Copper and Zinc Phytoremediation by Native Herbaceous and Grass Species Colonized on Remediated Soils at the Bullion Mine, Montana

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Phytoremediation

Definition: The use of vascular plants to improve environmental quality.

Alan Baker, Botanist *(1980)*

University of Sheffield, UK (2000) and University of Melborne, Australia (Current)

<u>His studies include:</u>

-Ecological restoration of mineral wastes

-Phytomining, phytostabalization

-Heavy metal toxicity/tolerance in plants

Plant-Soil Relationships

Accumulators – Species shown to accumulate greater metal concentrations in the aerial portions of the plant with shoot/root ratio >1 (Baker 1981)

Hyperaccumulators – Accumulate higher concentrations of metals in aerial parts than found naturally in the soil

Cu >1000 ppm dry weight

Zn >10,000 ppm dry weight

Excluders – Avoidance of metal uptake, metal restriction to the roots

shoot/root ratio <1 (Baker 1981)

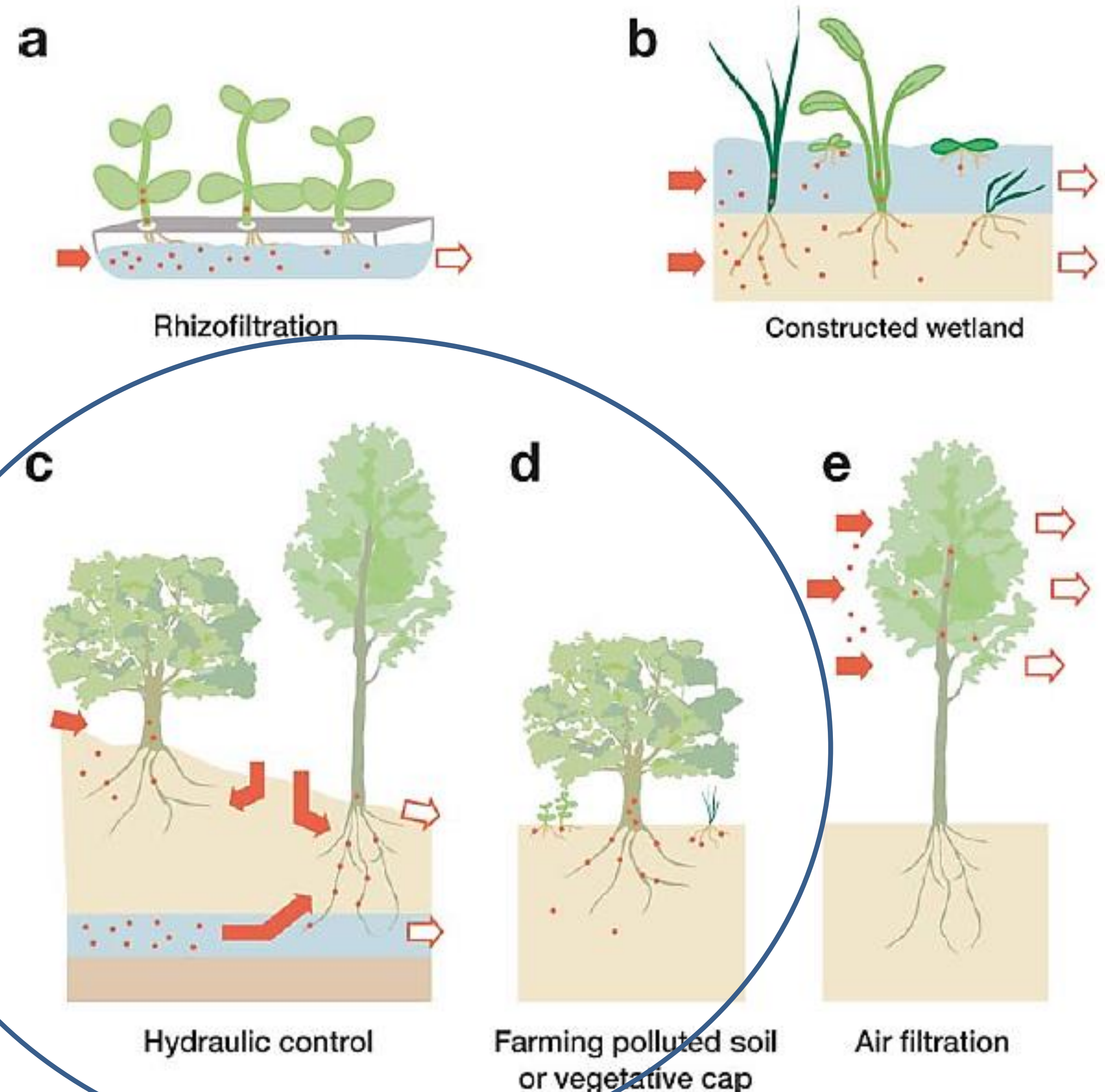
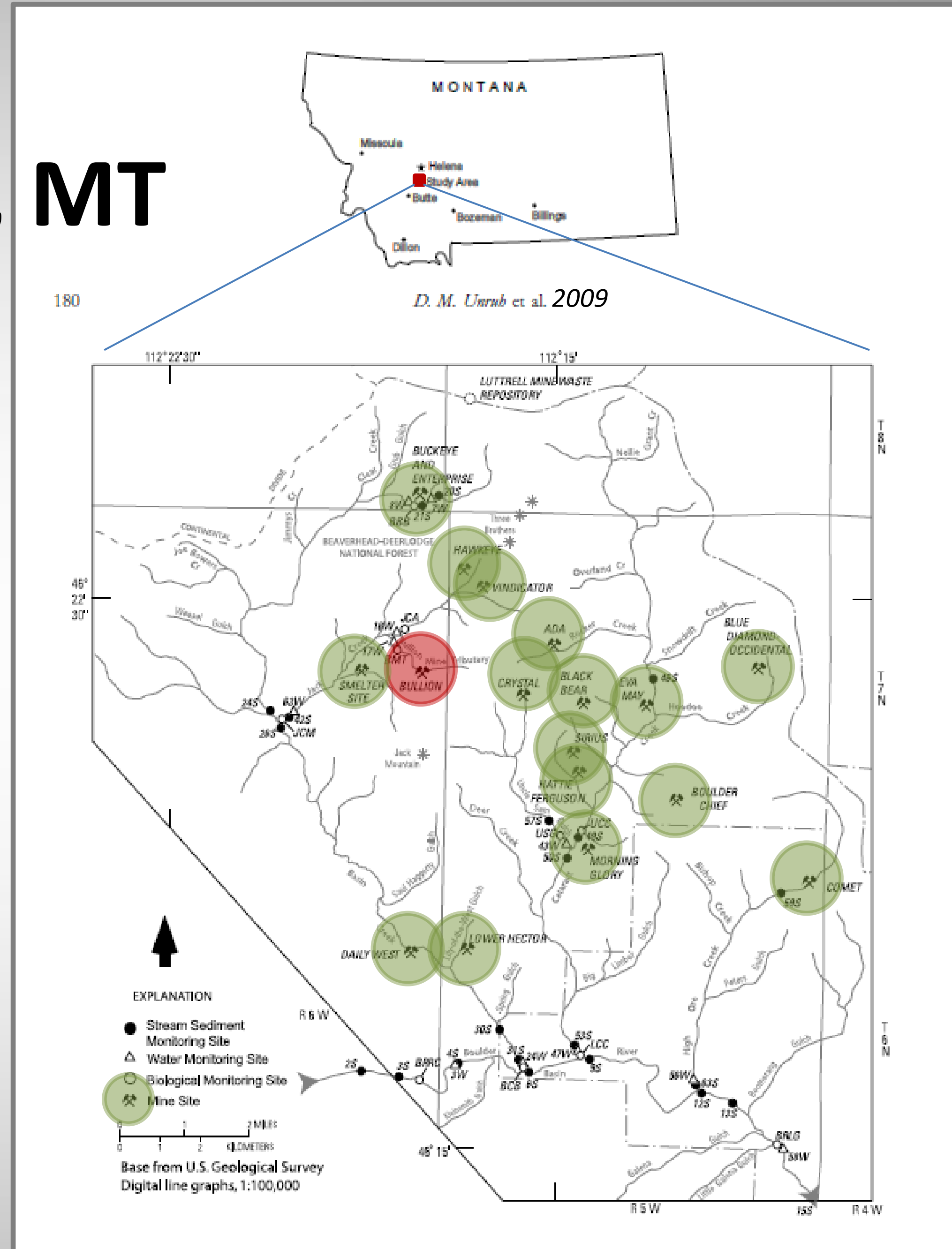


