Demonstration Projects
for the
Application of
Soil Amendments
at
Mining Related Sites

Biosolids Remediation of a Base Metals Mining Site

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Sally Brown, Ph.D. and Mike Zimmerman

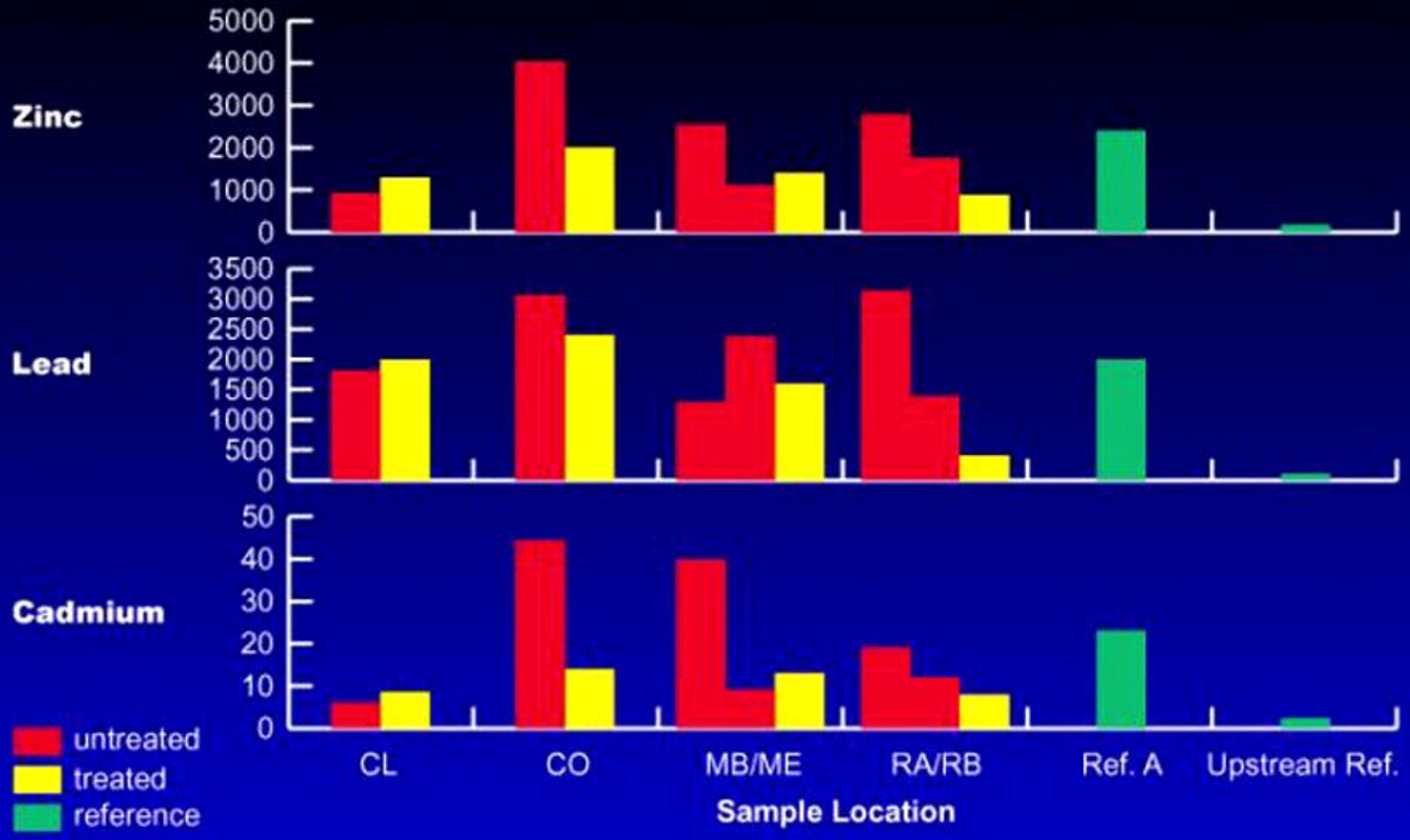
7 26 98

9 24 '99

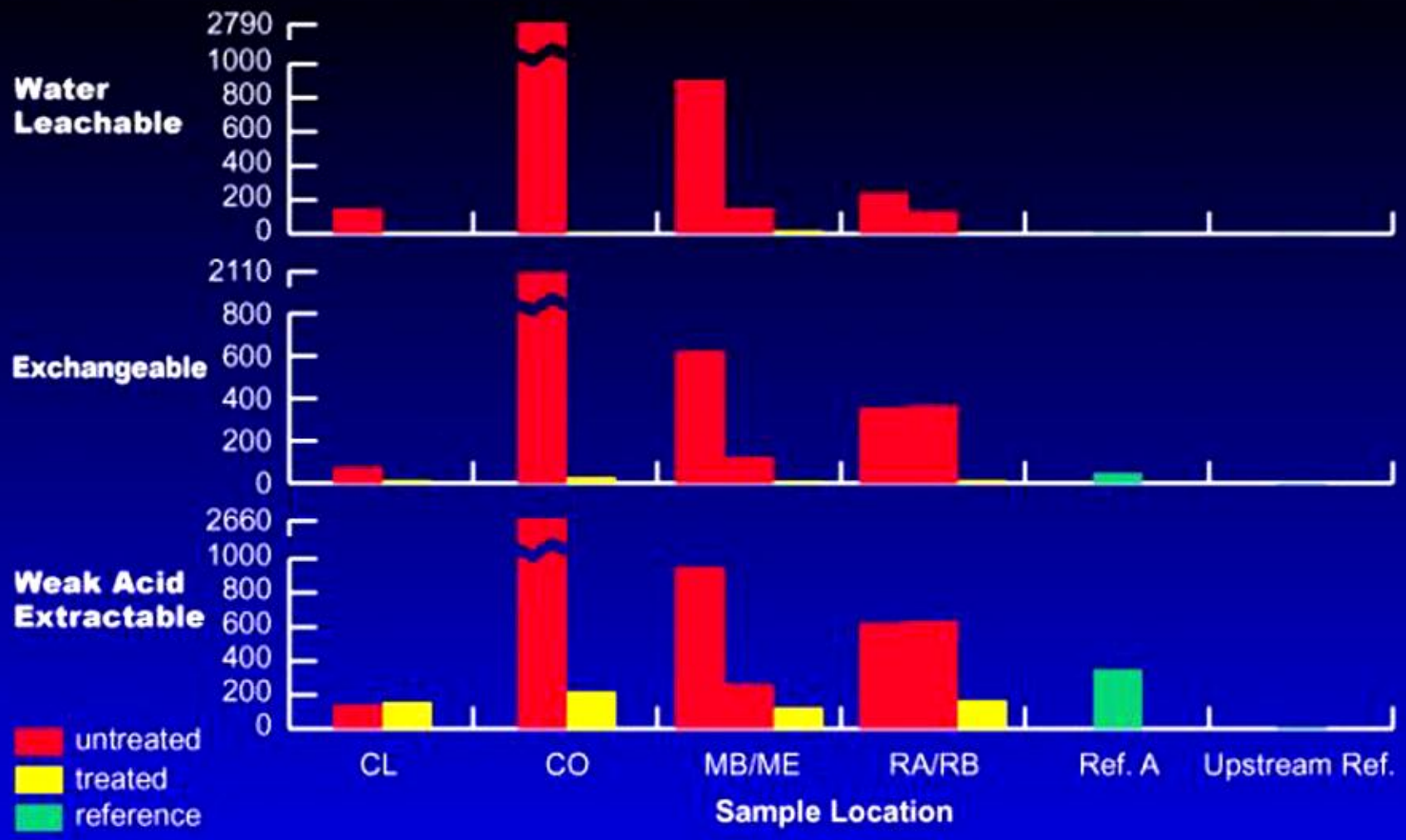
9 23'96

6 17 '98

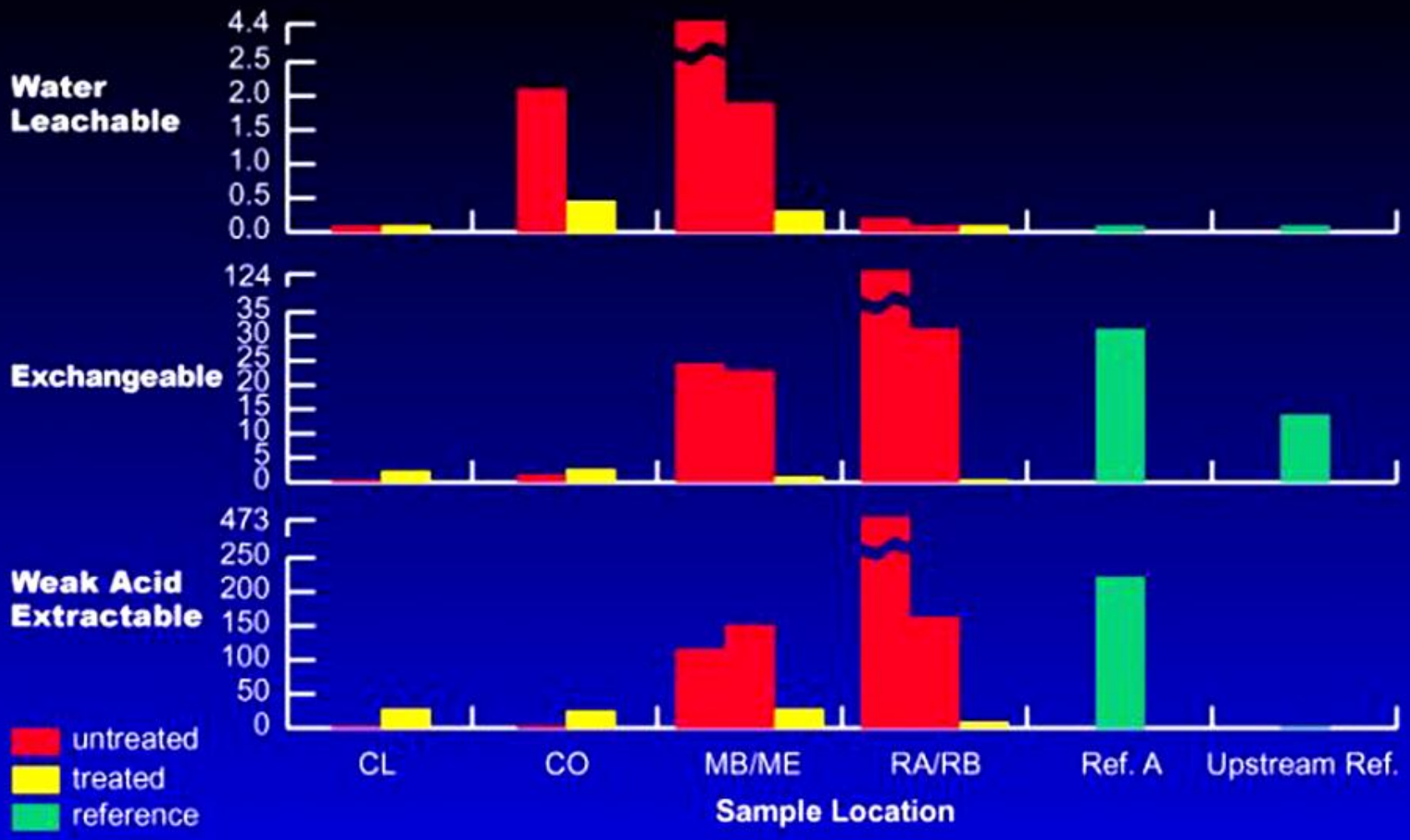
TAL Metals in Soil (mg/kg)



Availability of Zinc in Soil (mg/kg)



Availability of Lead in Soil (mg/kg)



Physical Parameters Measured

pH → increased

TOC → increased

Grain Size Distribution → same

Specific Gravity → same

Water Holding Capacity → increased

Questions for Contaminated Area Amendment Treatment:

