Revegetation and Soil Function Evaluation at Leviathan Mine

Vic Claassen
Land, Air and Water Resources
UC Davis

Fall 2013 Field Tasks:

1. Evaluation of plant cover: Pit, Pond 2 slopes, and Delta Slope
    + Line transects of live and dead plant litter
2. Evaluation of existing substrate growth conditions associated with plant transects.
    + Infiltration (rainfall simulator and tension infiltrometer)
    + Moisture retention (lab analysis of water content)
    + Acidity (intensity and buffering), and
    + Nutrient availability (conventional soil fertility analysis with threshold values)
3. Prepare field plots at each location addressing growth conditions

2014 Field Tasks:

+ Measure plant cover and growth conditions
+ Measure field trial plots showing potential treatments
+ Measure associated substrate growth conditions

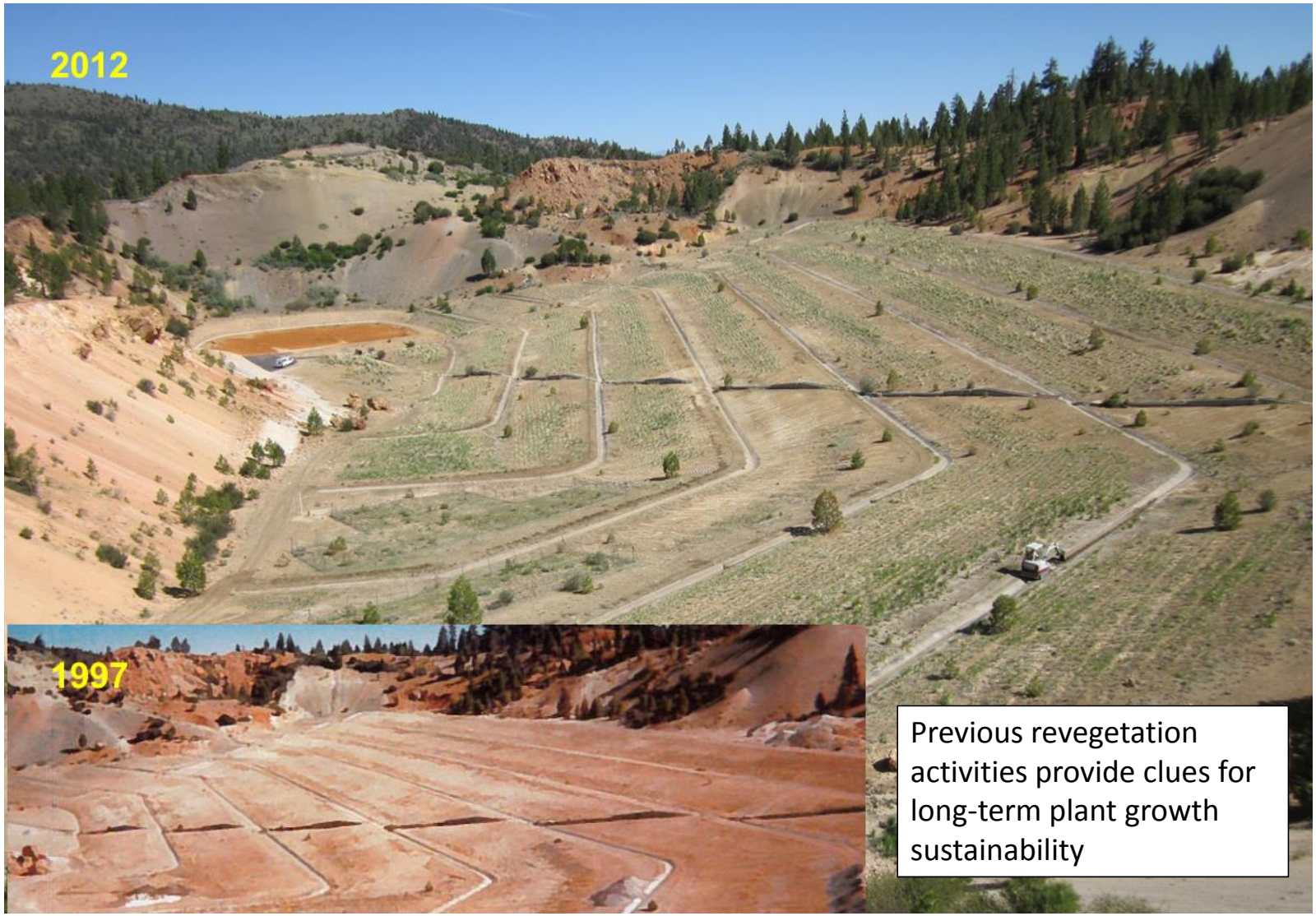
2015 Lab Analysis Tasks:

+ Evaluation of organic matter residues in substrates
+ Carbon pool sizes and stable carbon fraction analysis
+ Nutrient release through organic decomposition
+ Soil aggregation properties
+ Basic soil hydrology evaluation

