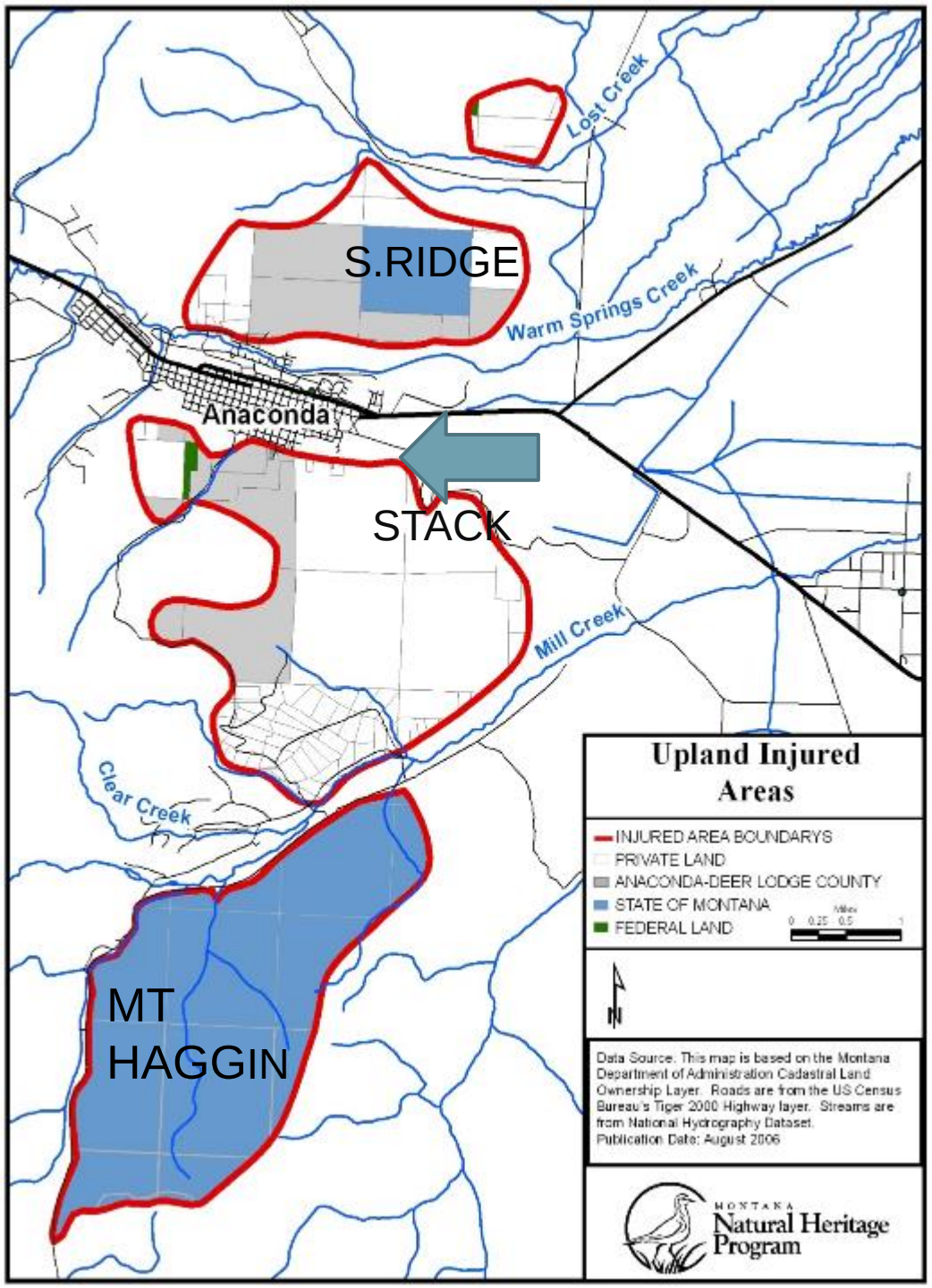
REMEDIATING AND RESTORING SMELTER-DEVASTATED LANDS NEAR ANACONDA, MONTANA

State owned area for remedy and restoration




Old Works
Smelters
from 1883-
1900

Superfund Law

Remediation

- Cleanup of hazardous substances to protective levels
- Human Health

And Environment

Restoration

- Picks up where remediation leaves off
- Return to baseline condition or replace lost services
- Natural resources State is trustee for gw/aq/terr
- Deepwater & Exxon-$8B & 1B; CF=$220m


Stucky Ridge State
owned section


First thing…build
a road and divide
into three areas
to spread the risk


Basin wildrye and sheep fescue dominate ARCO revegetation
Typical Pretreatment Area


120 Years of
Severe Erosion

Grading


Large Rocks
in Drainages


LOWLAND CREEK
VOLCANICS


PARALITHIC RHYOLITE TUFF


SYSTEMATIC
250-METER GRID


ST47


S/36


5132

14 INCHES (35 CM) ANNUAL PRECIPITATION

ELEVATION 5,400 feet (1,660 meters)

Soil Textures SL – SCL

SUBAREA 3 PREREMEDIATION SOILS

	Upper Half Foot	2nd Half Foot
OM	2.3%	not sampled
pH	4.4	4.9
pH	4.9	5.3
As	185 ppm	76 ppm