Is the amendment just dilution?

Because there was toxicity, will the treatment be permanent?

If amended, what is the residual risk? (Is it now an attractive nuisance?)

Assessment endpoints

Viability and Function of Soil community

Viability and Function of the Terrestrial Vascular plant Community

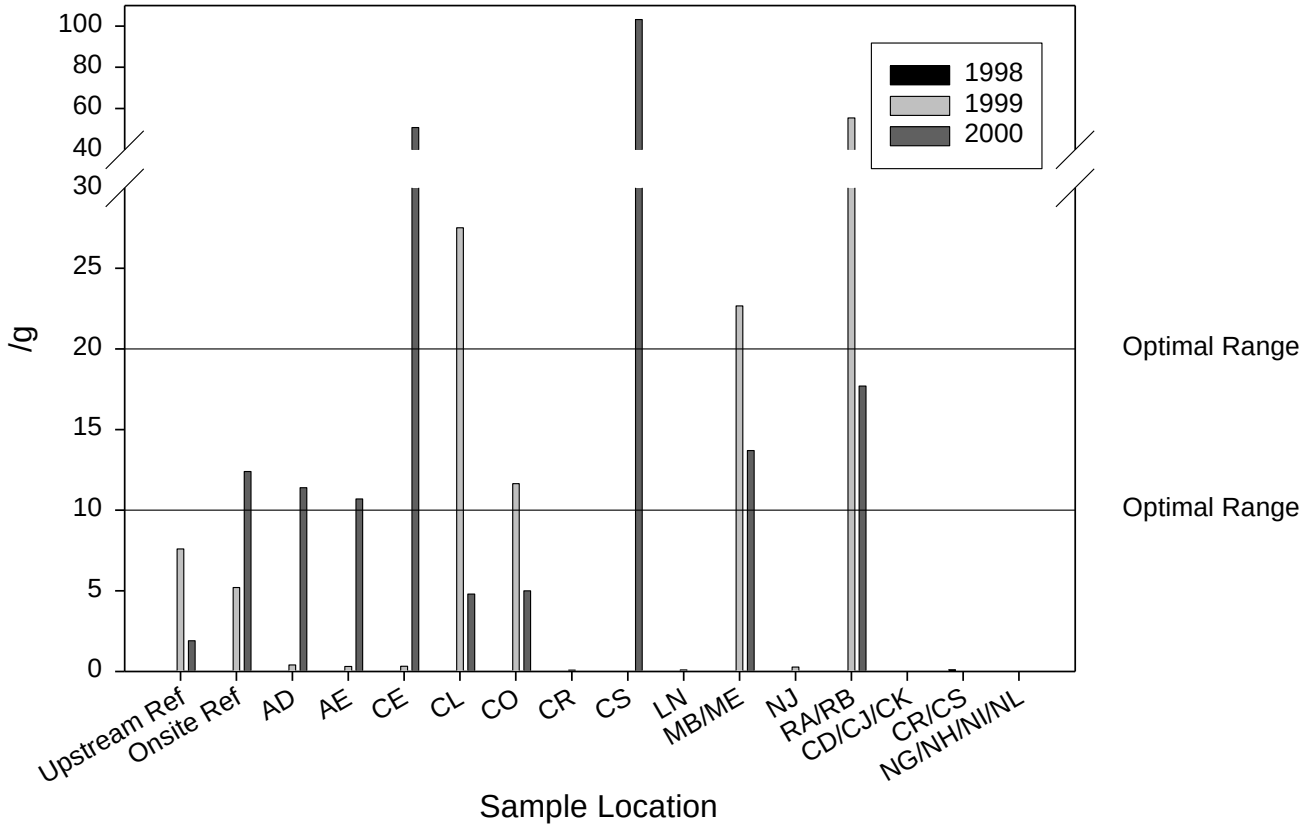
Viability and Function of the Herbivorous Mammal community

Earthworm *(Eisenia foetida)* Assays - Survivorship & Biomass/Organism

Sample	Untreated		Treated	
	Survival (%)	Biomass (mg)	Survival (%)	Biomass (mg)
CL	0	NA	100.0	329.3
CO	0	NA	98.9	323.0
MB/ME	0/0	NA	90.0	372.0
RA/RB	0/0	NA	10.0*	280.3
Ref. A	-	-	98.7	244.0
Upst. Ref.	-	-	96.7	196.0
Lab Con.	100	not measured	100.0	258.6