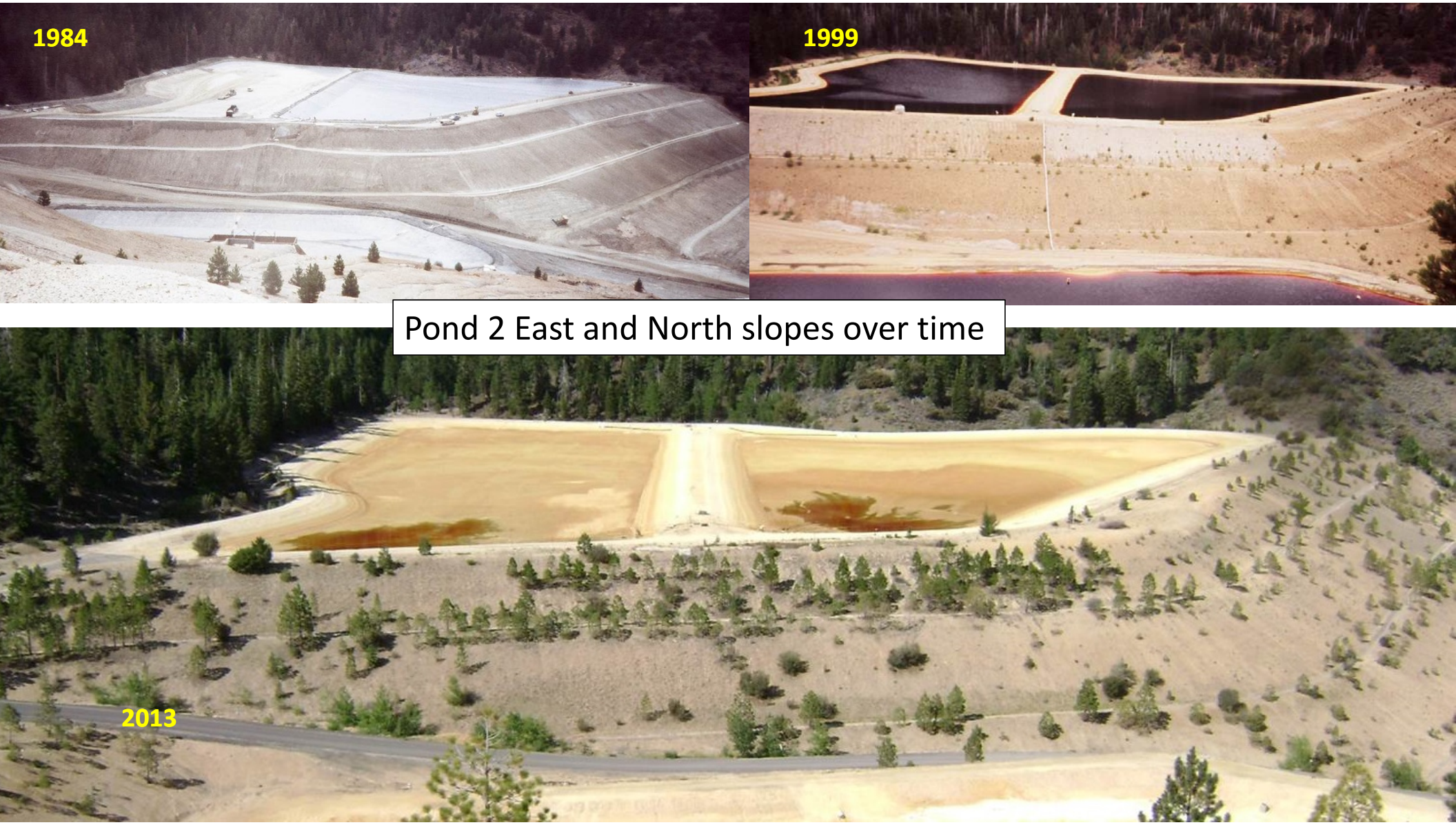
Application to Site Management:

+ Reduce sediment mobilization from surface flows and dust mobilization from wind scour
+ Reduce surface sloughing by increased vegetative cover and root strength
+ Reduce deep percolation by increasing transpiration and reducing subsurface saturation

Map of vegetation evaluation plots in the Pit, Pond 2 North and the Delta Slope areas.



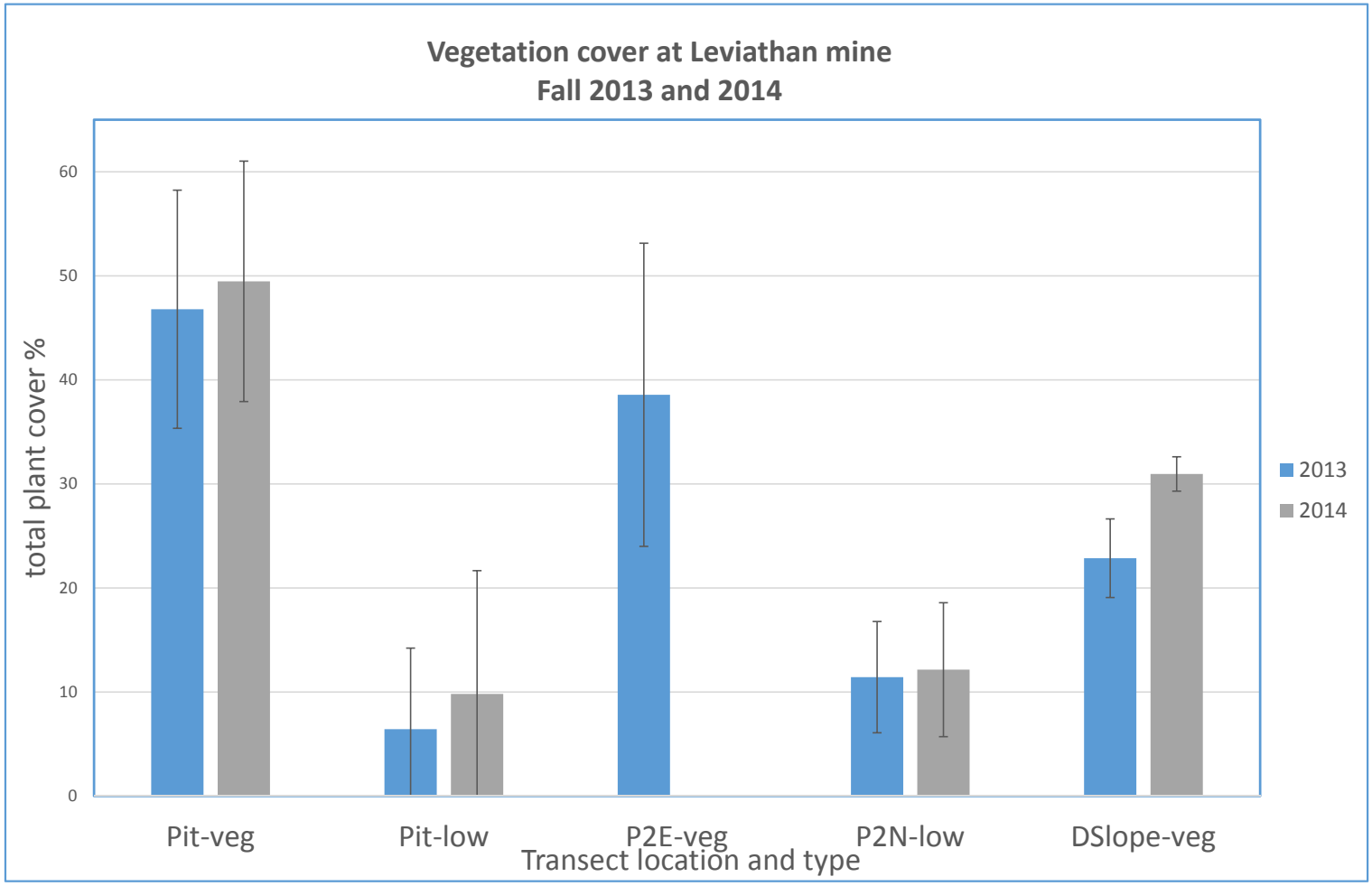
Previous revegetation activities provide clues for long-term plant growth sustainability


1984
1999
Pond 2 East and North slopes over time
2013

Delta Slope Stabilization Project during grading 2005

Delta Slope in 2013

Plant cover measured by point intercept line transects. Transects are oriented at an angle to fit in the band of low vegetation at toe slope positions.



