ECOLOGICAL RESTORATION OF BLM ABANDONED MINE SITES

International Phytotechnologies Conference

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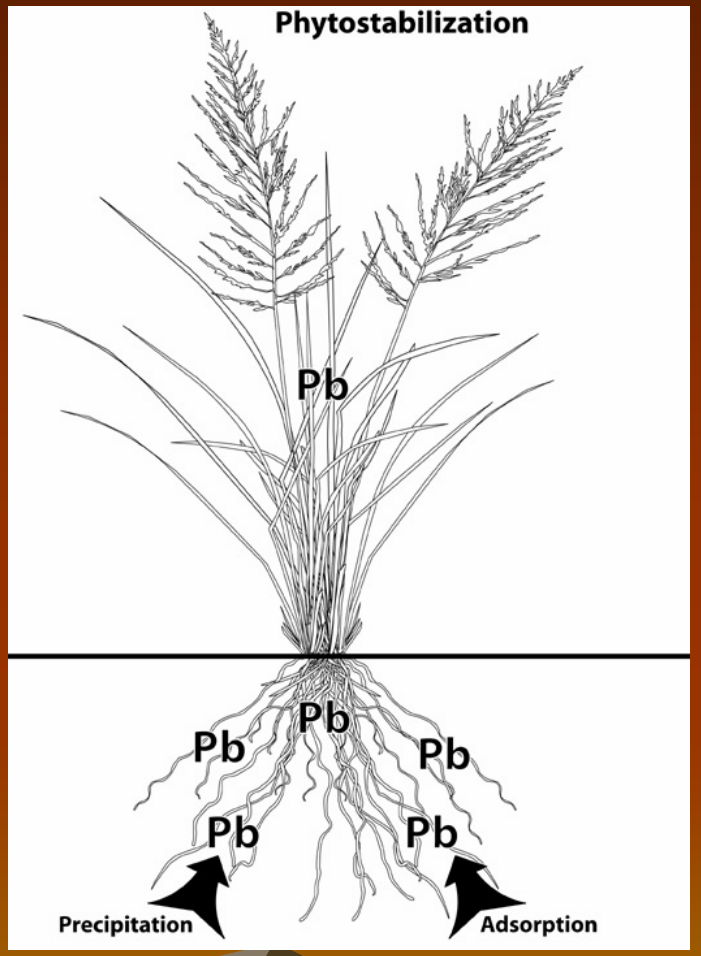
What is phytostabilization?

- Remediation technology uses **native** plants to:
  - **Immobilize contaminants in soil through adsorption and precipitation, rhizosphere**
  - **Use plant roots to prevent migration via:**
    - **Wind erosion**
    - **Water/soil erosion**
    - **Leaching**
    - **Safe to wildlife**
- EPA, Introduction to Phytoremediation
  EPA/600/R-99/107



Why Phytostabilization?

- BLM has thousands of AML sites, limited $
- Traditional remediations excavate waste and haul to a disposal site
- Very costly to handle and transport thousands of cubic yards
- Need in-situ technology
- Sites might be reclaimed in-situ at 1/10 of the cost and meet environmental requirements

