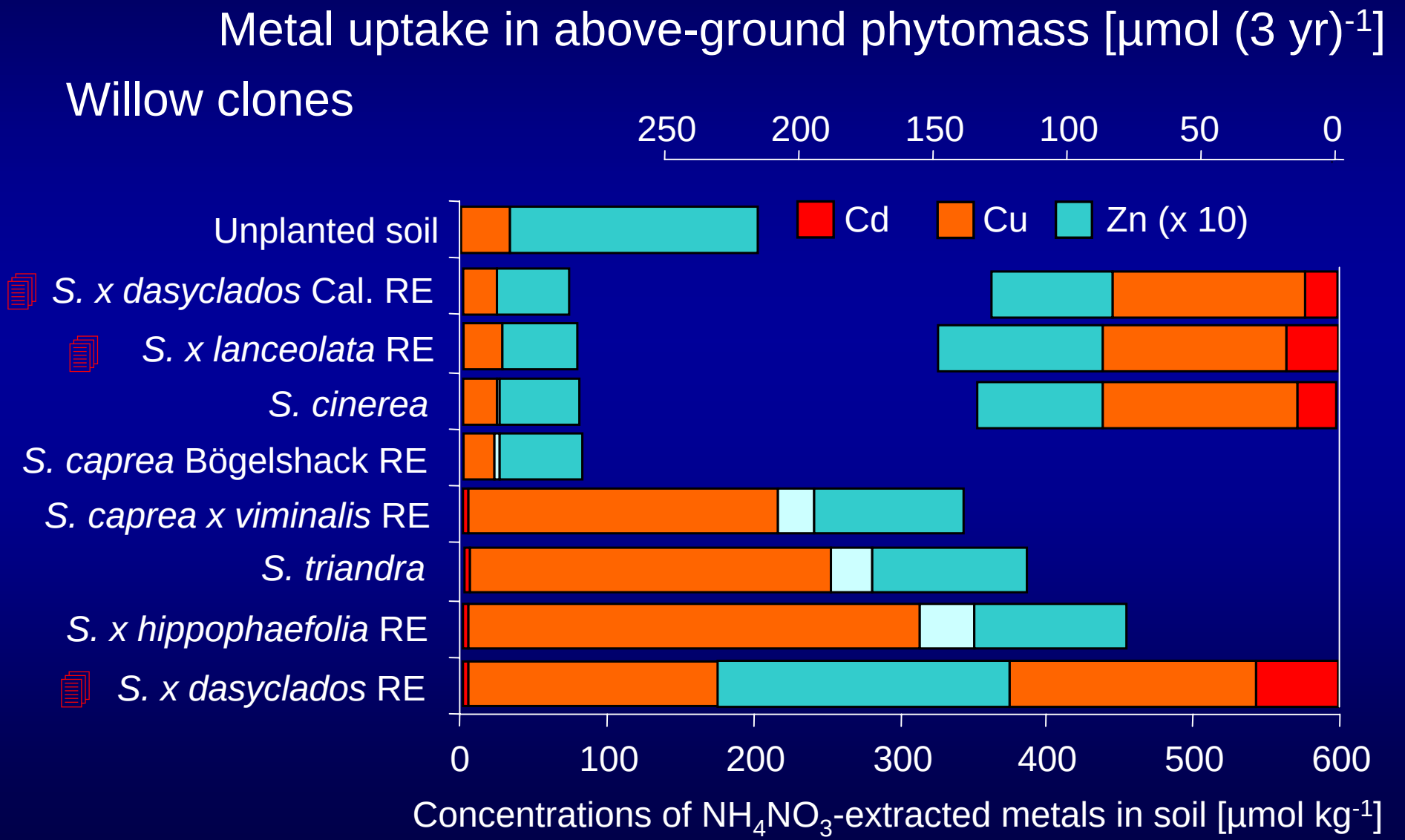