Figure 1

Phytoremediation technologies used for remediating polluted water, soil, or air. The red circles represent the pollutant.

Bullion Mine, Jefferson County, MT

- Gold and silver deposits
- Underlying igneous geology
- Ores and mine tailings pervasive
- Bullion Mine closed by 1933



Bullion Mine

- Jack Creek contamination and metal loading along the Bullion Mine Tributary (BMT)

- Listed as EPA Superfund site in 1999

  Metals of concern: **As, Cd, Cu, Fe, Zn**

- Soil cores under mine tailings contained:

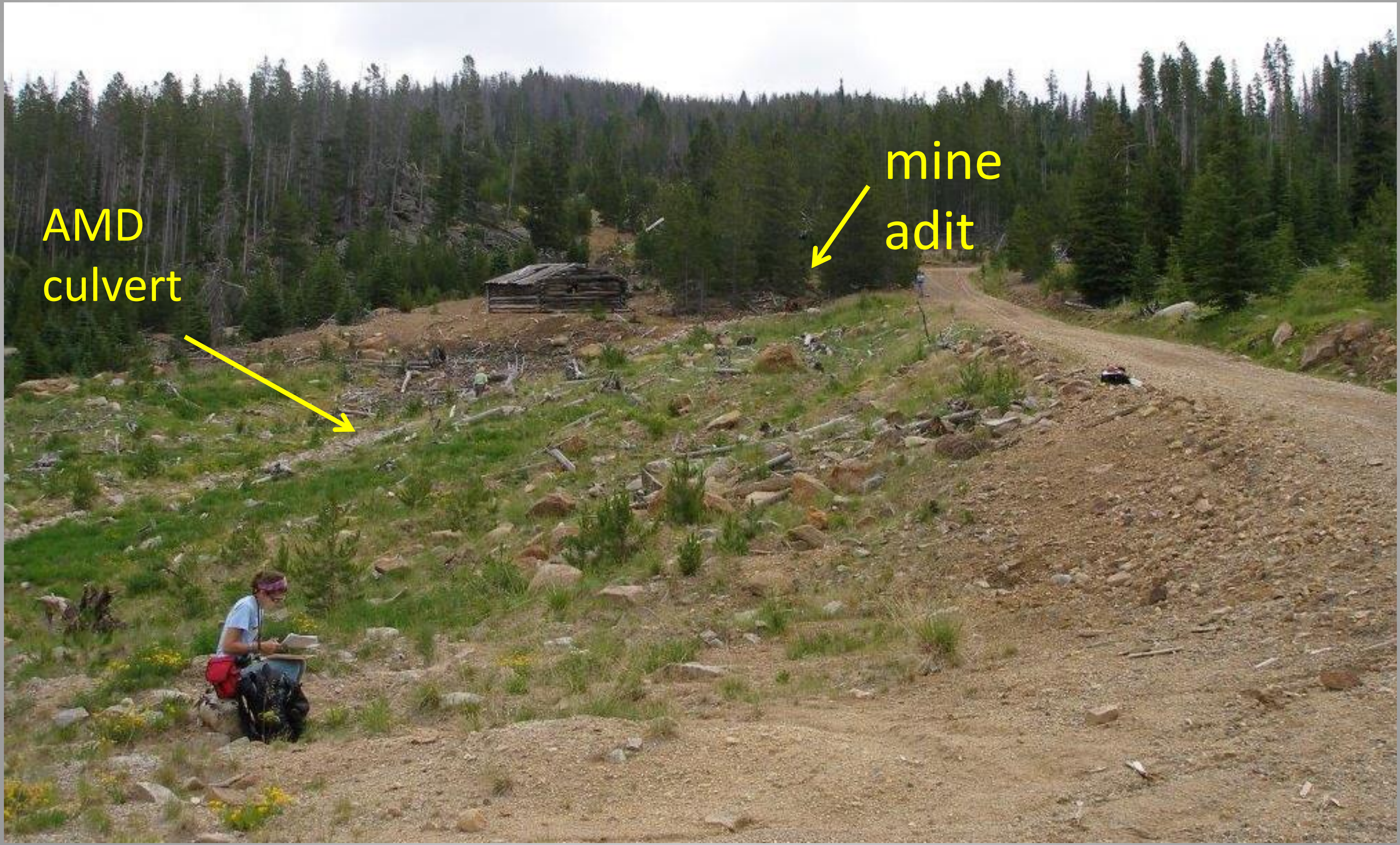
  16 – 9000 μg/g Cu

  300 - 18,000 μg/g Zn (Fey et al. 2000)