Applications of Science Grant

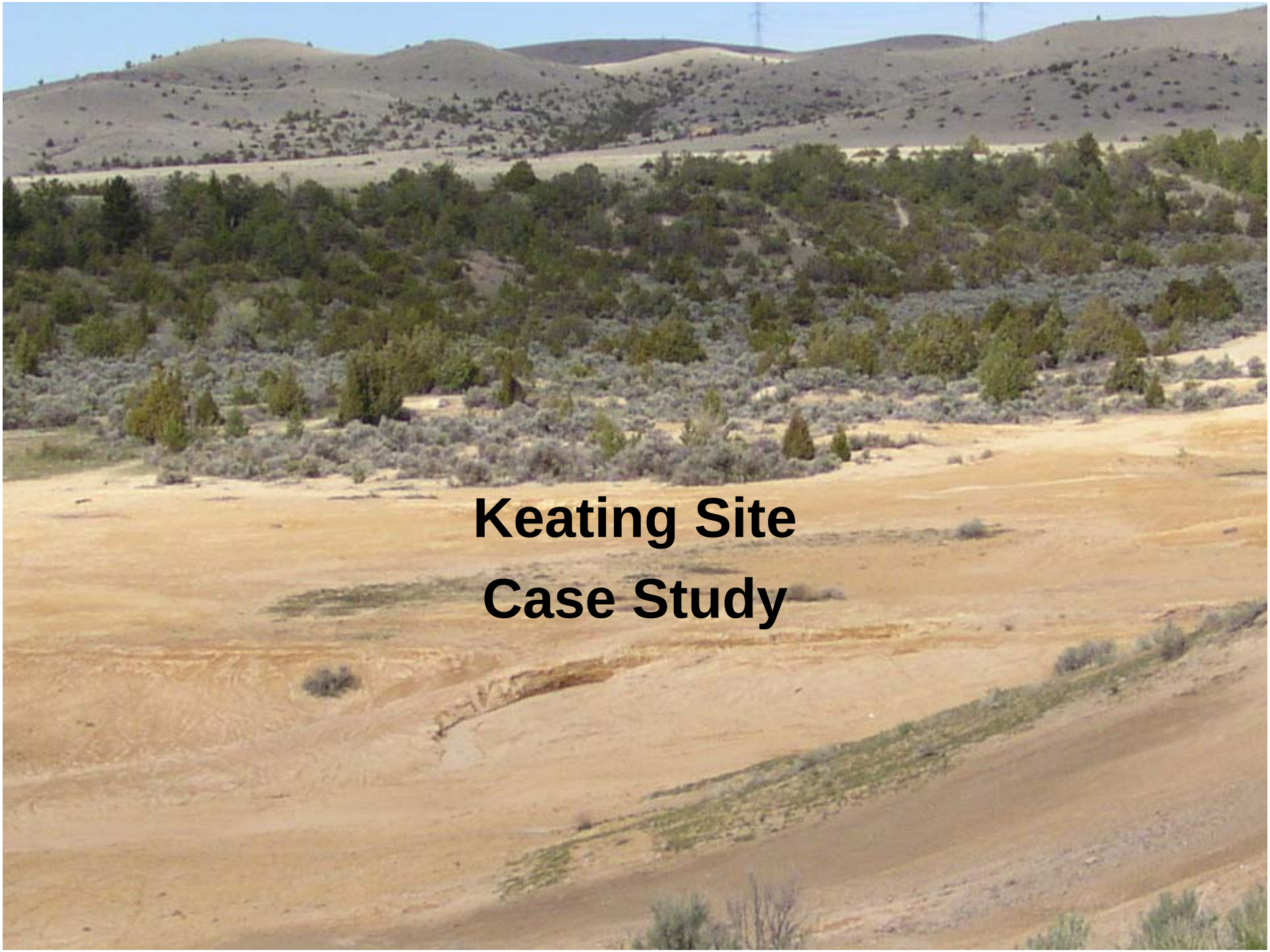
- NSTC directing demonstration projects to test phytostabilization at BLM mining sites
- Selected 3 sites in different states/ecoregions
  - Keating Tailings site in northern Rockies
  - Boston Mill site in SE Arizona
  - Perry Canyon site in Great Basin
- Cooperative Ecosystem Studies Units (CESUs) University agreements

CESU Partners

- Keating: Montana State University
  - Reclamation Research Unit
- Boston Mill: University of Arizona
  - Environmental Science Laboratory
- Perry Canyon: University of Nevada - Reno