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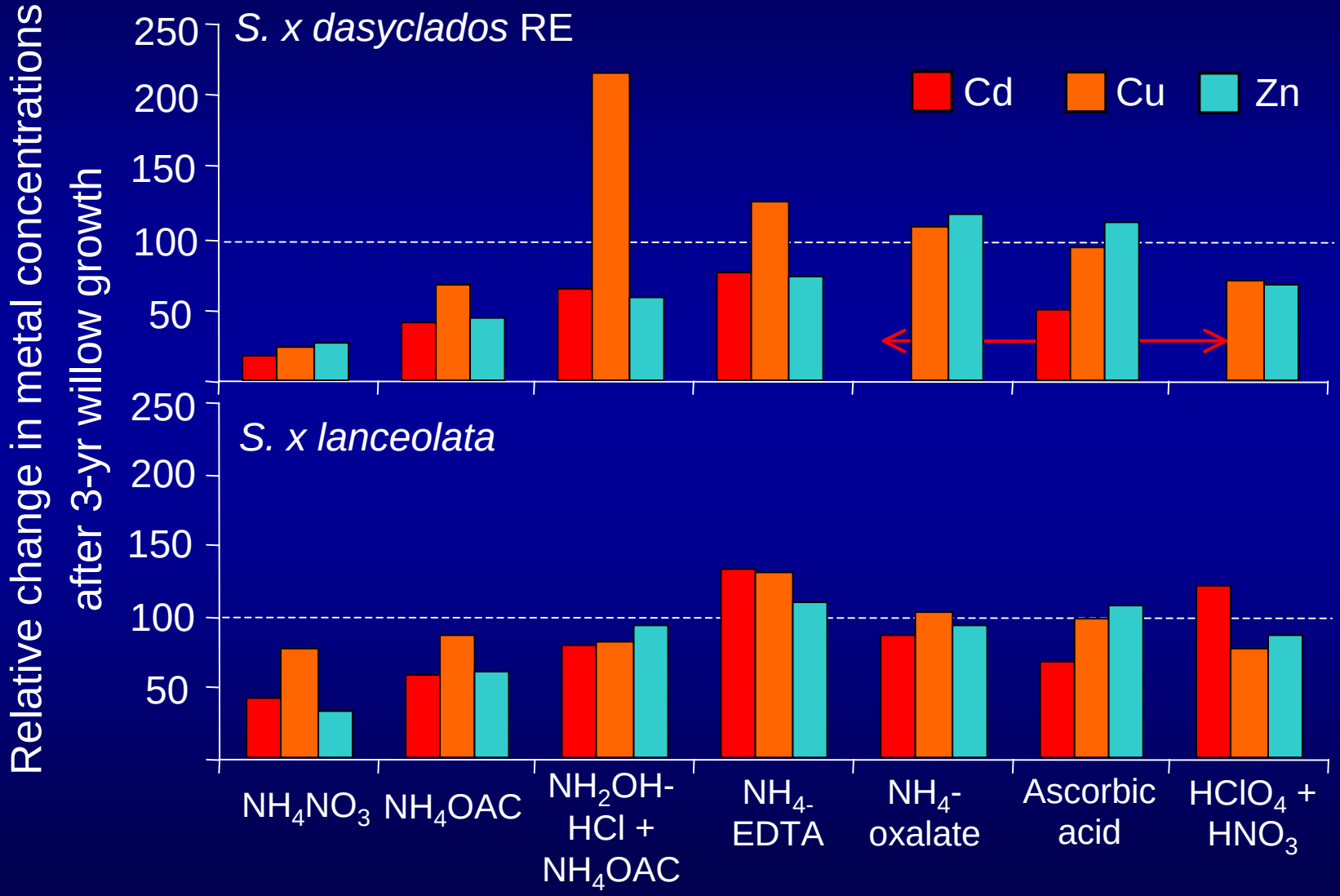