* significantly < reference samples and/or control sample

Nematodes in Soil
California Gulch Site
Leadville, CO
June 1998 - August 2000



optimal range = 10-20 µg/g (Ingham 2000)

1998 samples - CD/CJ/CK, CR/CS, and NG/NH/NI/NL
1999 samples - references, untreated AD, AE, CE, CR, CS, and NJ and treated CL, CO, MB/ME, and RA/RB
2000 samples - references, untreated LN, and treated AD, AE, CE, CL, CO, CR, CS, MB/ME, and RA/RB

references = Upstream Ref and Onsite Ref
treated with biosolids cake in 1998 - CL, CO, MB/ME, and RA/RB
treated with biosolids compost in 1999 - AD and AE
treated with biosolids pellets in 1999 - CE, CR, and CS

Ryegrass *(Lolium perenne)* Assays - Germination

Sample	Untreated (%)	Treated (%)
CL	0	85.7
CO	0	71.4*
MB/ME	-	100.0
RA/RB	-	90.5
Ref. A	-	95.2
Upst. Ref.	-	90.5
Lab Con.	85.7	95.2

* significantly < reference samples and/or control sample

Ryegrass *(Lolium perenne)* Assays - Mean Shoot & Root Weights/Chamber

Sample	Untreated		Treated	
	Shoot (mg)	Root (mg)	Shoot (mg)	Root (mg)
CL	no germination	no germination	90.20	26.92*
CO	no germination	no germination	36.70	13.18*
MB/ME	-	-	80.50	31.33*
RA/RB	-	-	45.33	12.13*
Ref. A	-	-	27.80	93.86
Upst. Ref.	-	-	64.12	139.37
Lab Con.	9.72	16.26	21.50	9.29

* significantly < reference samples

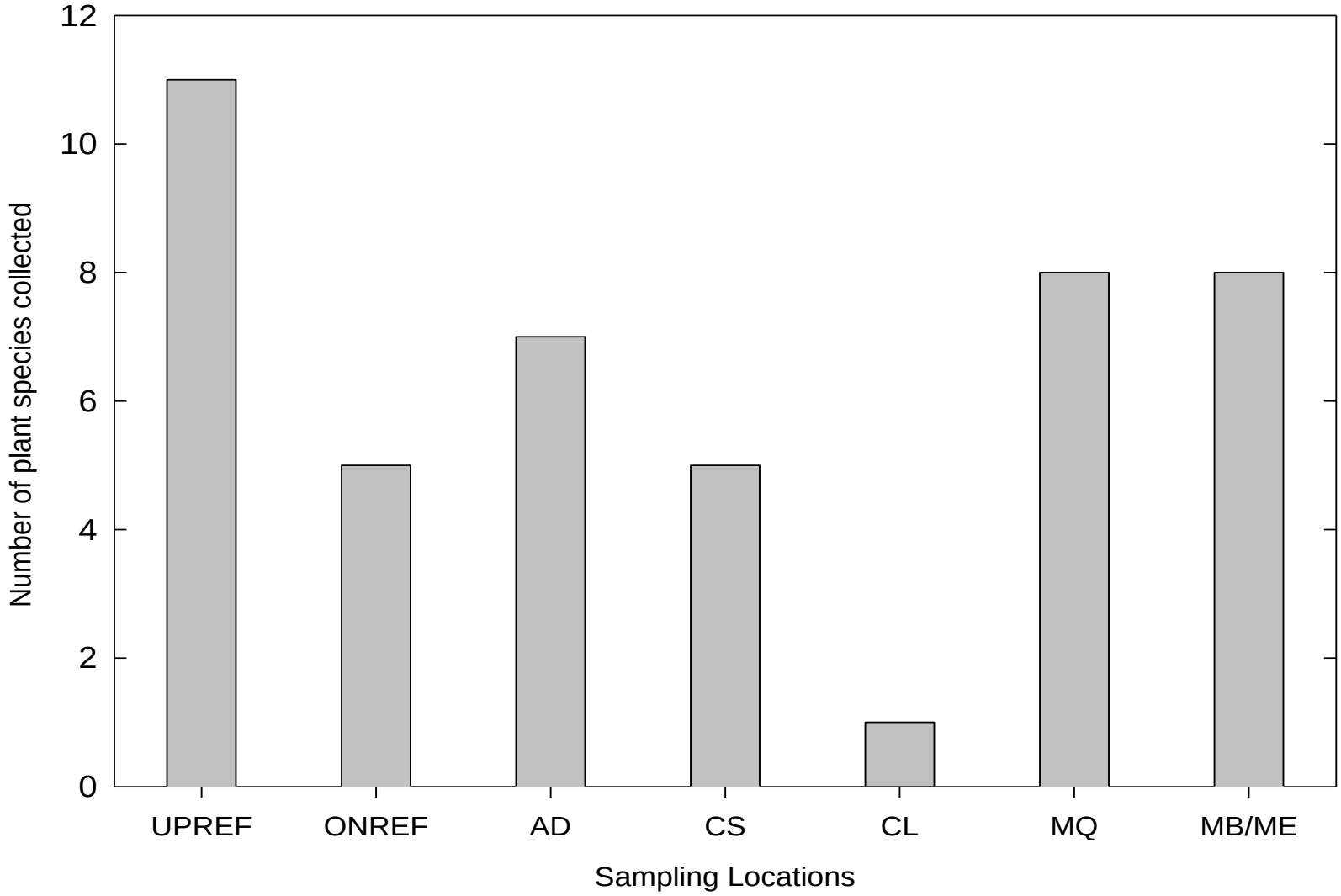
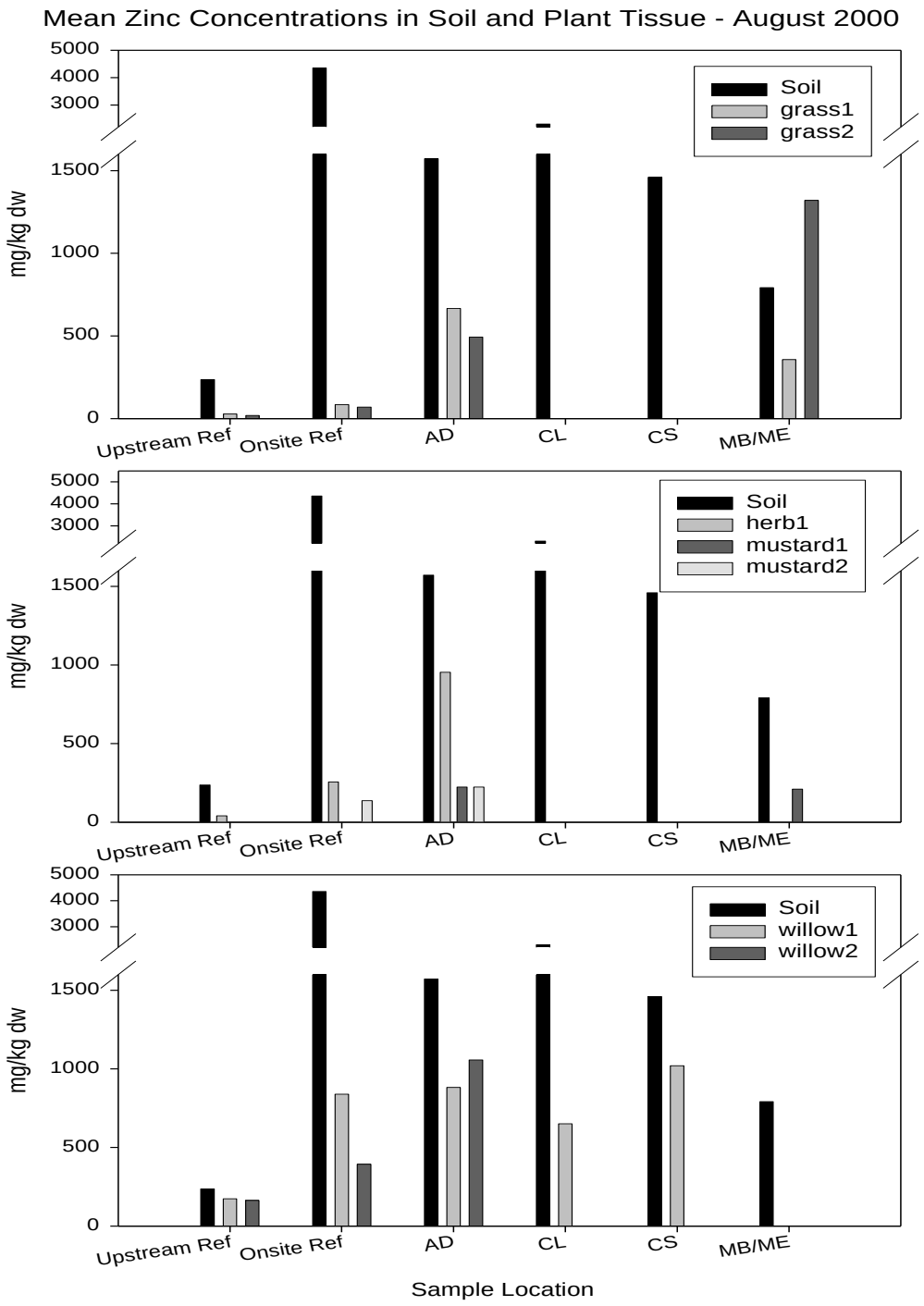
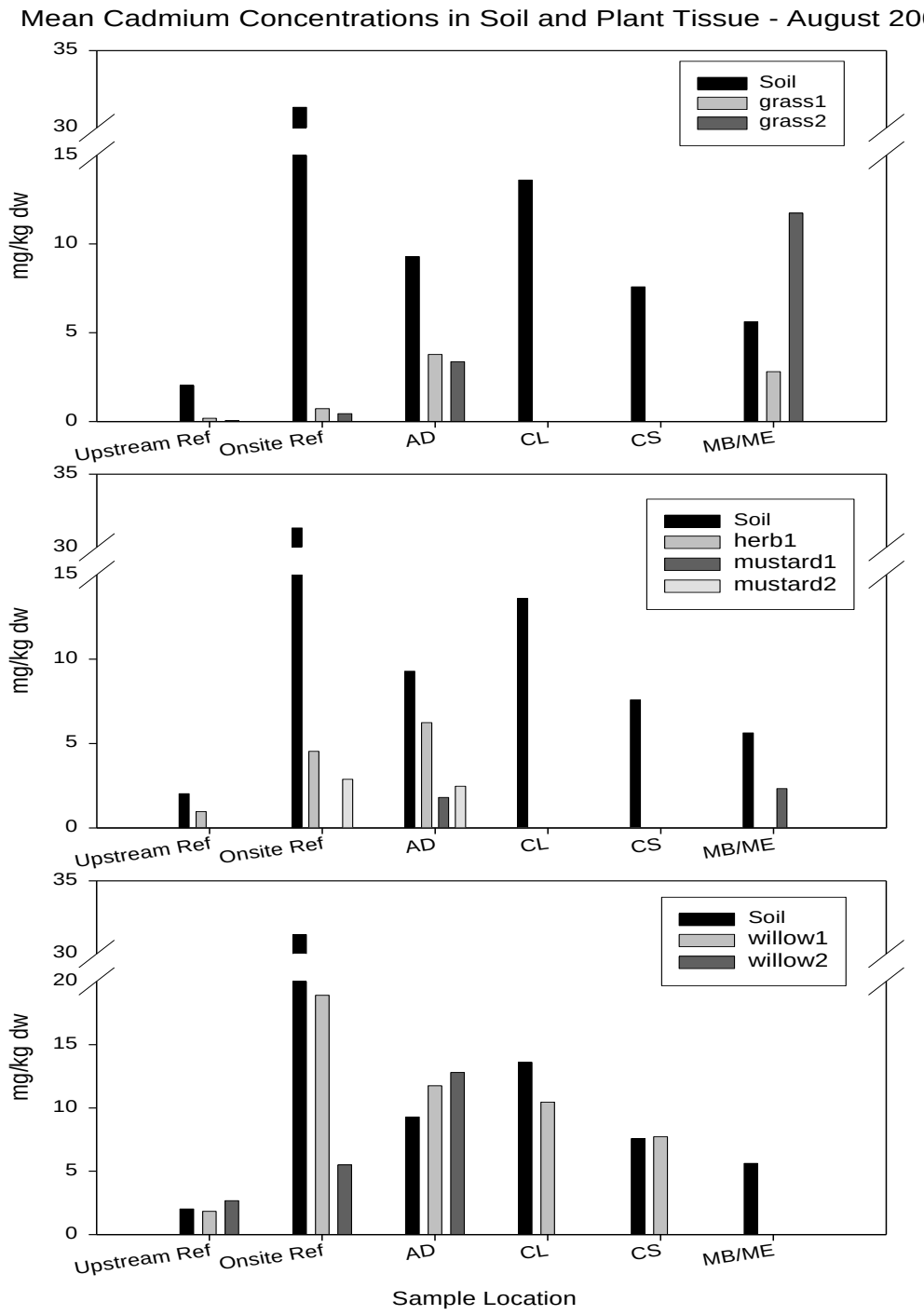