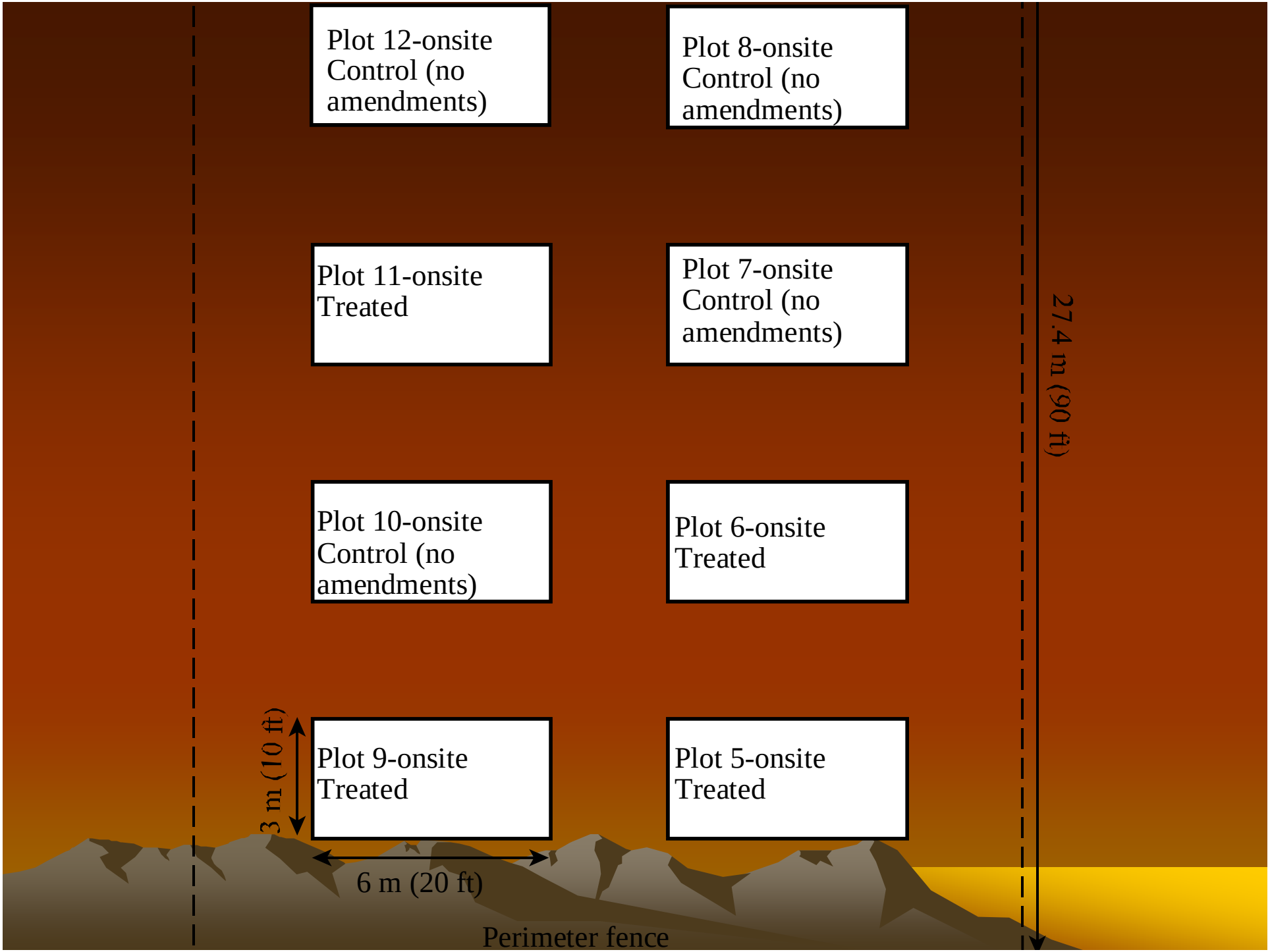
Work Scope

- Establish test plots on tailings
- Characterize chemistry
- Prescription for soil amendments
- Construct test plots, amend and seed
- Test plant growth parameters, metal uptake, toxicity


Keating Site
Case Study

Keating Test Plots

- Tailings chemistry: pH 4.1-5.6;
  - As, Pb, Cu, Zn in 300-1000 mg/kg total metals range
  - Water extractable Cu, Zn in the 30-300 mg/L range
- Replicated experimental plots 10x20’ installed 9/03
  - 4 offsite control
  - 4 onsite control
  - 4 onsite treatment (18”) based on sampling
    - 63-150 lbs $Ca(OH)_2$
    - 300-400 lbs CaCO3
    - 2250 lbs compost (upper 6”)
  - Seeded northern wheatgrasses, fescues, forbs
- Fenced to exclude animals, signed.