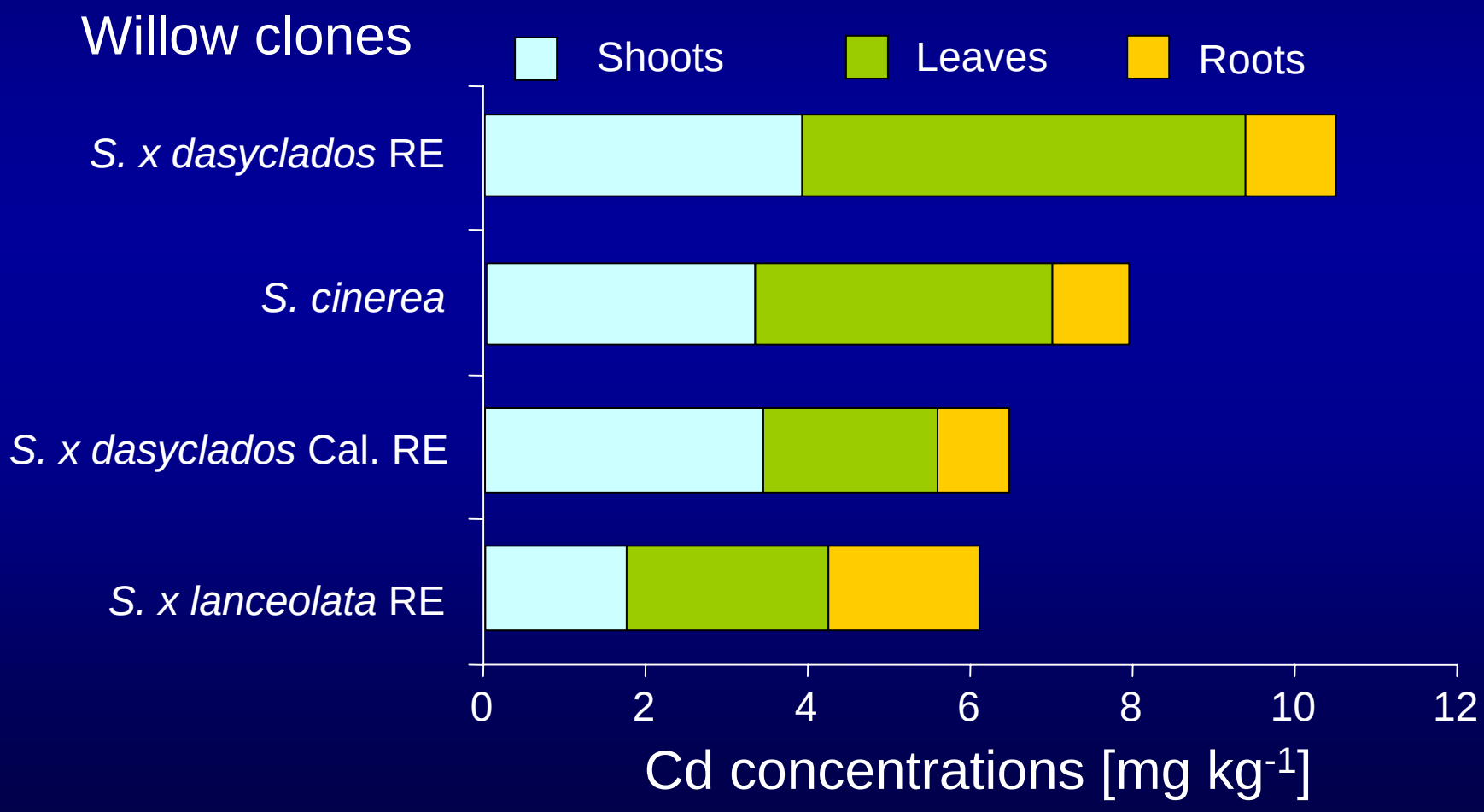