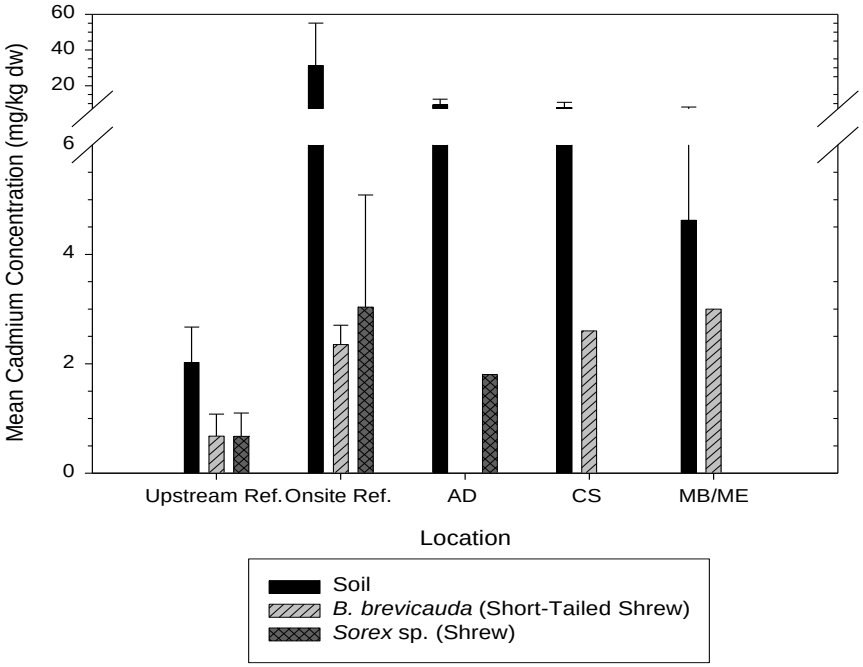
Figure 1. Number of plant species at the California Gulch Superfund Site in August 2001. The values are the number of total plant species identified from the three sampling points at each location.