Cd	2.8 ppm	2.7 ppm
Cu	1,480 ppm	990 ppm

	Upper Half Foot	2nd Half Foot
Pb	65 ppm	30 ppm
Zn	250 ppm	220 ppm
NO3-	5 ppm	2.5 ppm
NH4+	3 ppm	1.2 ppm
Olson P	20 ppm	10 ppm
AmAc K	440 ppm	290 ppm
Buffer pH	5.8	5.9

HOW MUCH LIME TO NEUTRALIZE?

SIKORA OR SMP

MEANINGLESS UNLESS YOU SPECIFY DESIRED pH

6, 6.5, 7

Added 1 t/a for elemental S


BUT WE USED SUGAR LIME

CORRECT SUGAR LIME TO EQUIVALENT PURE FINE AGRICULTURAL LIME

PURITY, FINENESS, MOISTURE SUBTRACT SOME ROCKS IN SOIL (e.g., SA 1 1/3 rocks by volume)

Sugar Lime Example SA 3

Moisture X $CaCO_3$ Eq. X Fineness

1.25 X 1.28 X 1.00

1.6 tons sugar lime for each ton of pure, fine, agricultural lime from Sikora or SMP


FINENESS = 99+%

	Upper Half Foot	2nd Half Foot
Lime Rate	---------Means---------	
to pH 6.5	8.1 t/a	6.1 t/a
Range	0-13.5 t/a	0-12.5 t/a

That's pure, fine agricultural lime

APPLY HOW MUCH?

STRATIFY BY LIME RATE

2 SAMPLES IN LOW CLASS

16 SAMPLES MEDIUM RATE

9 SAMPLES HEAVY LIME RATE

MEDIUM LIME RATE

Mean = 13.3 t/a SD = 1.4 t/a

CV = 10%

At 13.5 tons of lime/acre, only half the area would be adequately limed.