Plant cover did not decrease in the second dry season.

Larger relative increases in the DS plots may be due to the more recent lime addition.

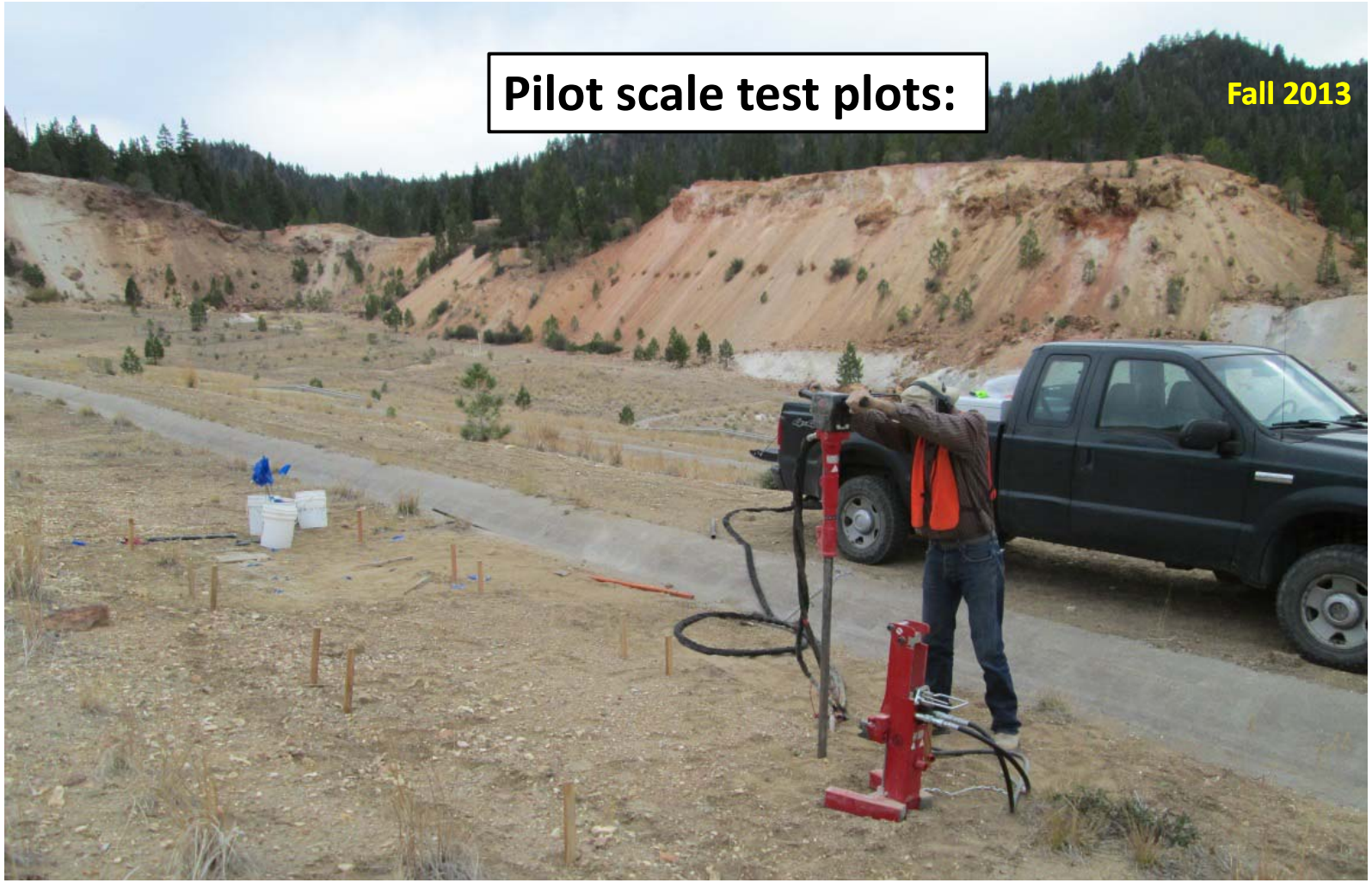
Observations:

+ vegetation cover appears stable but remains sparse on some areas
+ limited depth of rooting attributed to acidity or compaction or poor structure
+ steep slopes not accessible to heavy machinery