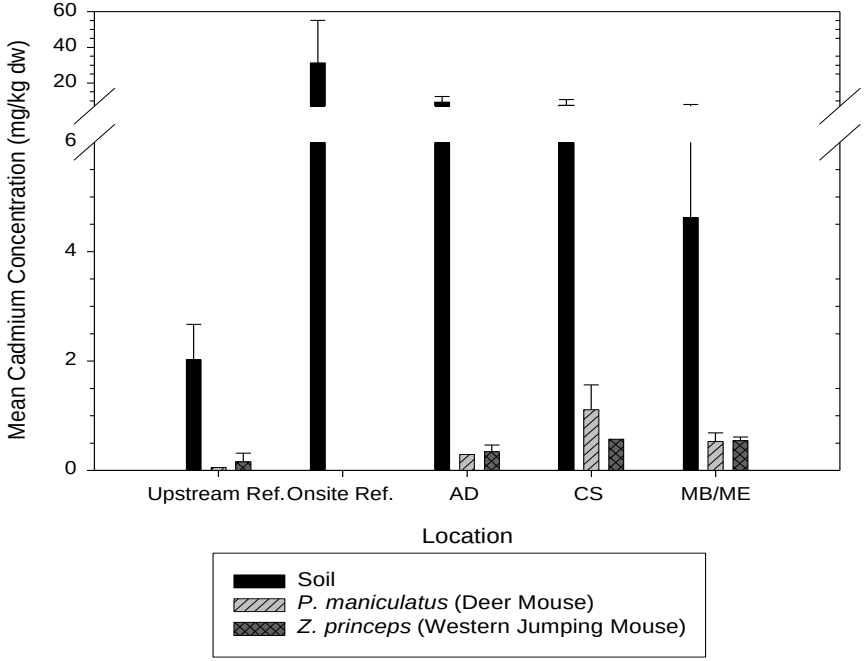
True Value
STANDARD SLOTTED FOLDING

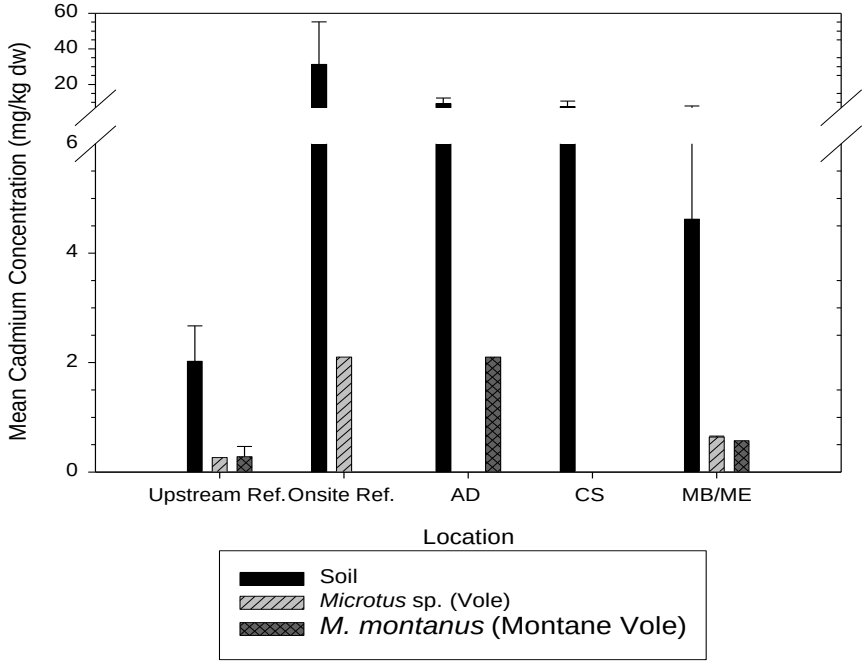

Mean Zinc Concentrations in Soil and Plant Tissue - August 2000
mg/kg dw
5000
4000
3000
1500
1000
500
0
Soil
grass1
grass2
herb1
mustard1
mustard2
willow1
willow2
Upstream Ref
Onsite Ref
AD
CL
CS
MB/ME
Sample Location

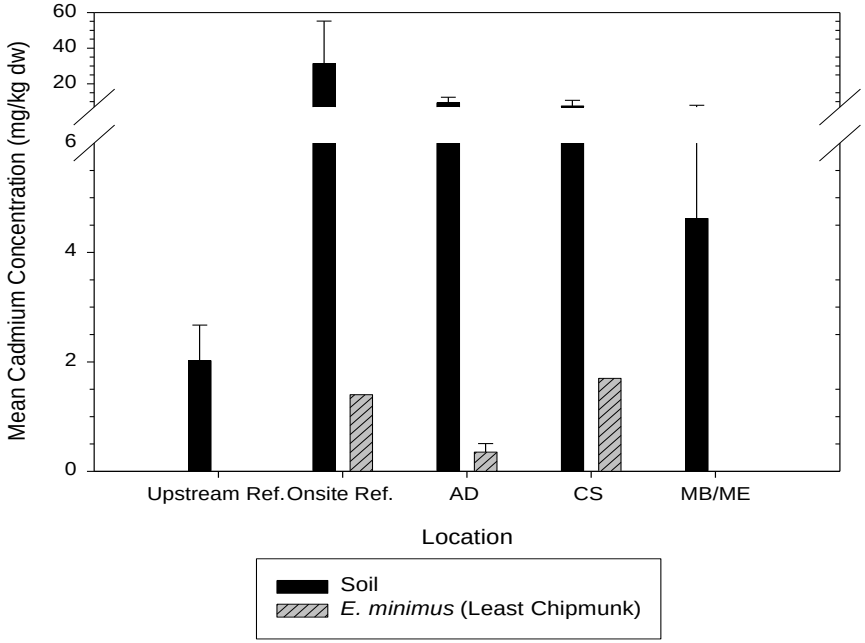

Mean Cadmium Concentrations in Soil and Plant Tissue - August 2000
Soil
grass1
grass2
mg/kg dw
35
30
15
10
5
0
Upstream Ref
Onsite Ref
AD
CL
CS
MB/ME
Soil
herb1
mustard1
mustard2
mg/kg dw
35
30
15
10
5
0
Upstream Ref
Onsite Ref
AD
CL
CS
MB/ME
Soil
willow1
willow2
mg/kg dw
35
30
20
15
10
5
0
Upstream Ref
Onsite Ref
AD
CL
CS
MB/ME
Sample Location