Plot 12-onsite Control (no amendments)
Plot 8-onsite Control (no amendments)
Plot 11-onsite Treated
Plot 7-onsite Control (no amendments)
Plot 10-onsite Control (no amendments)
Plot 6-onsite Treated
Plot 9-onsite Treated
Plot 5-onsite Treated
27.4 m (90 ft)
3 m (10 ft)
6 m (20 ft)
Perimeter fence

June 2004 Growth

Seedling Density Results, June

	Mean Seedling Density (#/m^2)	SD
Offsite Control	460	176
Onsite Control	373	137
Onsite Treated	**257**	**123**

July 2004 Growth

Mean Cover Results, July

	Mean % Cover	SD
Offsite Control	52.6	11.9
Onsite Control	16.4	9.4
Onsite Treated	**53.8**	**9.4**

Next, we analyzed plants for metals:

- Composite leaf and stem samples collected for each plot and sent for metals analysis
- Onsite treated plots reduced Cd, Cu and Zn concentrations by 59%, 26, and 63% respectively, compared to onsite control plots
- Onsite treated plots statistically the same as background
- Comparison to published safe foliage toxicity levels show no exceedances except slightly for Cd

Plant Tissue Metals Results, mg/kg Keating Tailings

	As	Cd	Cu	Pb	Zn
Offsite	<4	<0.5	6.3	<4	19.8
Onsite Treated	<4	1.3	10.3	<4	60.0
Onsite Control	<4	3.1	14	<4	161.5
Safe level NRC, 1980	50	0.5	100	30	1000

Boston Mill Case Study

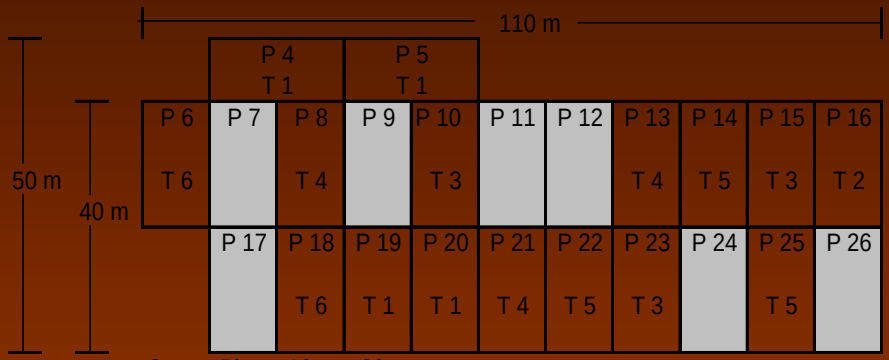
- Similar project
  - Chihuahuan desert
- San Pedro River NRCA
  - Biodiversity - refuge
- Results of research were used in Engineering Evaluation/Cost Analysis e.g. treatability study
- Restoration Plan in progress by U of A

Wall Plots: 7.5 m x 12 m

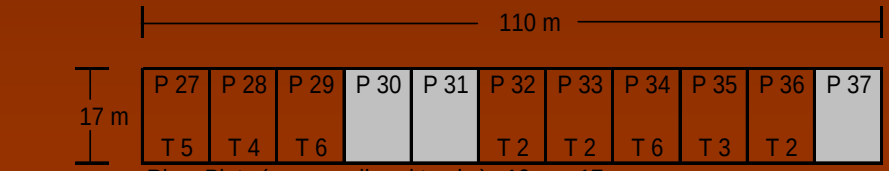
1 each from random location within each wall plot 8
Total soil samples 25

Wall plot area divided into eight equal plots, and one random point chosen in each plot for transplant plot locations.