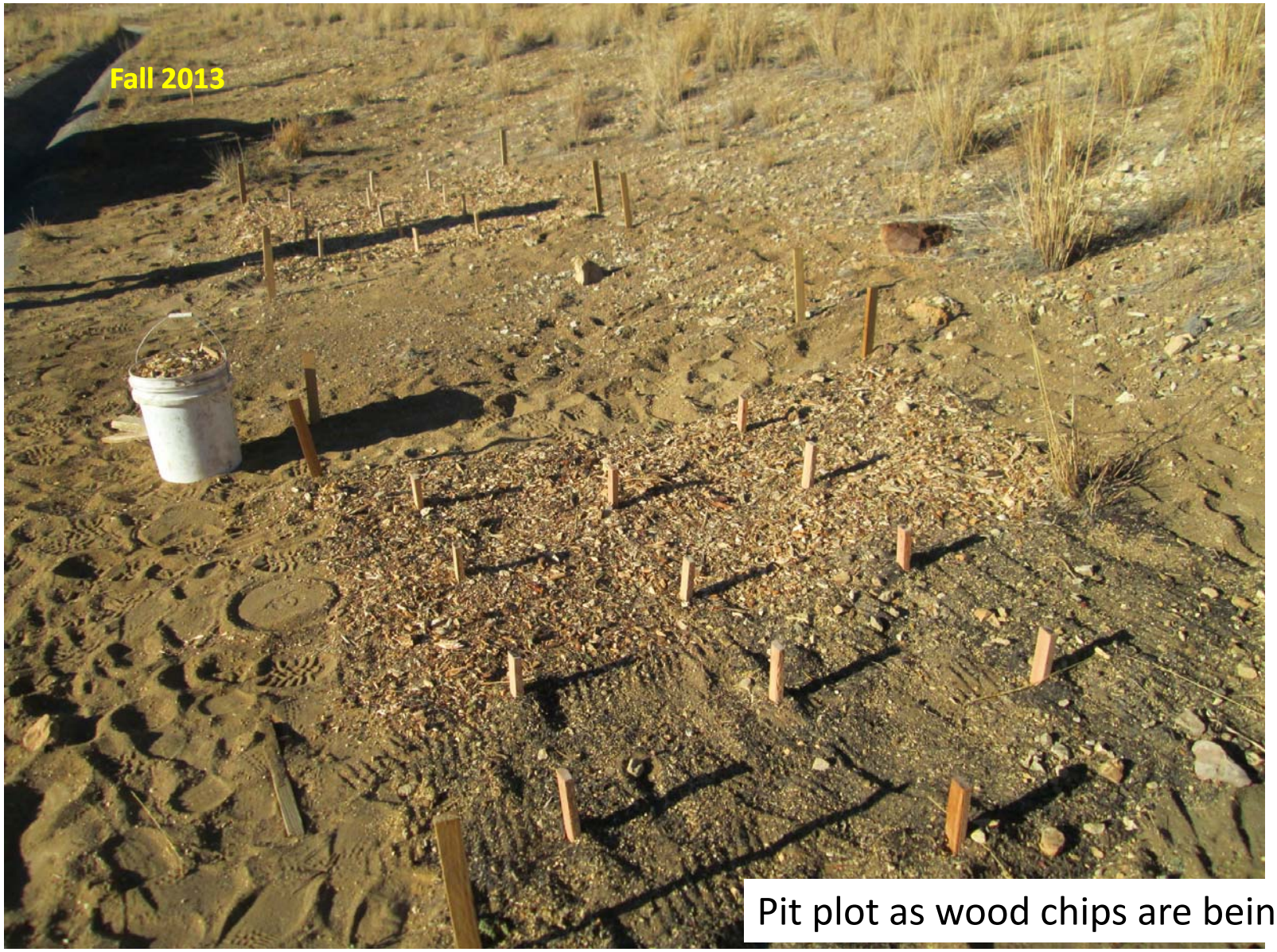
Approach:

+ pilot scale treatment plots to facilitate deep rooting and increase plant growth
+ portable hydraulic hammer with a bit enclosed in a casing sleeve
+ lime to neutralize rooting depth injected through the casing sleeve
+ modest compost / organic component (10% v/v)
+ create deep rooting channel with minimal surface excavation

(full scale method would amend/mix by lifts or rip/incorporate existing slope)



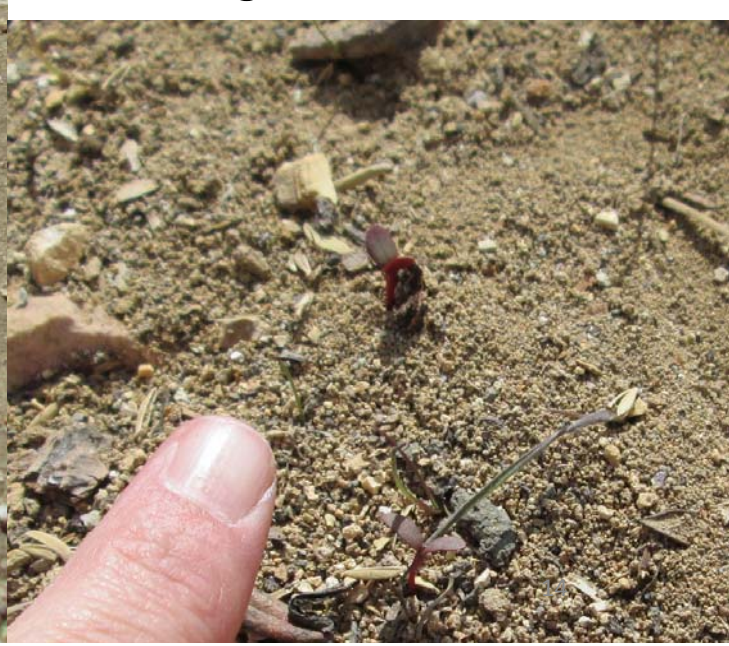
Pilot scale test plots: (amended to 1 m (3 ft)) in bare toe slope area in the pit.



Pit plot as wood chips are being spread

Dense seedling germination on Pond 2 North plot during spring when damp with snow melt.

Completed Pond 2 North plot after first winter. Surface sloughing generates down-slope creep of mulch and uproots small emerging seedlings.



Pond 2 North test plot showing plant cover prior to summer dry spell

Seedlings germinating on the shallow rooting (areas between the stakes) dried by mid-summer. Seedlings close to the rooting column treatment continued to grow until Fall.