1. Metal distribution in plants

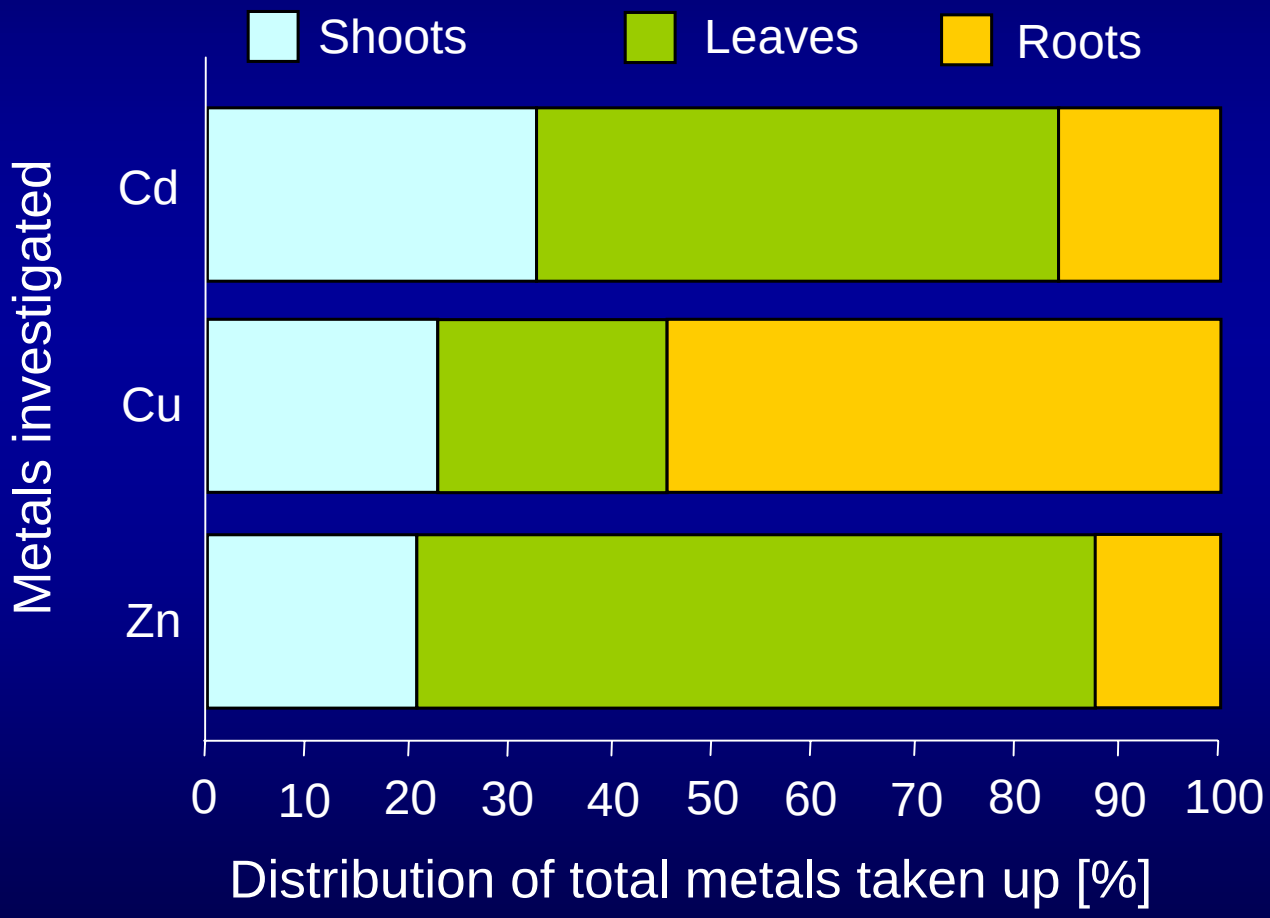
Concentrations of Cd in above-ground and below-ground parts of various willow clones (means of 3 yrs, 3rd yr for roots)