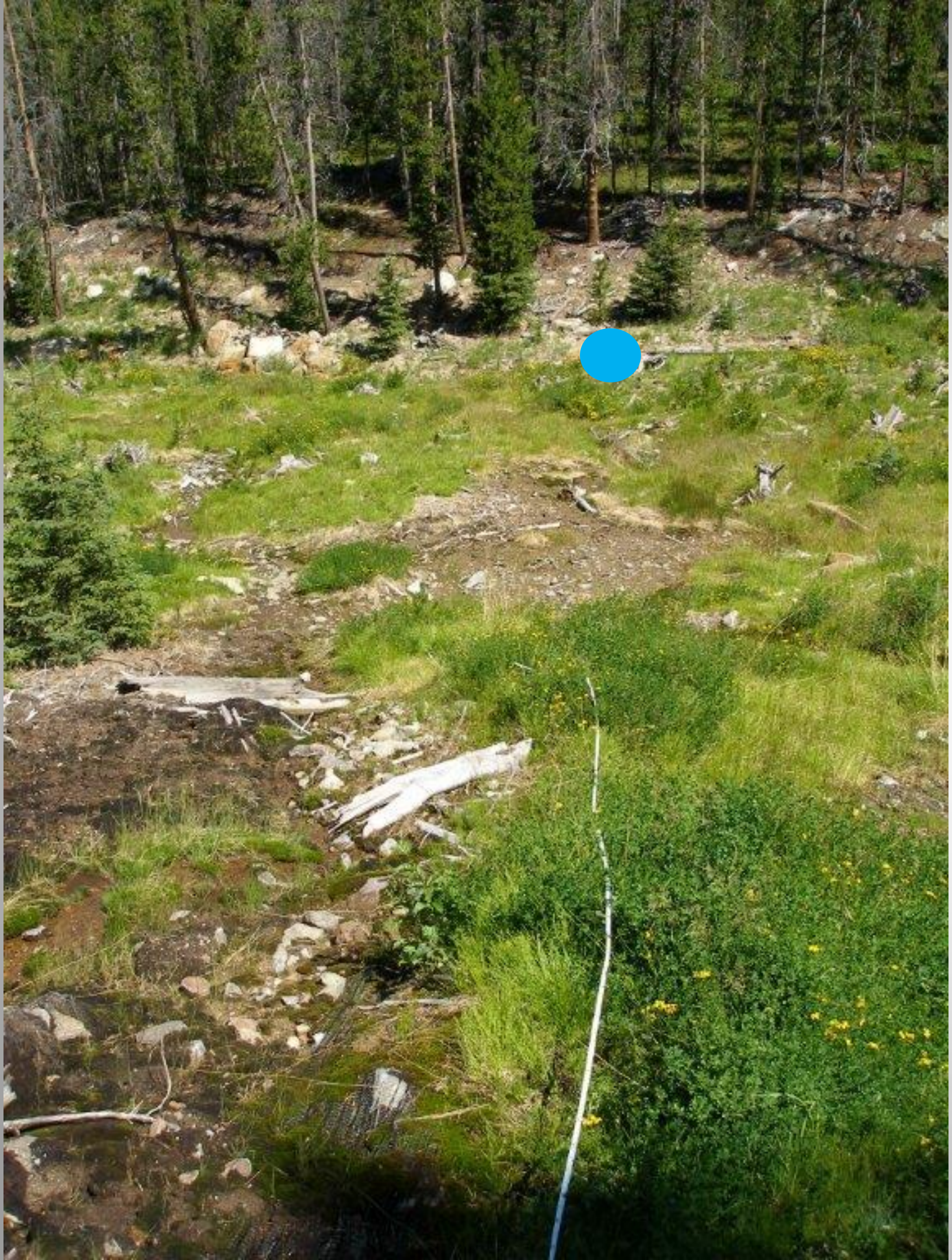
Remediation Efforts

- USFS and EPA removed mine tailings and contaminated sediment from Jack Creek from 2001-2005
- Acid mine drainage(AMD) was still present in 2005 post remediation (Unruh *et al.* 2005)
- Site was re-graded in 2008
  - No re-seeding, allowed natural re-establishment

Site Characteristics



Bullion Mine Tributary (BMT)



0 m

Transect view north from 60 m

Note patchy plant distribution

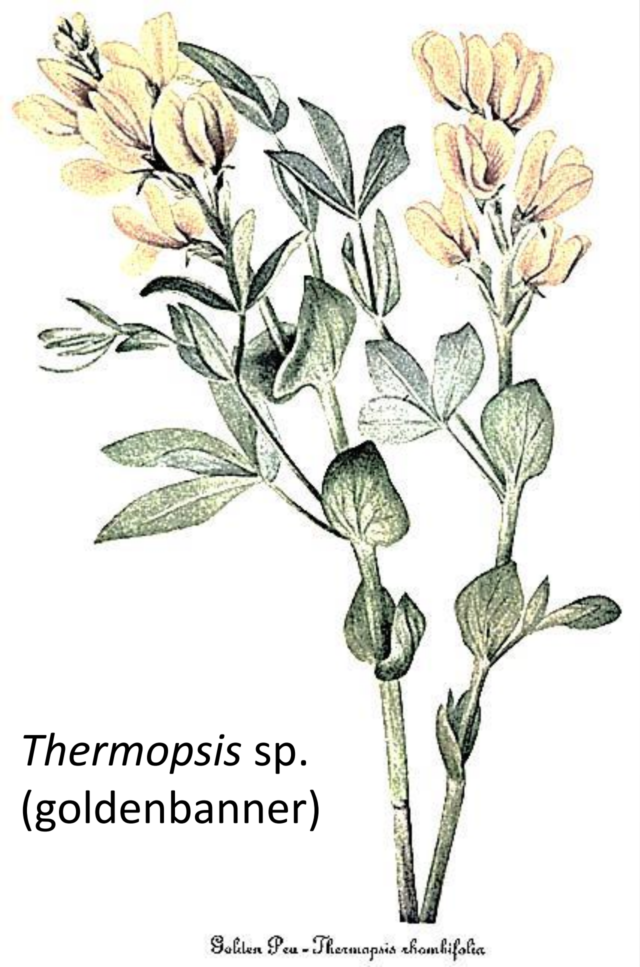
60 m

Deschampsia cespitosa
(tufted hair-grass)

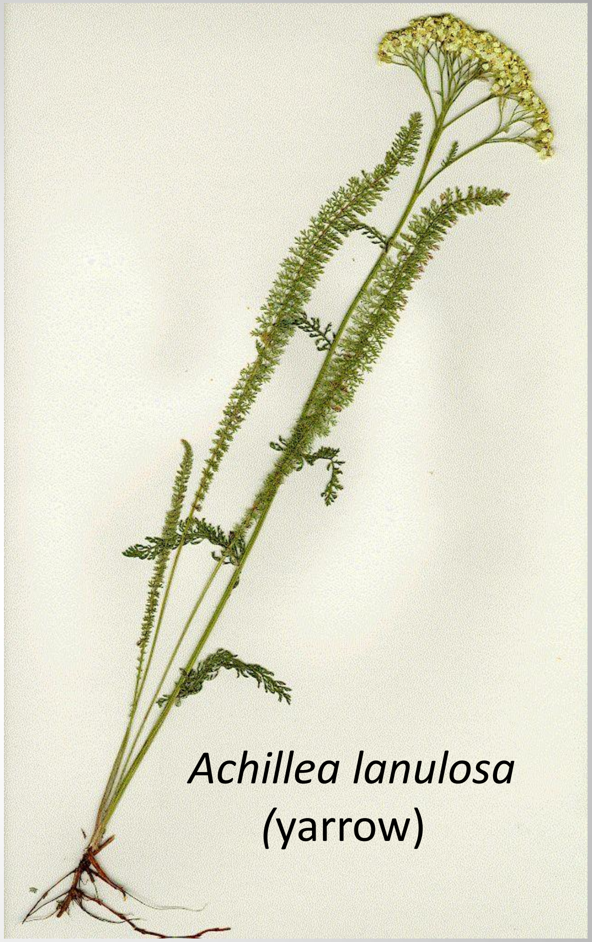
Phleum alpinum
(mountain Timothy)

Oryzopsis hymenoides
(Indian ricegrass)

Select native grasses that dominate along the transect.