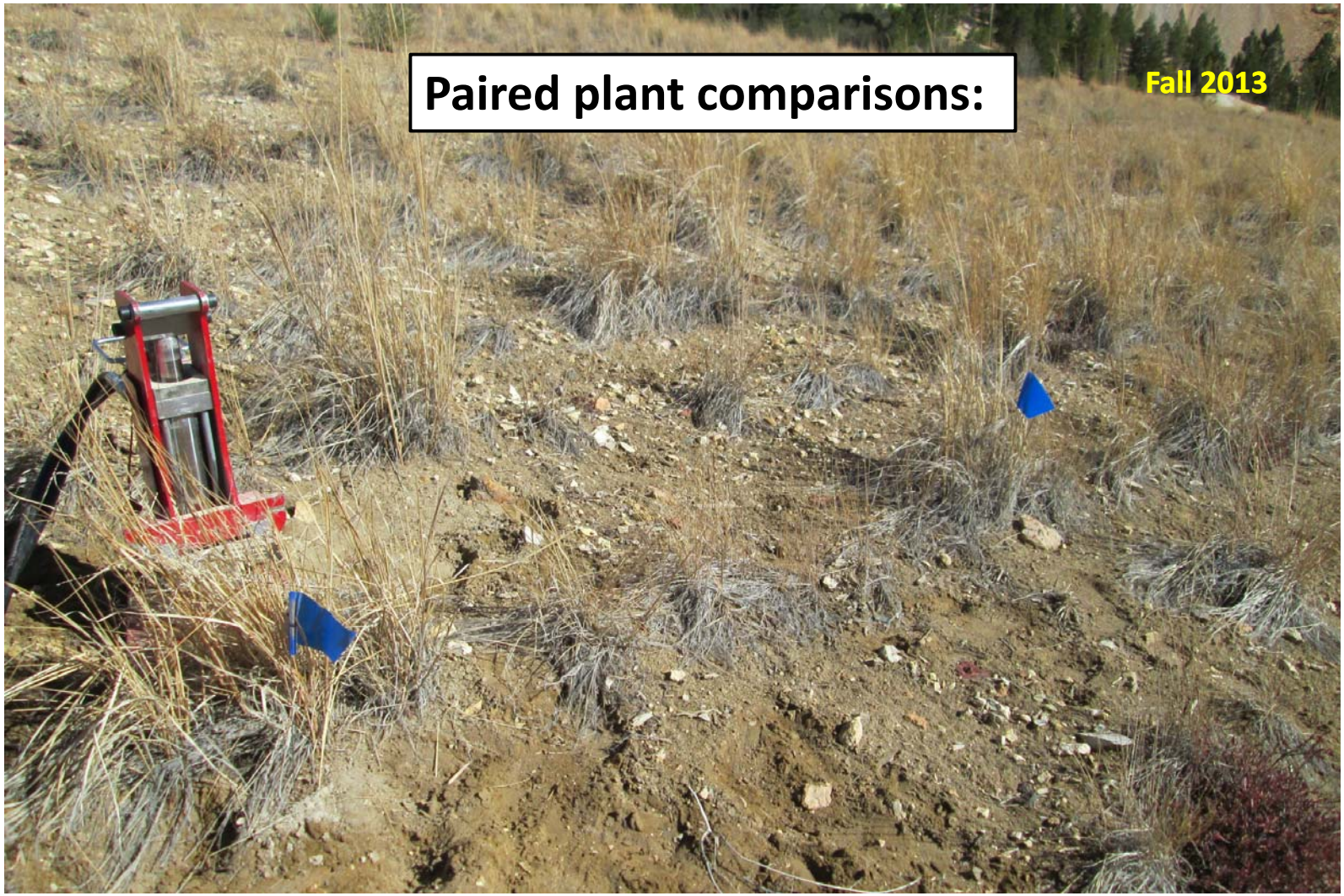
Delta Slope	means	S vs B?
100 cm plot	(cm)	*p* =
XS	476.5	0.0070
XB	95.3	
75 cm plot		
XS	414.0	0.0498
XB	52.7	
50 cm plot		
XS	472.0	0.0185
XB	33.3	

P2N	means	S vs B?
100 cm plot	(cm)	*p* =
XS	411.3	0.0047
XB	140.3	
75 cm plot		
XS	201.8	0.1617
XB	132.6	
50 cm plot		
XS	280.6	0.0808
XB	102.8	

PIT	means	S vs B?	100 vs 75?
100 cm plot	(cm)	*p* =	*p* =
XS	356.0	0.0093	0.324
XB	83.8		0.059
75 cm plot			
XS	264.75	0.0005	
XB	41.5		

Total leaf length and *p* values of mean separation for quadrats centered on the treatment column (XS) versus nontreated (XB).

Mean plant size was always larger in the treatment (XS) and the difference was generally significant.



Paired plants in the pit area, with amended (left blue flag) and unamended control (right).

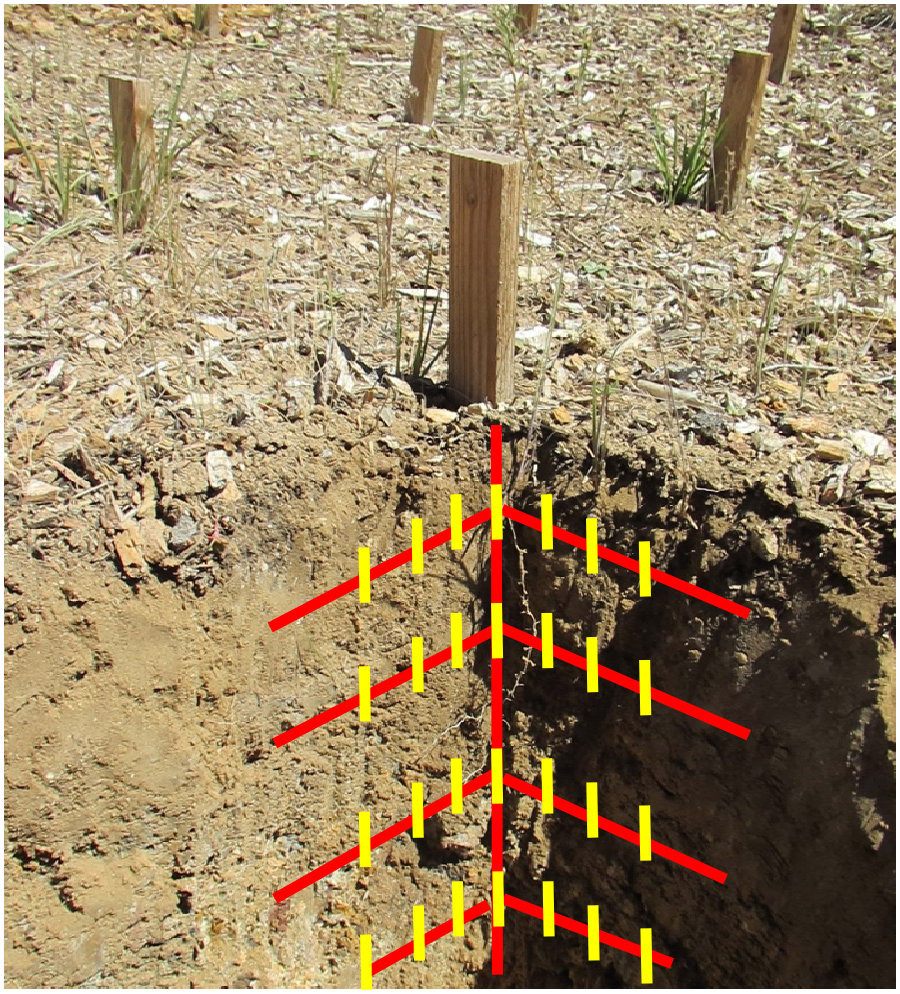
Examples of plant clumps used for paired plant comparisons on Pond 2 North.