1. Metal distribution in plants

Distribution of metals in the biomass of *S. dasyclados*

(1-year-experiments, means of 2 clones x 2 substrates x 4 replicates



1. Summary: effects of willow clones on metal uptake, distribution and on metals remaining in soils

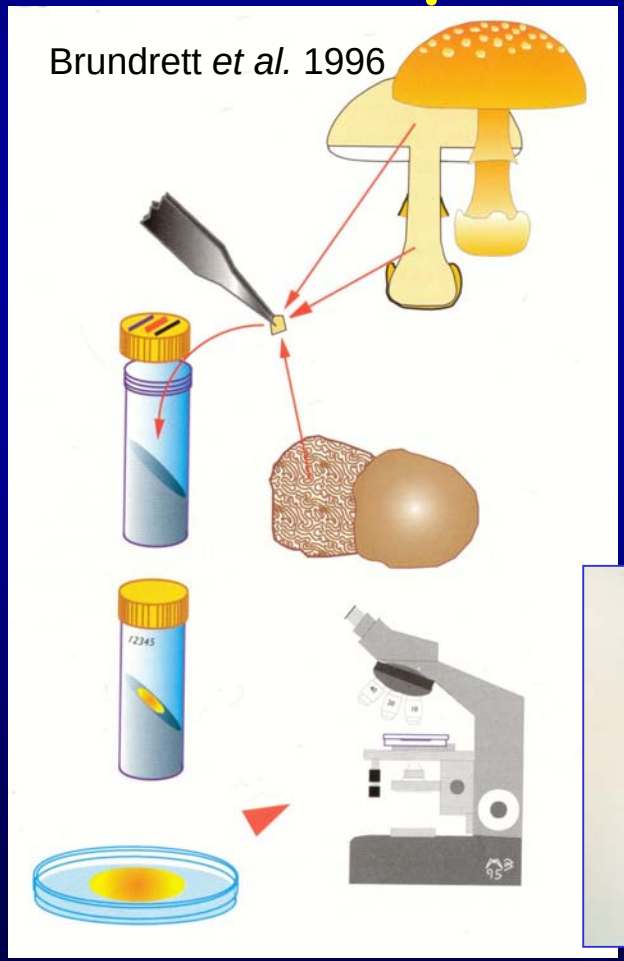
- Metal mobilization, uptake and distribution in willow biomass are clone-specific.

- Metals are mobilized from different types of chemical bonds. A net depletion of total metals and the most mobile fractions was achieved by clones of *S. x dasyclados* and *S. x lanceolata*.

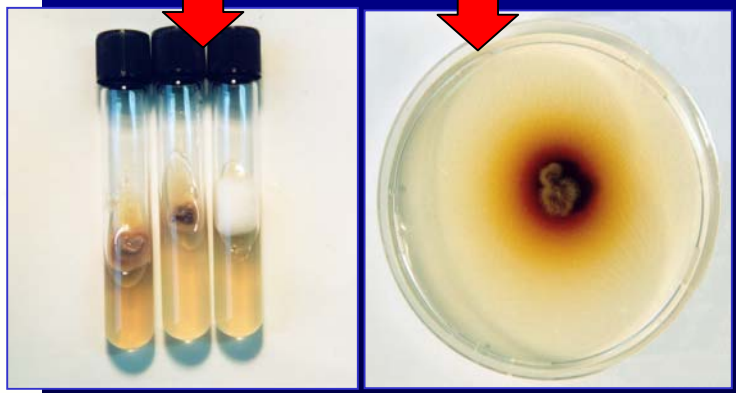
- Metal concentrations and total uptake follow the order: leaves > shoots > roots (except for Cu with large enrichments in roots).

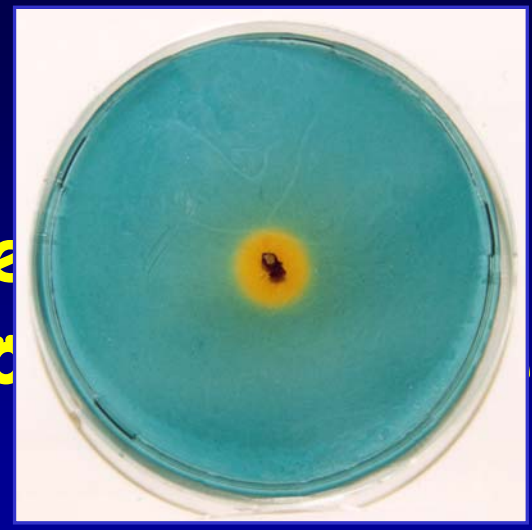
2. Effects of inoculation with ectomycorrhizal fungi