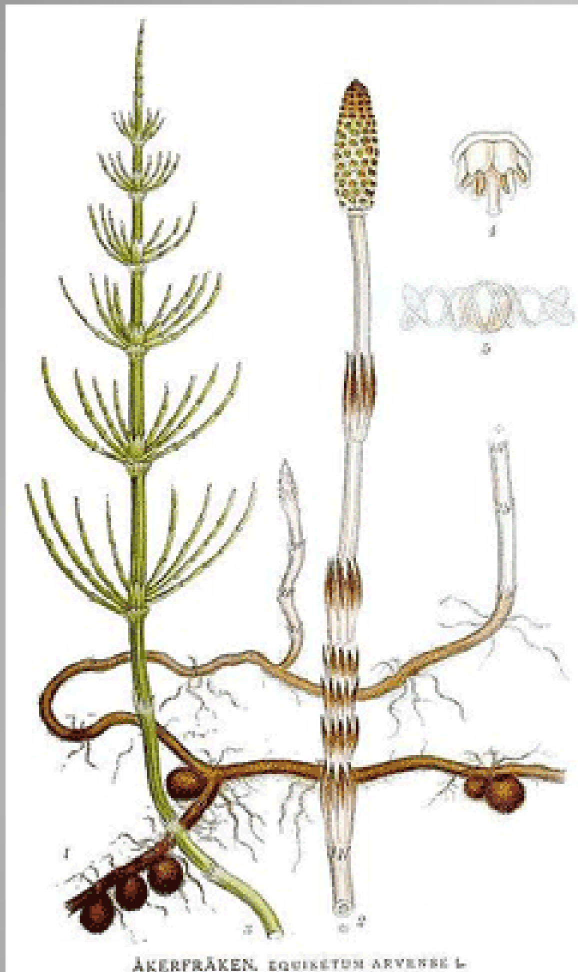


Thermopsis sp.
(goldenbanner)

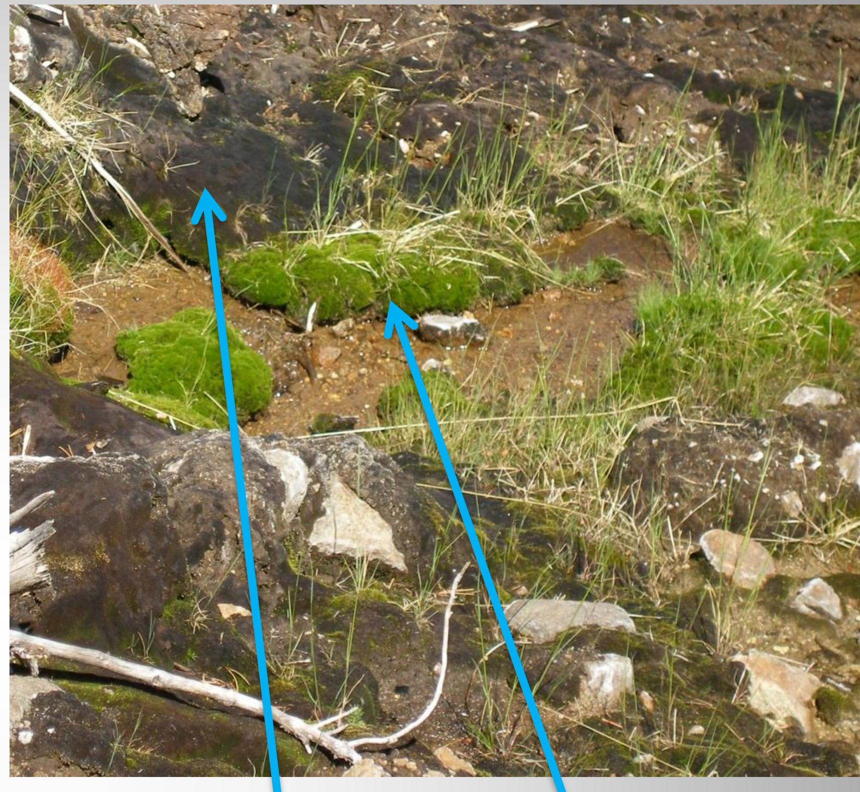


Achillea lanulosa
(yarrow)

Select native herbaceous species that dominate along the transect.