Total Cadmium in Soil and Whole Body Mammal Tissues

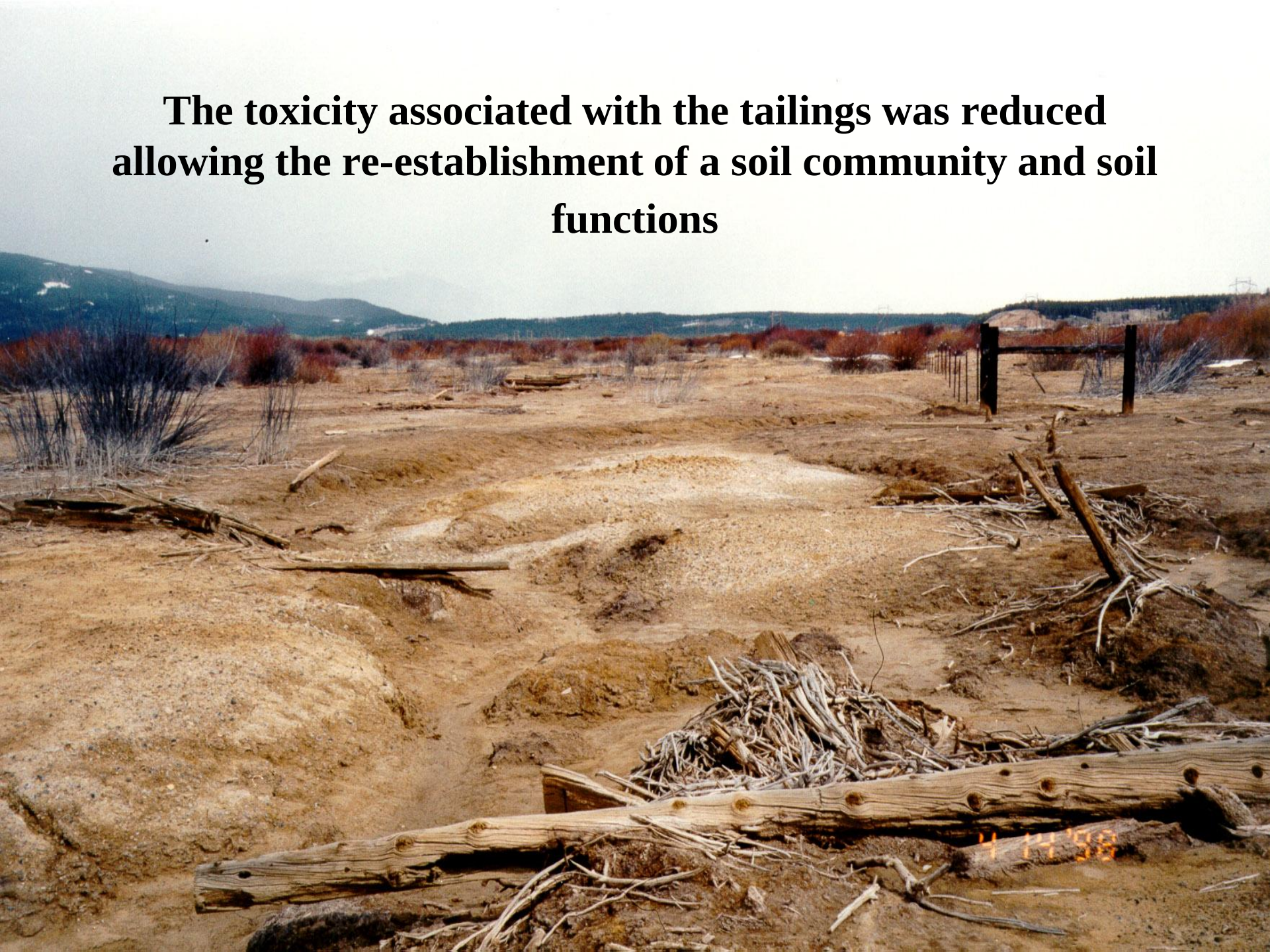


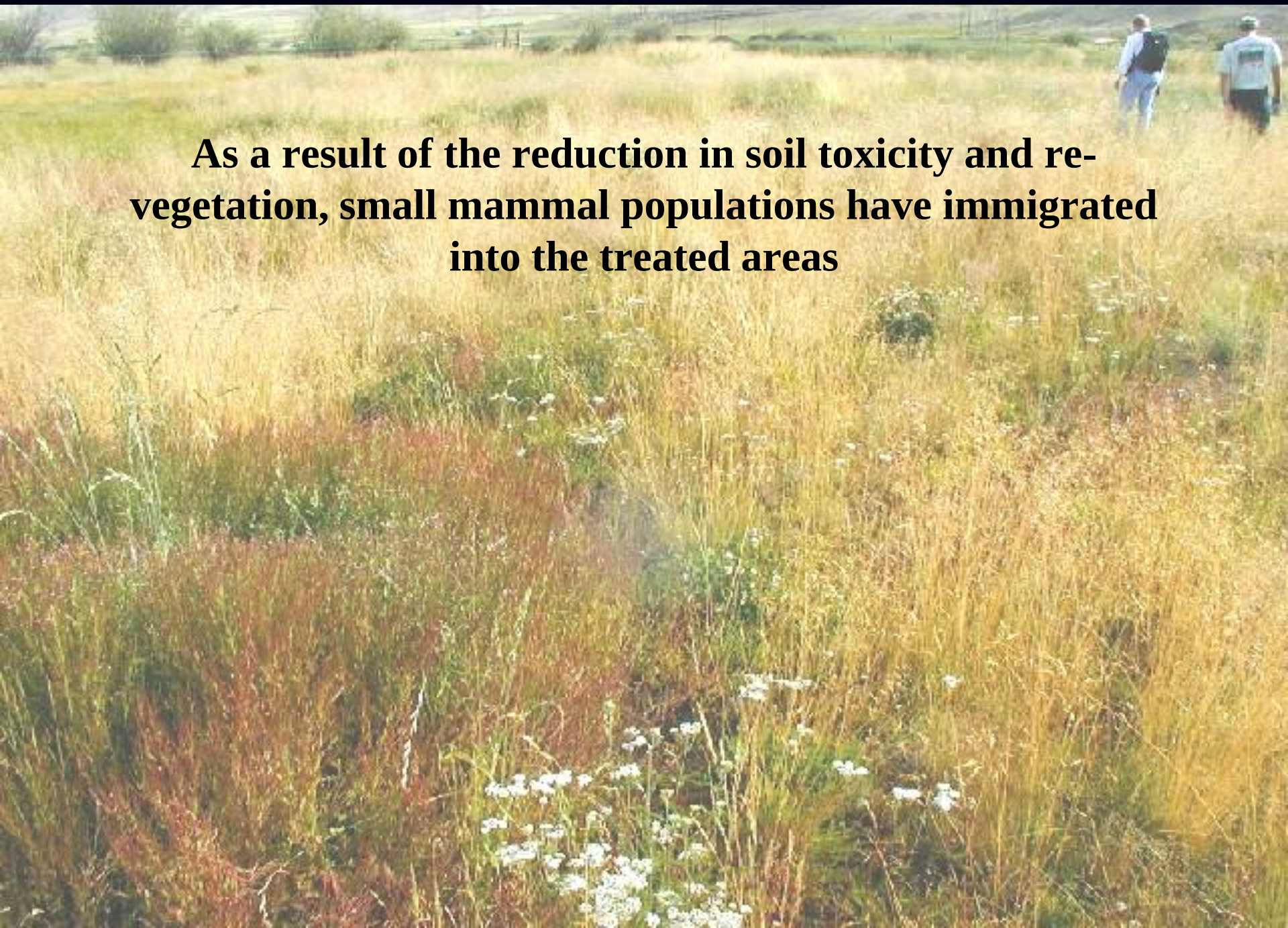






The toxicity associated with the tailings was reduced allowing the re-establishment of a soil community and soil functions





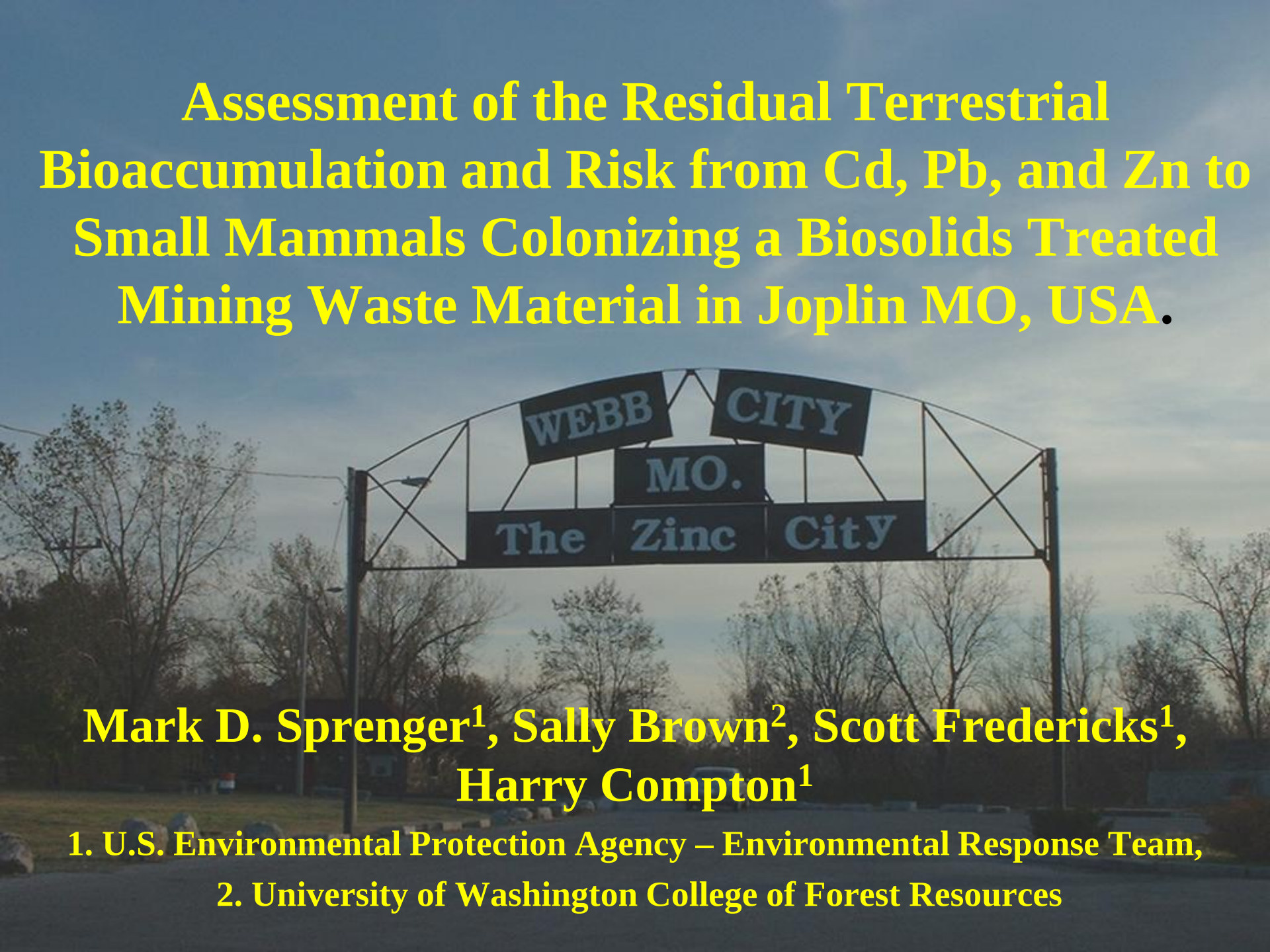
As a result of the reduction in soil toxicity and re-vegetation, small mammal populations have immigrated into the treated areas

Remaining questions:

Has the treatment resulted in a functioning and therefore sustainable ecosystem?