Growth comparisons of paired plant clusters following deep lime / compost amendment			
treatment	previous year	current year	active green growth
Pit control	0.164 g/cm^2	0.217 g/cm^2	0.037 g/cm^2
Pit amended	0.156 g/cm^2	0.271 g/cm^2	0.110 g/cm^2
relative growth ratio	0.95	1.25	2.97

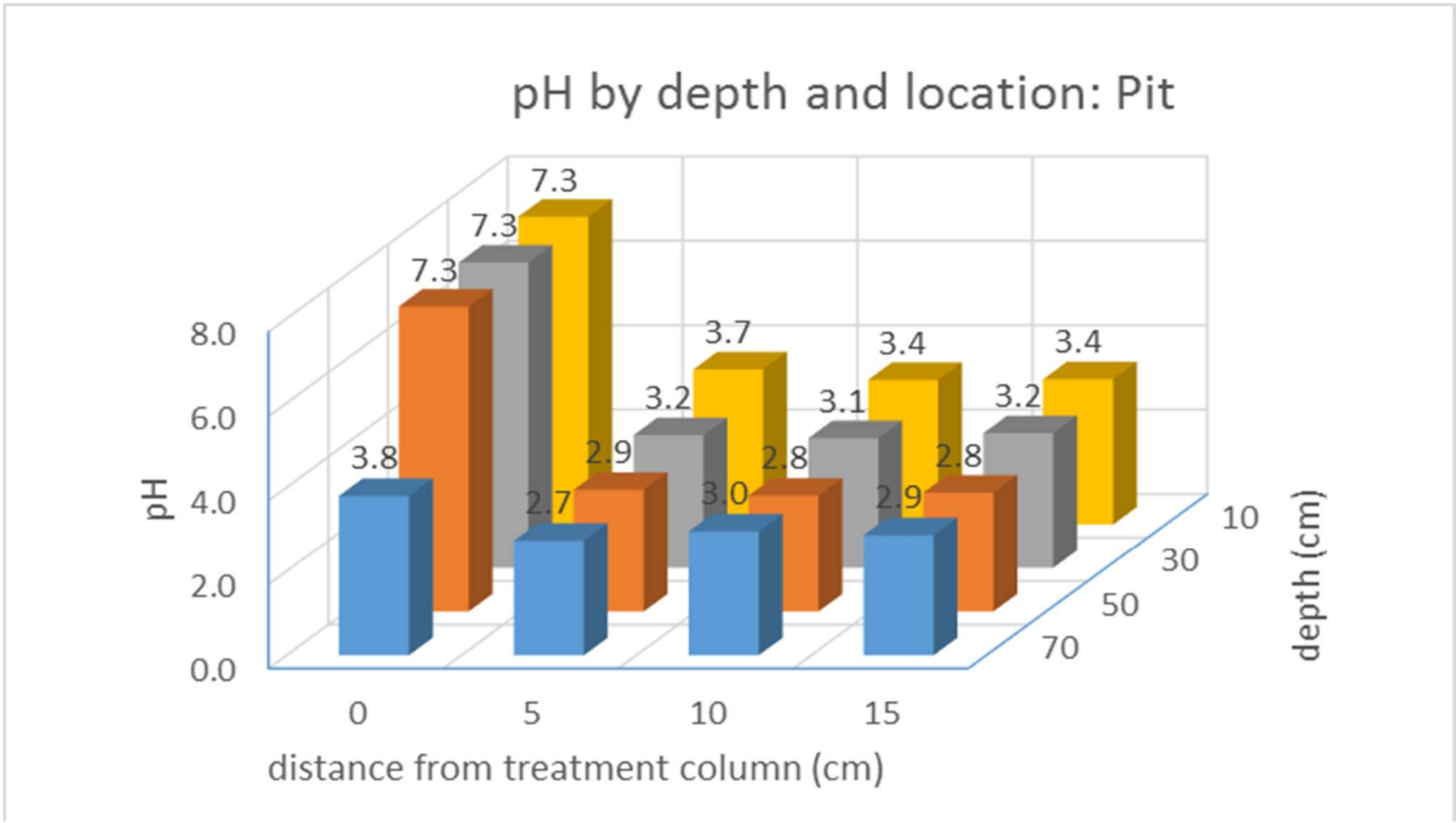
Established grasses growing near a vertical rooting column grew larger and had nearly three times greater transpiration surface in late summer.