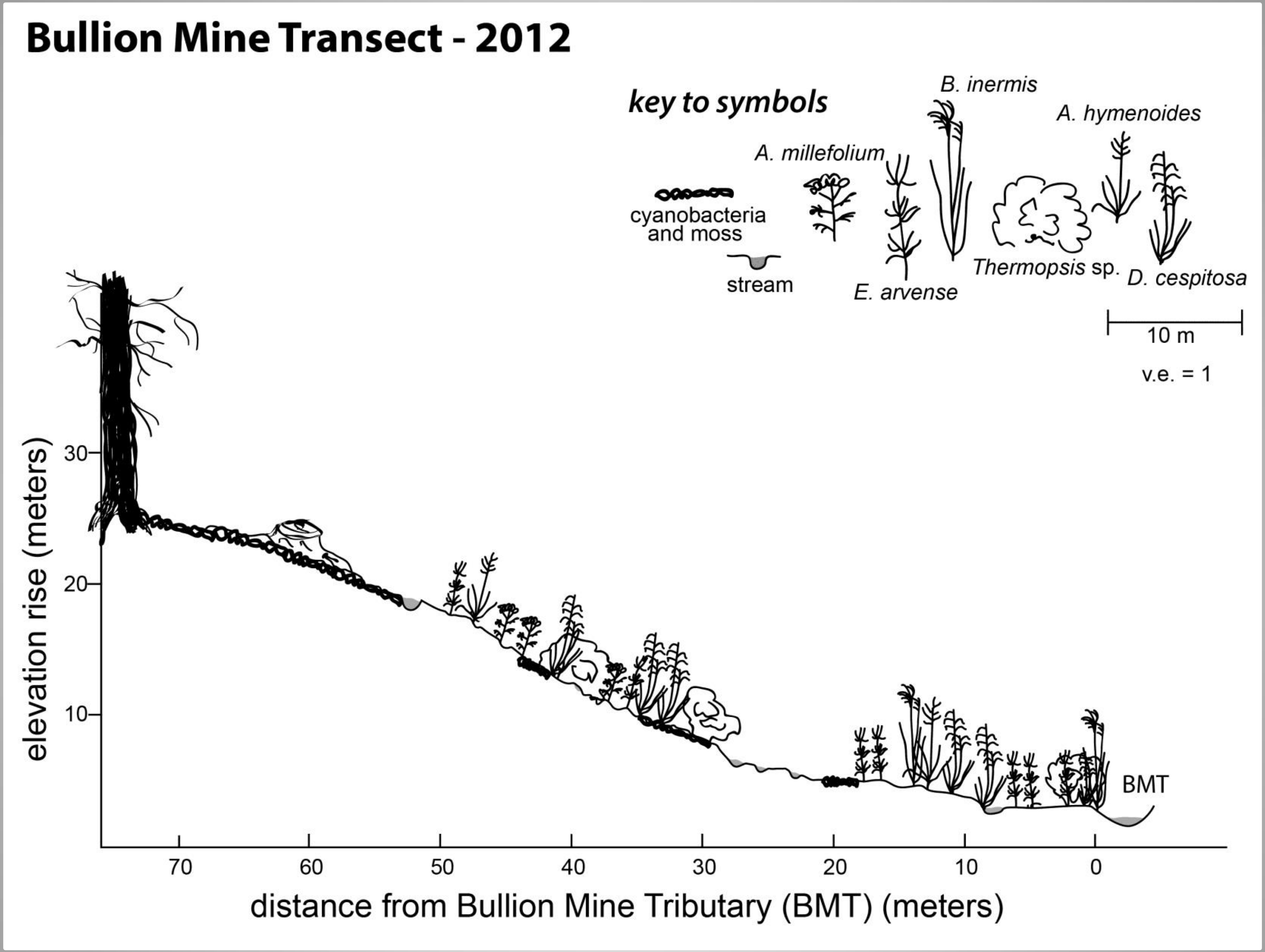


Equisetum arvense
*(*common horsetail)



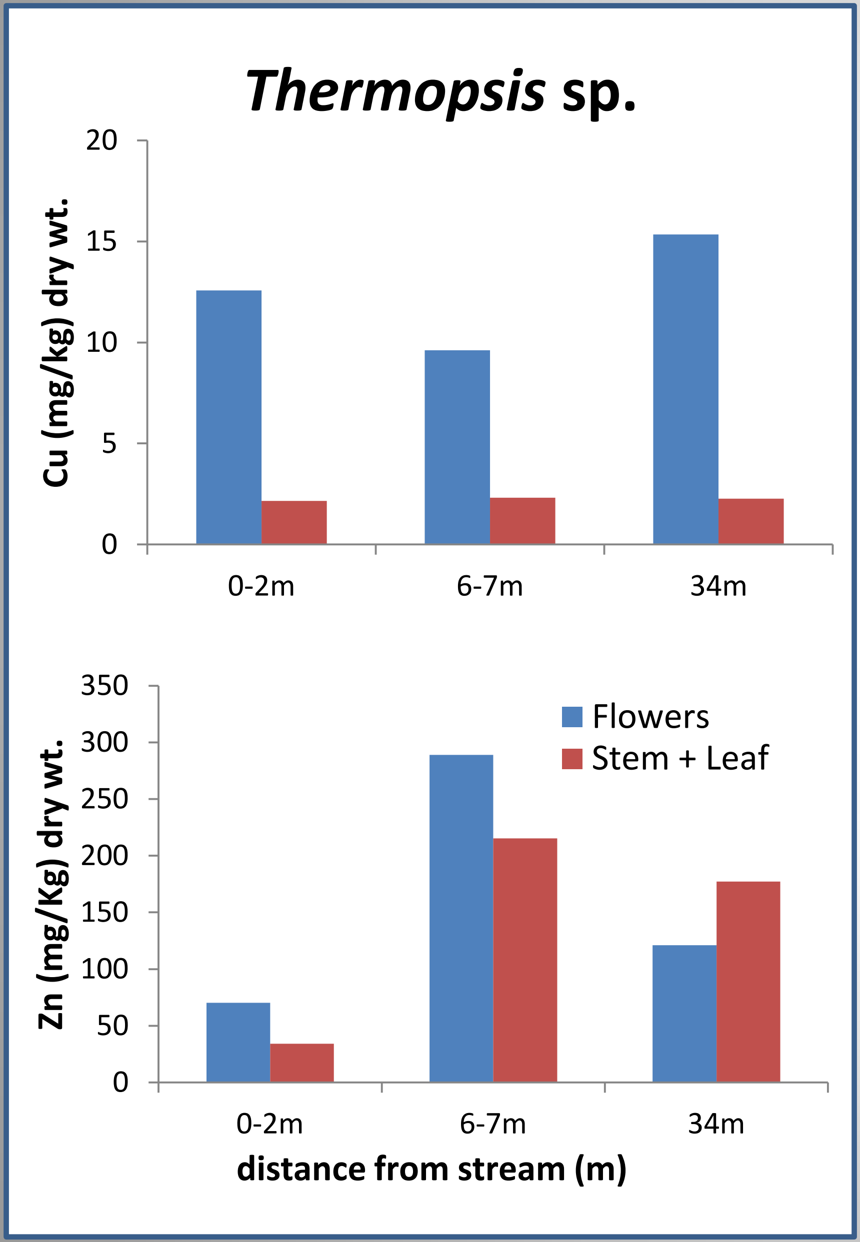
cyanobacteria and moss mat

Other select species found along the transect.