Methodological approach: metal re
soil. Isolation of suitable ectomyc



Tramaregeneration of fruitbodies





Siderophores from *Paxillus involutus* on CAS Medium

Tests for

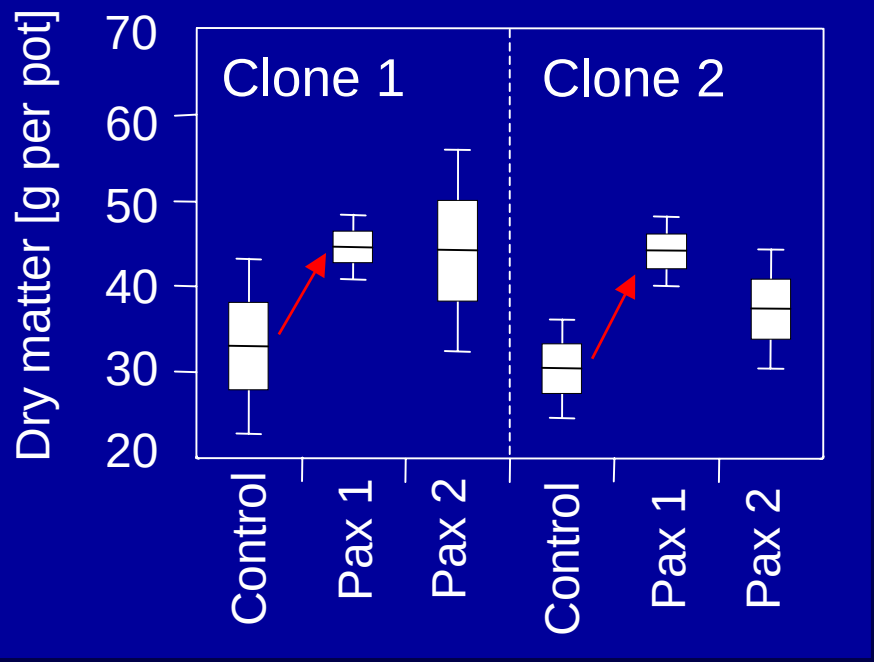
- Mycelium growth
- Hydrophobic/hydrophylic properties
- Enzyme activities
- Production of siderophores