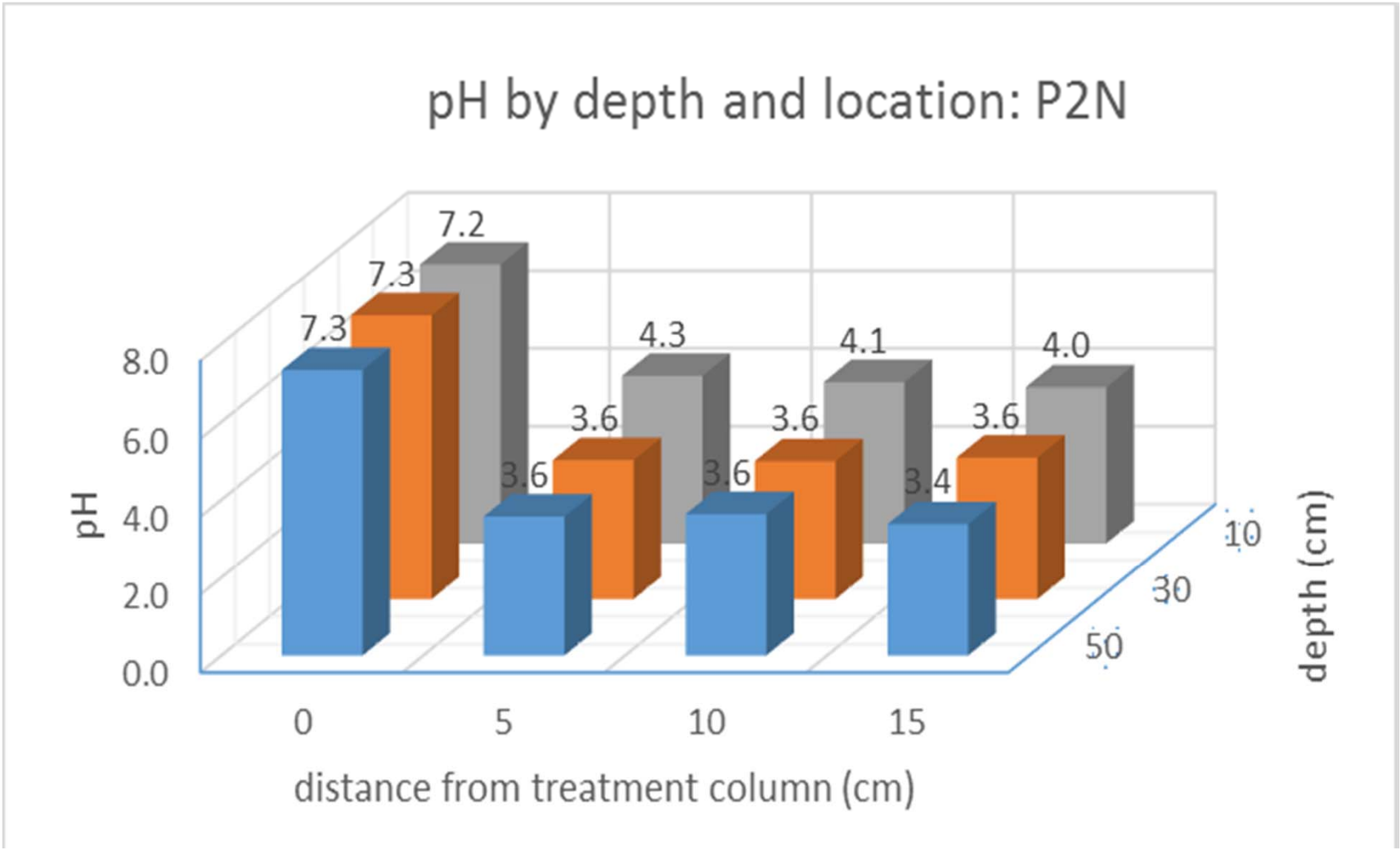
Vertical rooting columns (brown cylinder) created by cased jackhammer bit. Roots followed column down to depth.

Vertical rooting columns created by cased jackhammer bit (right). Substrate was sampled for pH 0, 5, 10 and 15 cm from the column and at 10, 30, 50, and 70 cm depths (yellow).

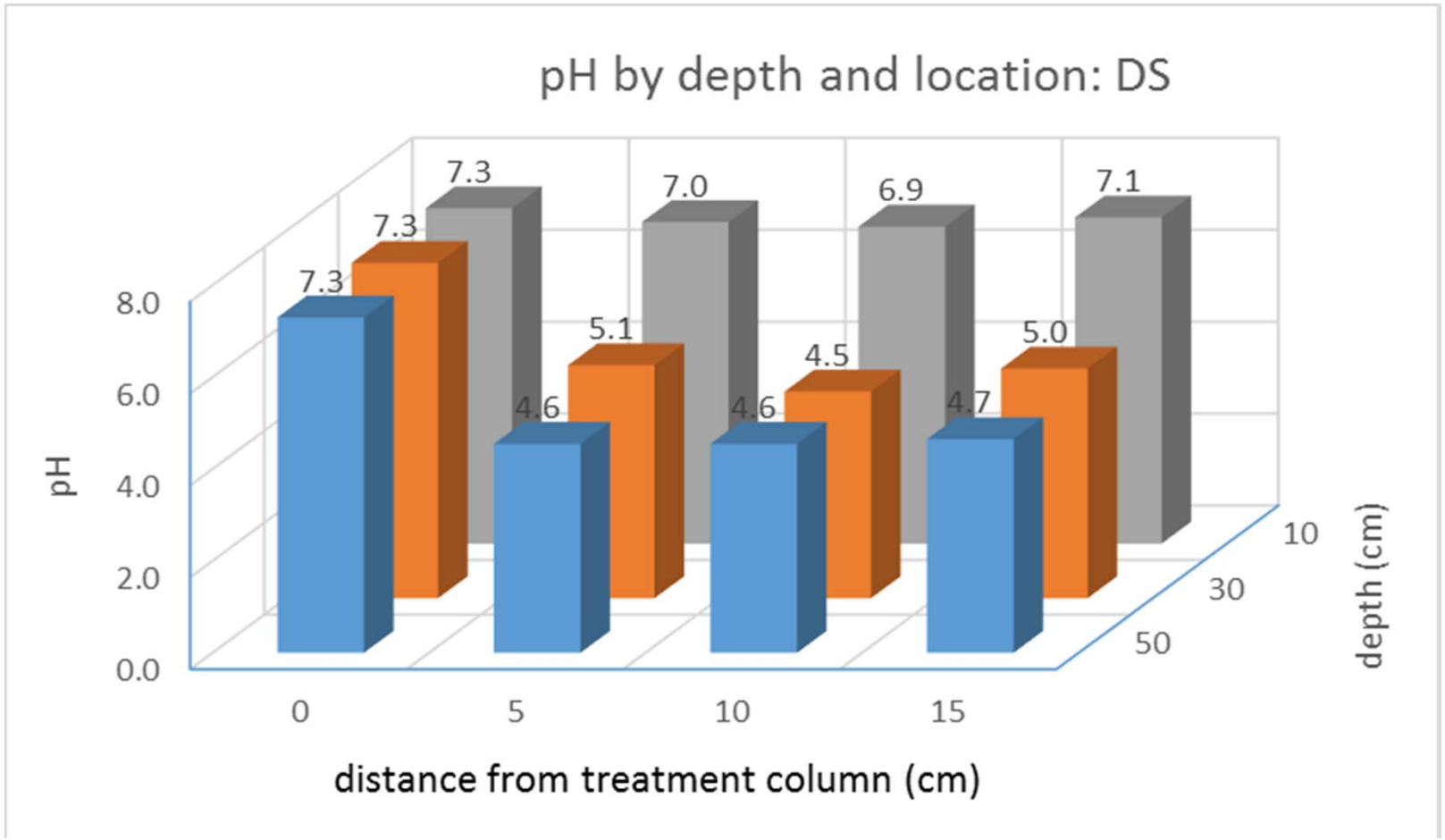


Treatment delivered alkalinity to the whole column but unamended subsurface substrates remain critically acidic.