Is the residual risk posed to wildlife acceptable?

Assessment of the Residual Terrestrial Bioaccumulation and Risk from Cd, Pb, and Zn to Small Mammals Colonizing a Biosolids Treated Mining Waste Material in Joplin MO, USA.



Mark D. Sprenger[1], Sally Brown[2], Scott Fredericks[1], Harry Compton[1]

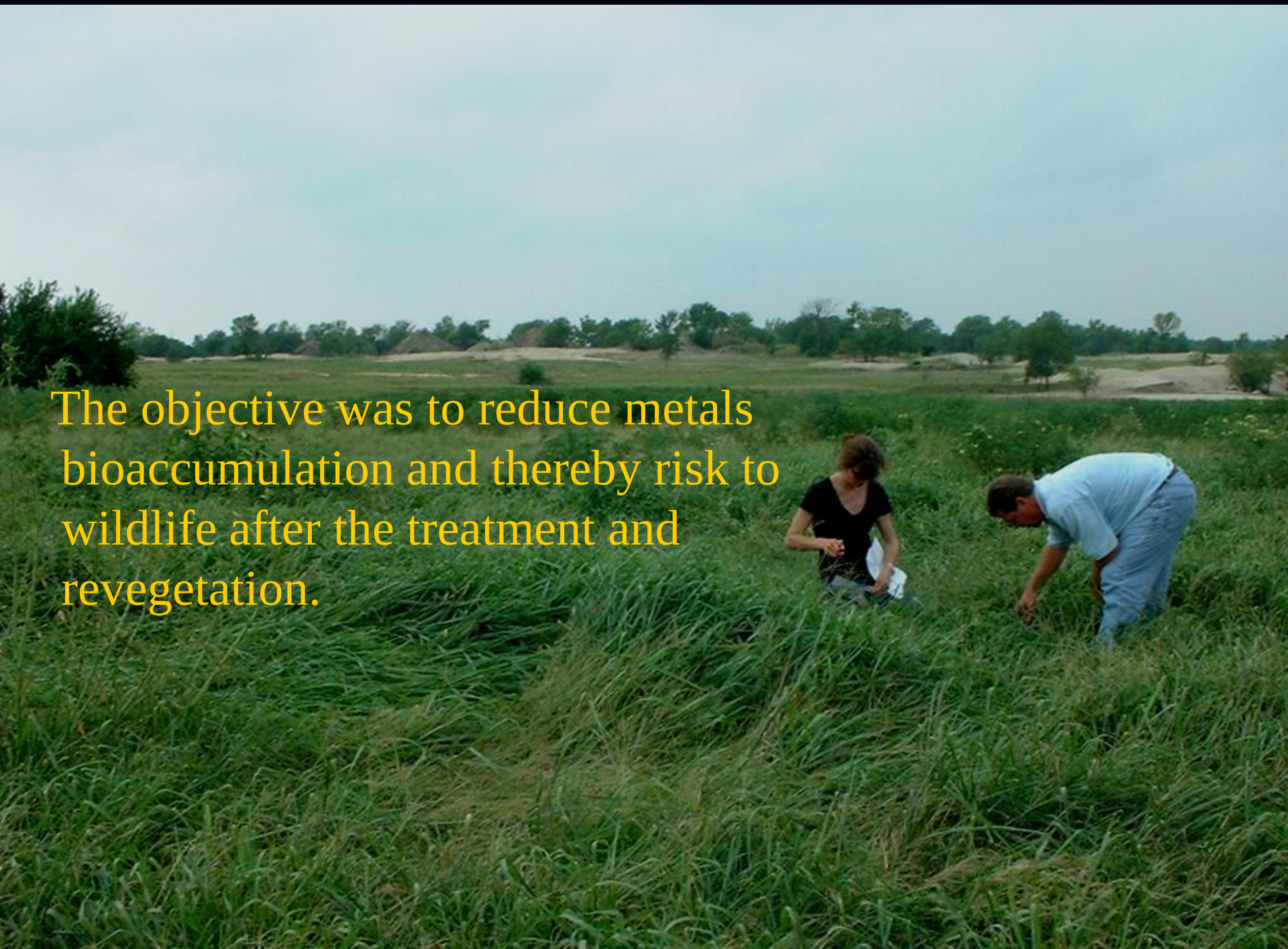
1. U.S. Environmental Protection Agency – Environmental Response Team,

2. University of Washington College of Forest Resources

Joplin MO, USA is located within what is referred to as the tri-State Mining District which covers an approximately 2500 square mile area in southwestern Missouri, southeastern Kansas, and northeastern Oklahoma.

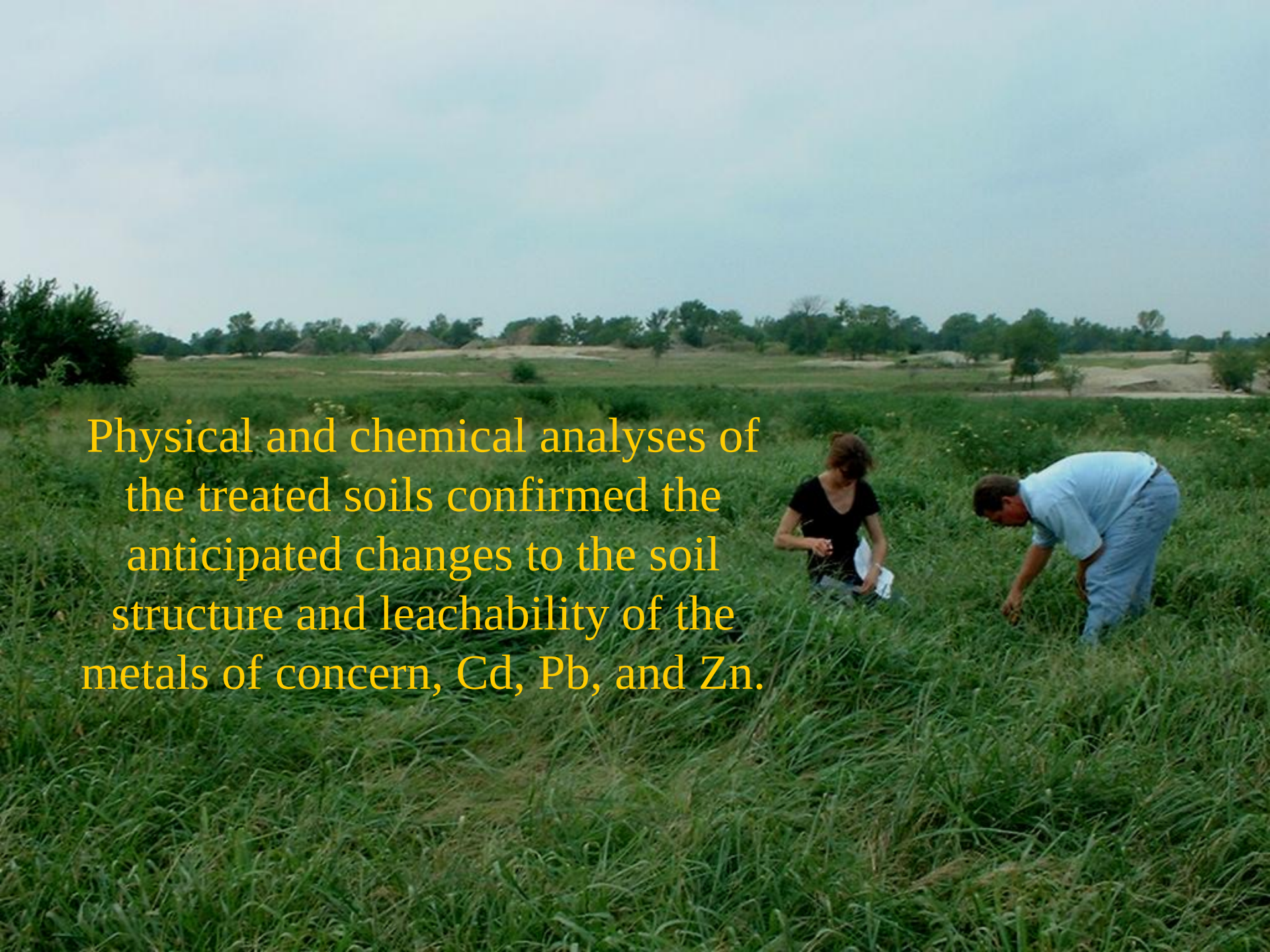
The primary metals of concern are Cd, Pb and Zn.