- Test Plot layout
- Characterization:
  - pH 9.0
  - Pb, Zn, 5000-30,000 ppm
  - Seeded Big Sacaton, atriplex



Center Plots: 10 m x 20 m

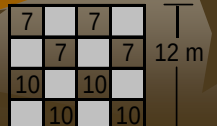


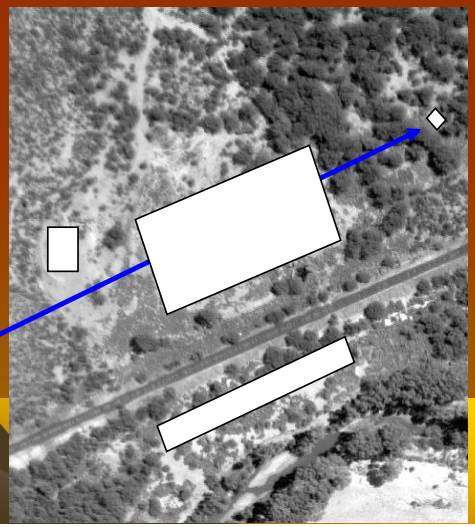
River Plots (across railroad tracks): 10 m x 17 m

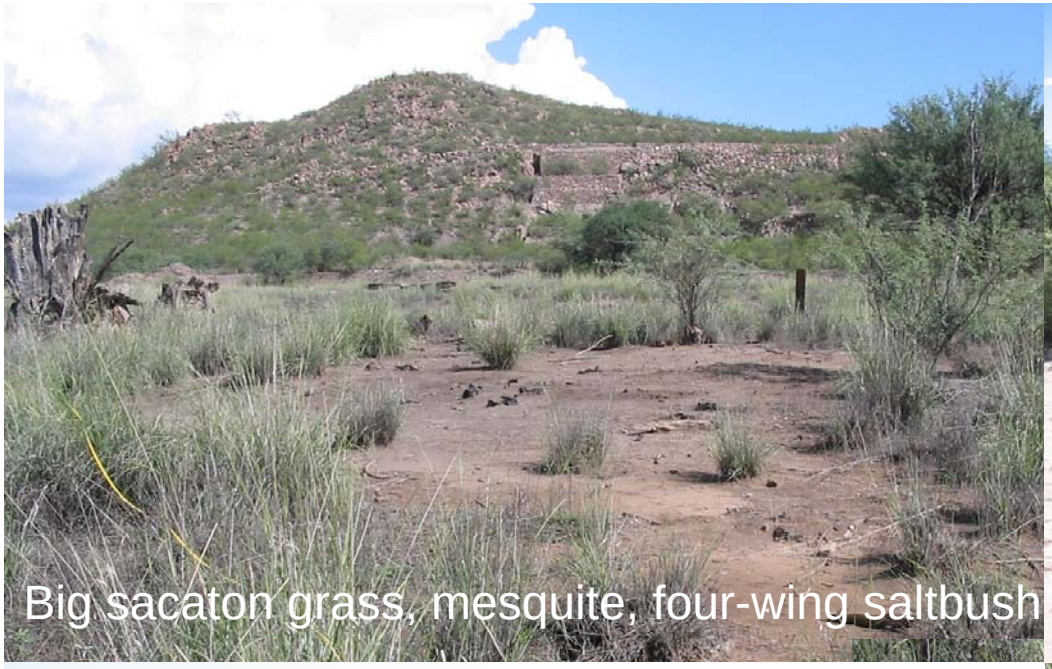
On-site treatments (random 3m x3m plots within larger plots)
1 SPWR seed, mulch
2 Control, no treatment
3 SPWR seed, rake
4 SPWR seed, mulch with mesquite litter, rake
5 SPWR seed, mulch with compost, rake
6 SPWR seed, mulch with compost, dig/chisel

8 ATCA transplants, irrigate
9 ATCA transplants, mulch with compost, irrigate

Off-site treatments (in 3 m x 3 m)
7 SPWR seed, rake
10 ATCA transplants, irrigate