Scaled horizontal profile with dominate species shown along the transect.

Thermopsis sp. (goldenbanner) metal accumulation

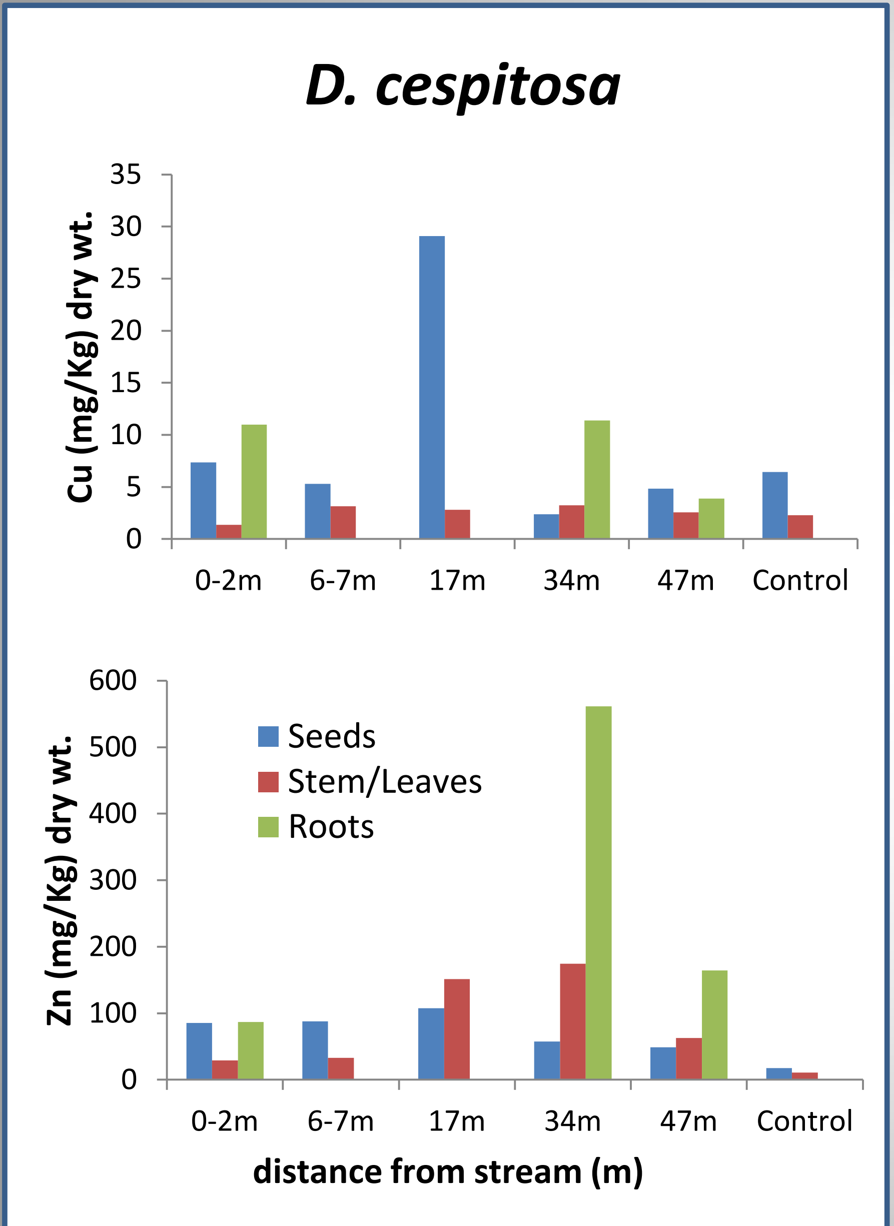


Cu accumulation in flowers

2-14 mg/Kg dry wt.

Zn 30-290 mg/Kg dry wt.