2. Effects of inoculation ...

Pot experiment over 6 month

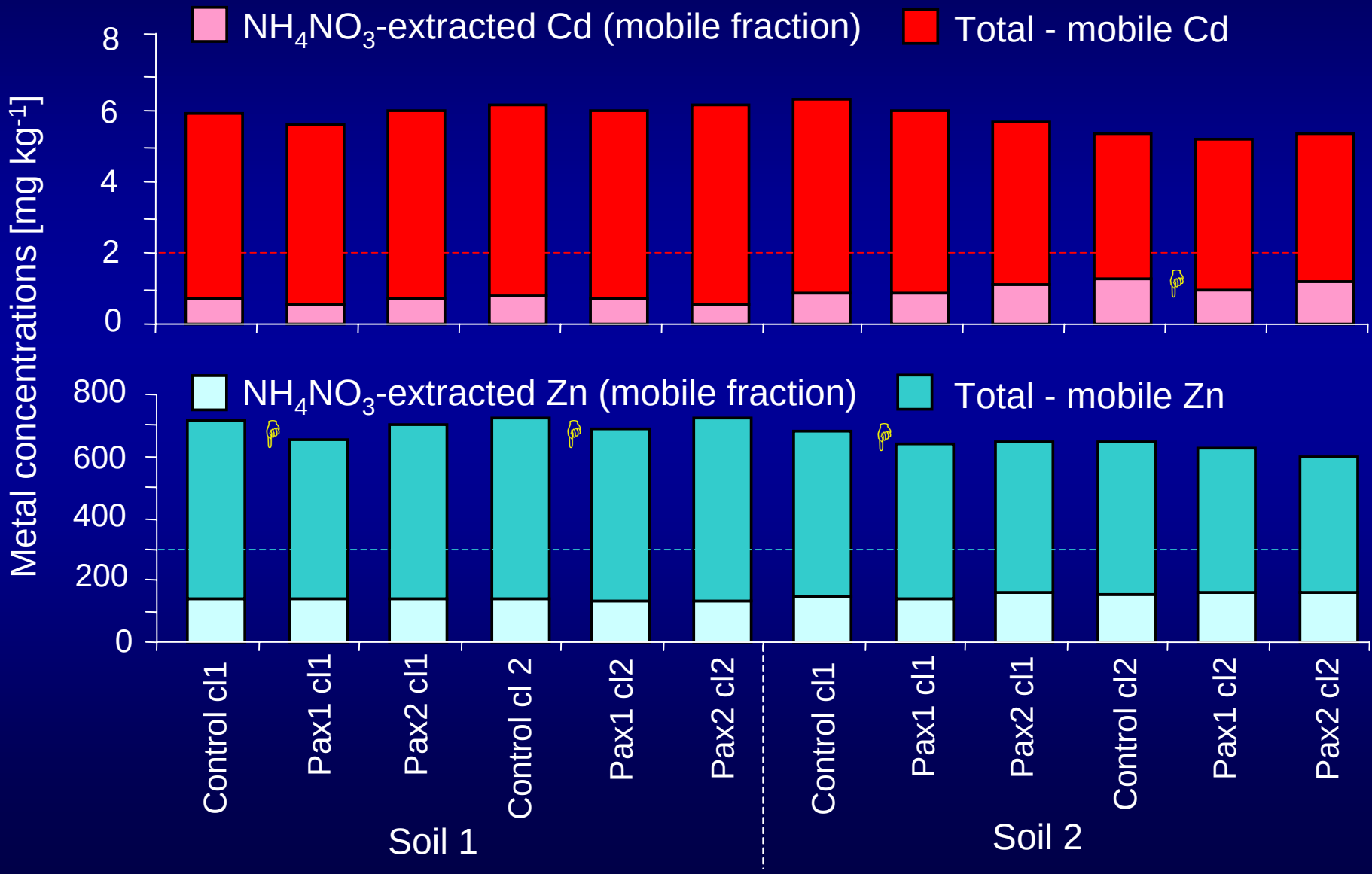
- 2 soils (Fluvisols at Elbe river)
- 2 clones of *Salix* x *dasyclados*
- 2 strains of *Paxillus involutus*

Inoculation effects on shoot biomass



2. Effects of inoculation ...

... on concentrations of mobile and total heavy metals in soil



2. Summary: effects of inoculation

- Inoculation with 1 strain of the ectomycorrhizal fungus *Paxillus involutus* significantly increased the biomass production of *S. x dasyclados* clones.

- Furthermore, metal concentrations in biomass remained constant so that inoculation led to
(1) increases in total metal uptake by willows, and
(2) some significant decreases in concentrations of mobile Cd and total Zn in soils.

- Factors which determined the efficiency of phyto-extraction of heavy metals by willows followed the order soil > interactions soil x willow clone and soil x inoculation > inoculation.

3. Conclusions

- Clones of *S. x dasyclados* and *S. x lanceolata* were the most suitable candidates for phytoremediation.

- What is our expectation / hope ? Clean-up of moderately Cd- and Zn-contaminated sites with 3 rotations of willows (9 years, root removal at the end to catch Cu as well).

- For future practical applications ⌫ site-adapted willow clones and the most beneficial ectomycorrhizal fungi must be selected site-specifically.

- Research needs: improved & accelerated selection methods to achieve growth enhancement without loss in stress tolerance, field demonstration, cost / benefit.

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