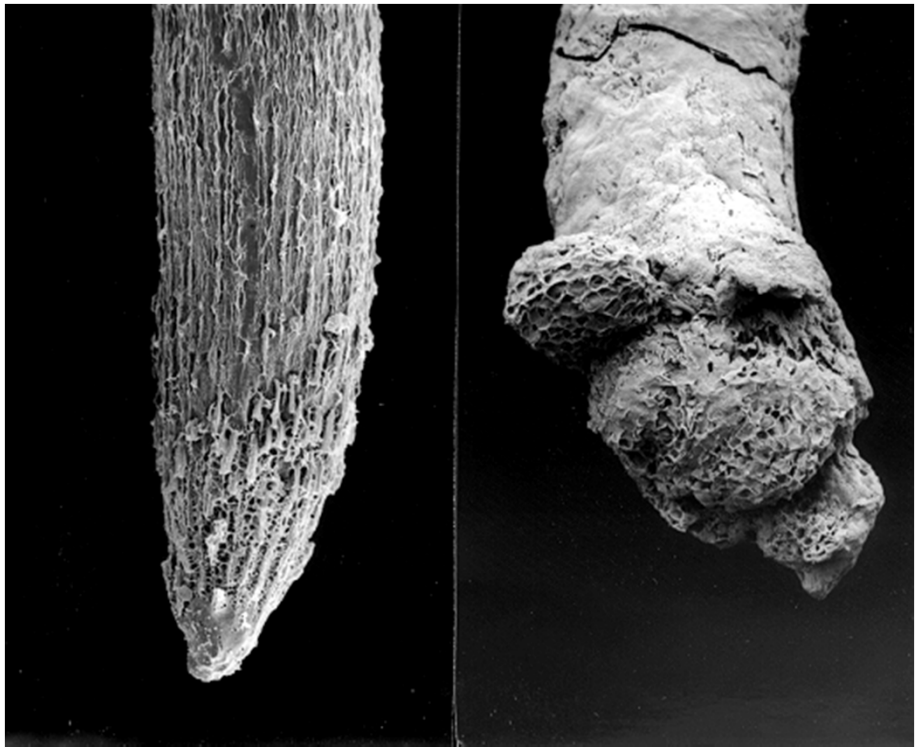



pH by depth and location: P2N
7.2
7.3
7.3
4.3
4.1
4.0
3.6
3.6
3.6
3.6
3.4
8.0
6.0
4.0
2.0
0.0
pH
0
5
10
15
distance from treatment column (cm)
10
30
50
depth (cm)

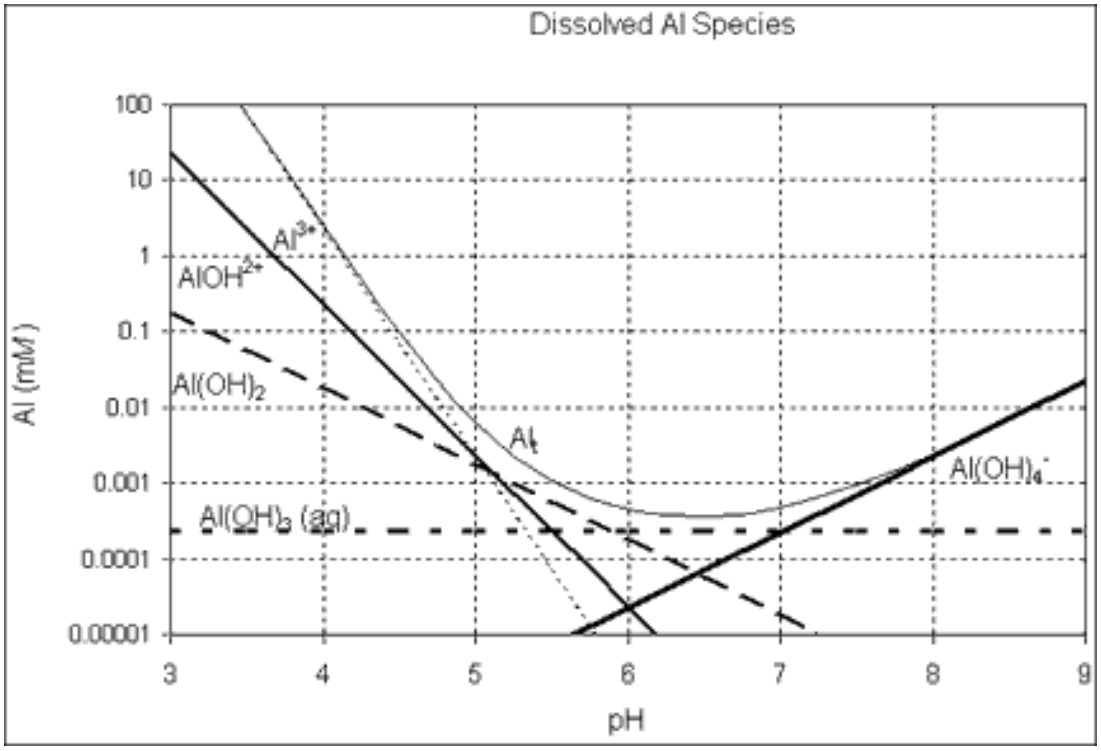
Evaluation of the rooting columns indicated that the method was effective to increase deep rooting, but that the alkalinity did not spread out from the vertical column.



Aluminum toxicity in wheat



http://www.intechopen.com/books/abiotic-stress-in-plants-mechanisms-and-adaptations/biotechnological-solutions-for-enhancing-the-aluminium-resistance-of-crop-plants



https://www.ec.gc.ca/lcpe-cepa/default.asp?lang=En&n=491F0099-1&printfullpage=true

Conclusions:

1. Vegetation is steady in treated areas over this short measurement interval.
2. Sparsely vegetated areas tend to have acidic subsurface horizons.
3. With substrate treatment, vegetation can be established from seed.
4. Plant roots reach deeply into the amended substrate the first year to access moisture and to continue growth through the summer.
5. Established plants also respond the first season to deep lime placement.
6. Amended plants had three times the transpiration surface as control plants.