Big sacaton grass, mesquite, four-wing saltbush

Results

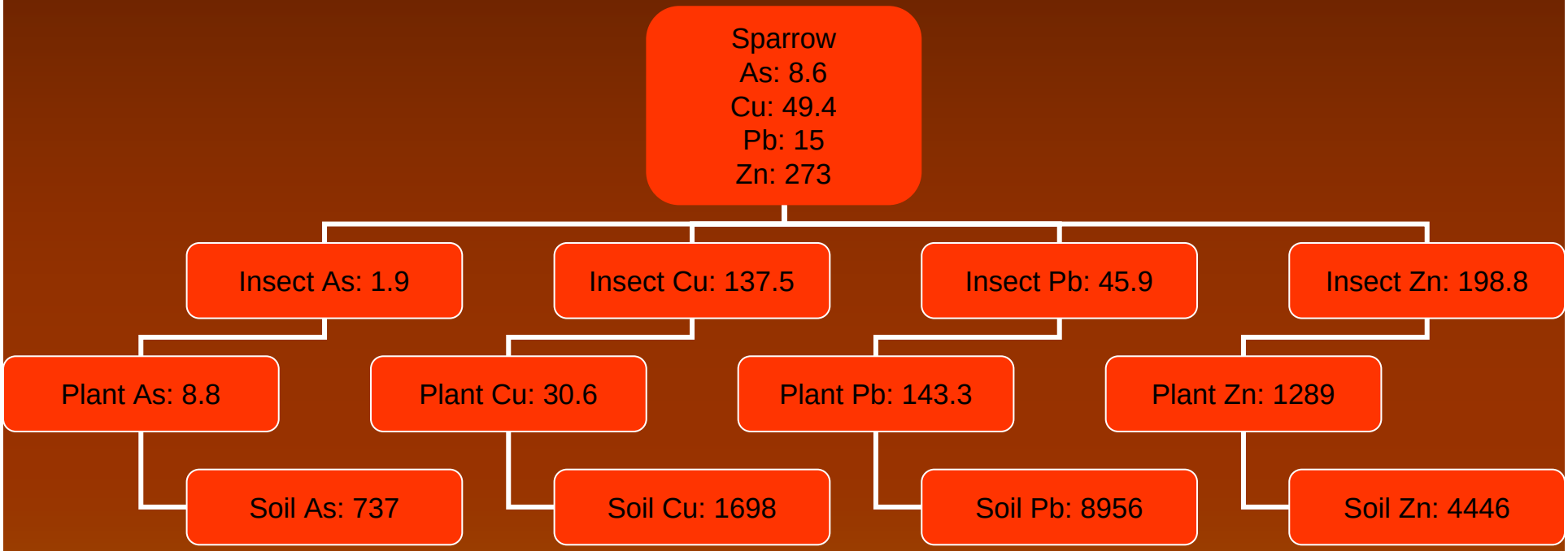
- Sacaton seeds failed to germinate
- Atriplex plantings survived and grew
- Sacaton germinated and propagated in greenhouse and replanted onsite
  - 80% survival
- Metals accumulation results:
  - Sacaton grass uptake about 1/10 of shrubs
  - Wildlife protection
    - Food chain accumulation modeled for ecological restoration
    - Indicates cleanup needed for Cu and Pb

Metals Bioaccumulation Results, mg/kg Boston Mill

Metal	Safe forage*	[Plant]	[Soil]	P/S	[Insect]	I/S
As	50	6.4	737	0.009	1.88	0.002
Cu	100	23.2	1698	0.014	137.9	0.081
Pb	30	127.5	8956	0.014	45.9	0.003
Zn	1000	92.0	4446	0.02	198.8	0.029

*NAS, 1980 Livestock

Ecological Risk Model
Boston Mill



Units in mg/kg concentration. Sparrow units are safe dietary intake.

Bioavailability

- In-vitro bioaccessibility for lead ~80%
  (Ruby et al, ES&T)
- Work of Sally Brown and others (JEQ) with compost shows ~ 80% bioavailable
- Net reduction in bioavailability to sparrow 50%

Cleanup Levels

- Used model to back-calculate cleanup levels using phytostabilization:
  - not accounting for bioaccessibility, Pb cleanup level for site would be 1719 mg/kg
  - with bioaccessibility & credit for providing compost, Pb cleanup level 2400 mg/kg
- Ecological restoration plan in progress
  - featuring removal or capping of hotspots and phytostabilization <2400 ppm Pb

Future work

- Want to continue to monitor plant production and metals uptake,
- Identify key western native range plants for phytostabilization,
- Install lysimeters to evaluate leaching.