Several repository areas for contaminated soils and mining wastes were identified as pilot scale treatment areas. These areas were treated with biosolids and seeded for revegetation.



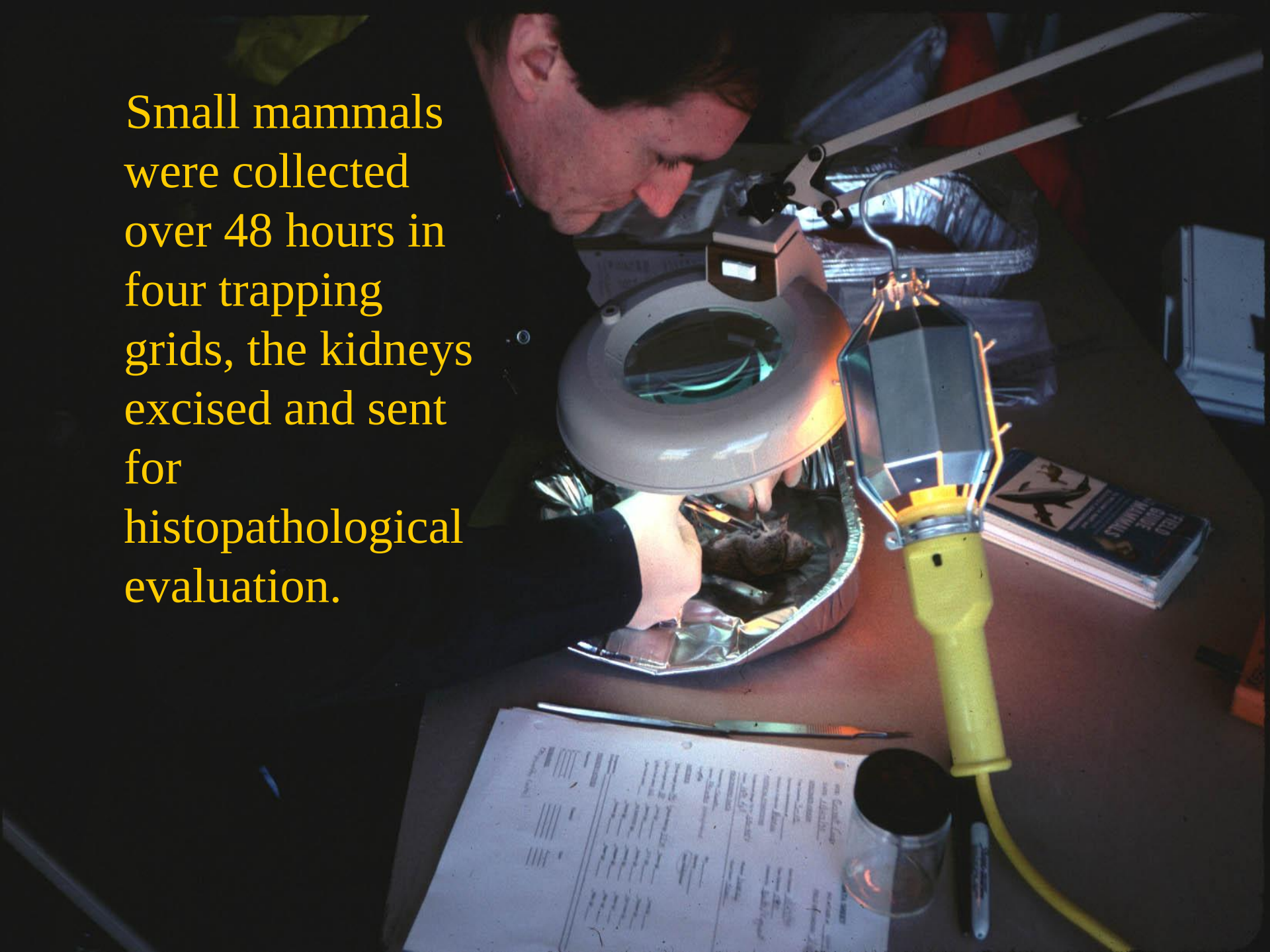
The objective was to reduce metals bioaccumulation and thereby risk to wildlife after the treatment and revegetation.

Within 9 months post
treatment, all areas had
heavy vegetative cover.



Physical and chemical analyses of the treated soils confirmed the anticipated changes to the soil structure and leachability of the metals of concern, Cd, Pb, and Zn.

A small mammal sampling effort was conducted to evaluate the bioaccumulation of metals of concern (Cd, Pb, and Zn).



Small mammals were collected over 48 hours in four trapping grids, the kidneys excised and sent for histopathological evaluation.

Mammal Trapping

- Overall Trapping Success
  18.9 %
- Total of 98 animals retained (five species)
- 94 kidney samples submitted for histopathology evaluation
- 37 subset of the 94 kidneys sent for Cd, Pb, and Zn analyses

Histopathology Results

- All Kidney Samples
- 9 could not be evaluated
- 61 no evidence of pathology
- 22 pathology consistent with metals exposure
- 2 pathology concludes metals exposure

- 37 kidney subset
- 1 could not be evaluated
- 27 no evidence of pathology
- 7 pathology consistent with metals exposure (included shrew)
- 2 pathology concludes metals exposure

Metals in Soil and Kidney (mg/kg dw)

	Area			
	A	B	C	D
Cd				
Kidney – median	12	19	3.6	6.9
(range)	(1.4 – 28)	(3.4 – 32)	(1.7 – 11)	(2.2 – 36)
shrew n=1				60
Soil	15	15	3.2	4.9
Pb				
Kidney – median	3.8	15	1.8	0.6
shrew n=1				5.6
Soil	300	2100	160	110
Zn				
Kidney – median	71	73	74	70
shrew n=1				115
Soil	2100	2200	510	630

Kidney Summary Relative to Cd

27 kidneys with no apparent pathology
(Cd range 1.4 – 36 mg/kg dw)

7 kidneys with pathologoly consistent with metals exposure
(Cd range 2.1 – 60 mg/kg dw)

2 kidneys with evidence of metals exposure
(Cd 2.7 and 4 mg/kg dw)

Cadmium

- Twenty four percent of the organisms evaluated showed some evidence of cellular level response to metals (Cd) exposure.
- There was no dose response relationship found.
- The conclusion of the pathology report was that there was some evidence of pathology in the kidneys of some of the animals but that the level of kidney effect was insufficient to “completely interfere with normal function”.

Palmerton, PA, 1980; Dead Ecosystem on Blue Mountain.

Palmerton, PA, 1990; Early large scale application of biosolids + flyash established grasses on Blue Mountain.

Plamerton Zinc Area 2

(mean concentration mg/kg dw)

	Soil	plants	microtus (whole body)
Cd	64	3	BD
Cu	1700	36	9.3
Pb	850	40	7.5
Zn	45000	600	177