D. cespitosa (tufted hair-grass) metal accumulation



Cu accumulation in seeds

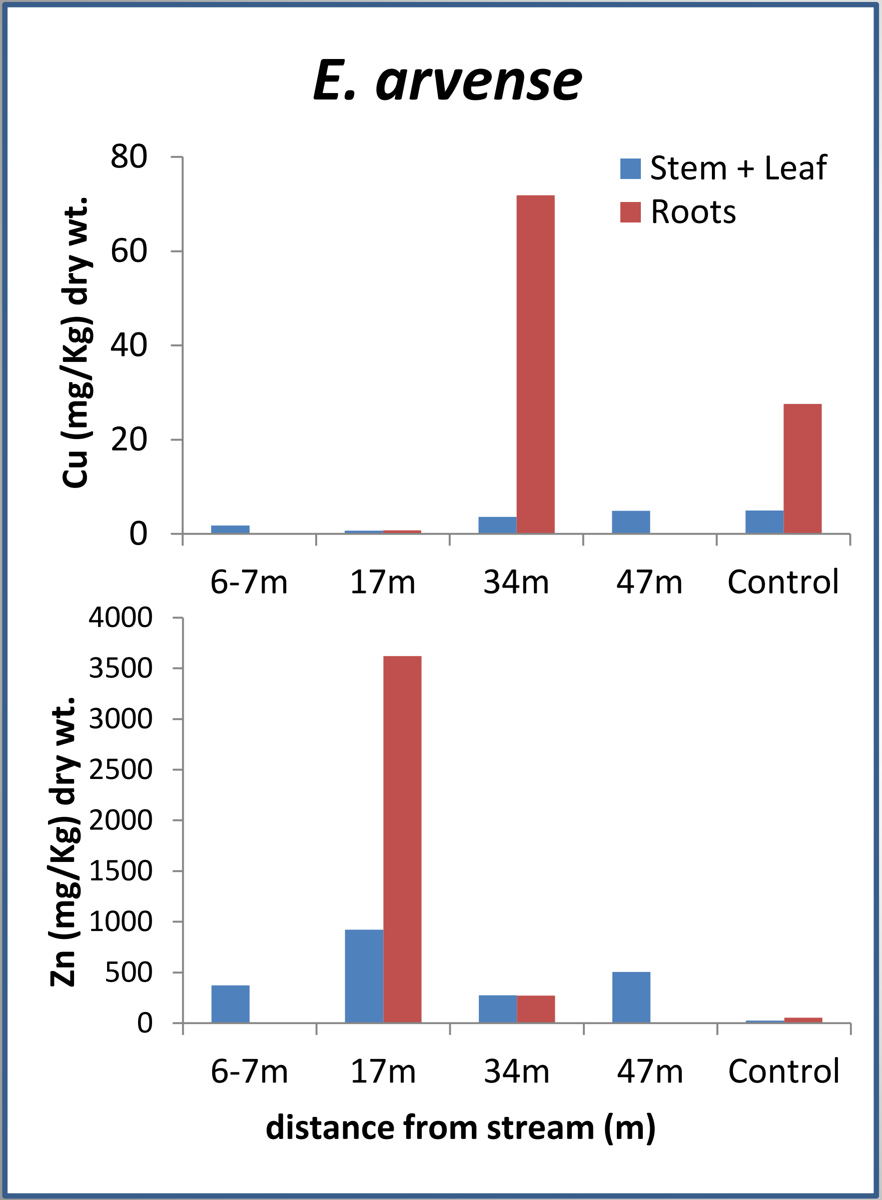
1-30 mg/Kg dry wt.

Zn accumulation in roots

10-560 mg/Kg dry wt.

Average shoot/root metal ratio	
Cu	Zn
1.7	0.3

E. arvense (common horsetail) metal exclusion



Cu restriction in roots

1-70 mg/Kg dry wt.

Zn restriction in roots

25-3620 mg/Kg dry wt.

Average shoot/root metal ratio	
Cu	**Zn**
0.1	**0.3**

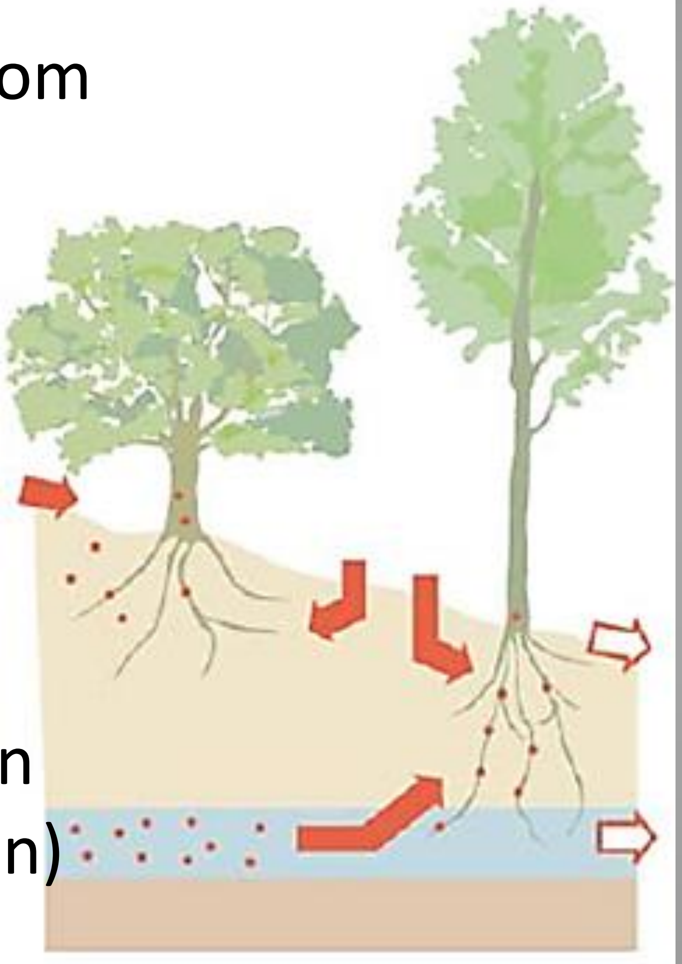
Accumulators & Excluders at Bullion Mine

Accumulators can remove copper from contaminated soils

Effective phytoremediation relies on **hyperaccumulators**

Excluders show greater tolerance

Excluders used to contain windblown contamination (phytostabilization) (Alkorta *et al.* 2010)



Natural succession on metal contaminated soils

Past remediation attempts were incomplete

Despite soil contamination, natural succession is occurring

Possible because of the different tolerance mechanisms present

Plant distribution controlled by soil moisture

Summary

- In future, examine other contaminants identified by EPA/USFS including **As, Cd**, and **Fe**

- AMD is an ongoing problem

- Not an isolated problem in this area

- Examining other related sites may lead to successful phytoremediation or better understanding of natural succession on these soils