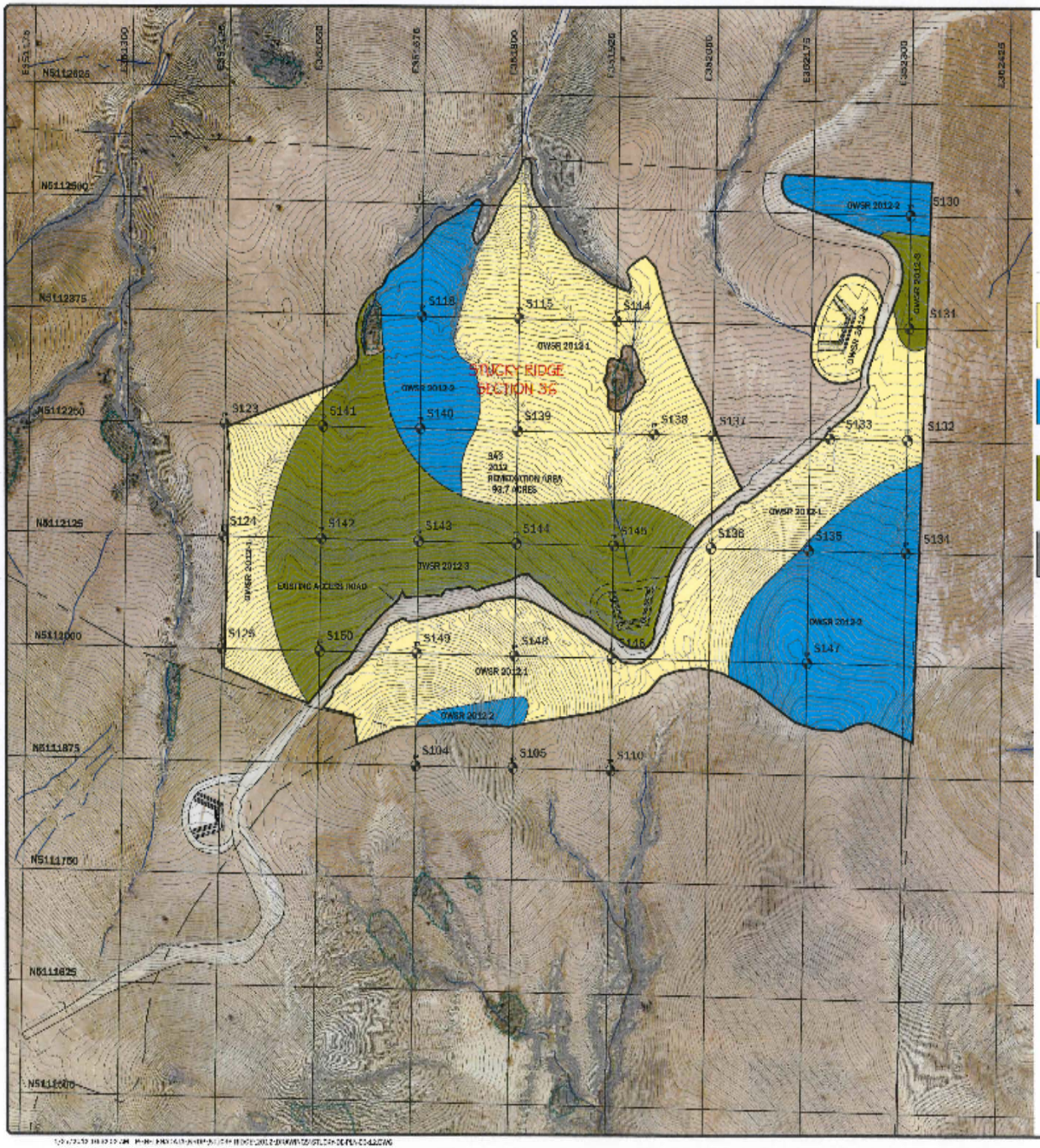
MEAN LIMES JUST HALF

APPLY THE Z STATISTIC

AREA UNDER THE NORMAL CURVE

SUBAREA 3 RATES OF SUGAR LIME TO ADEQUATELY NEUTRALIZE X% OF AREA

% OF AREA	BULK LIME RATE T/A
95	18.7
97	19.7
98	20.0
99	20.4
Almost All	22.3



NOTES

- STUCKY RIDGE 2012 REMEDY AREA WITH UTM COORDINATES (IN METERS)
- SA3 = 93.7 ACRES

LEGEND

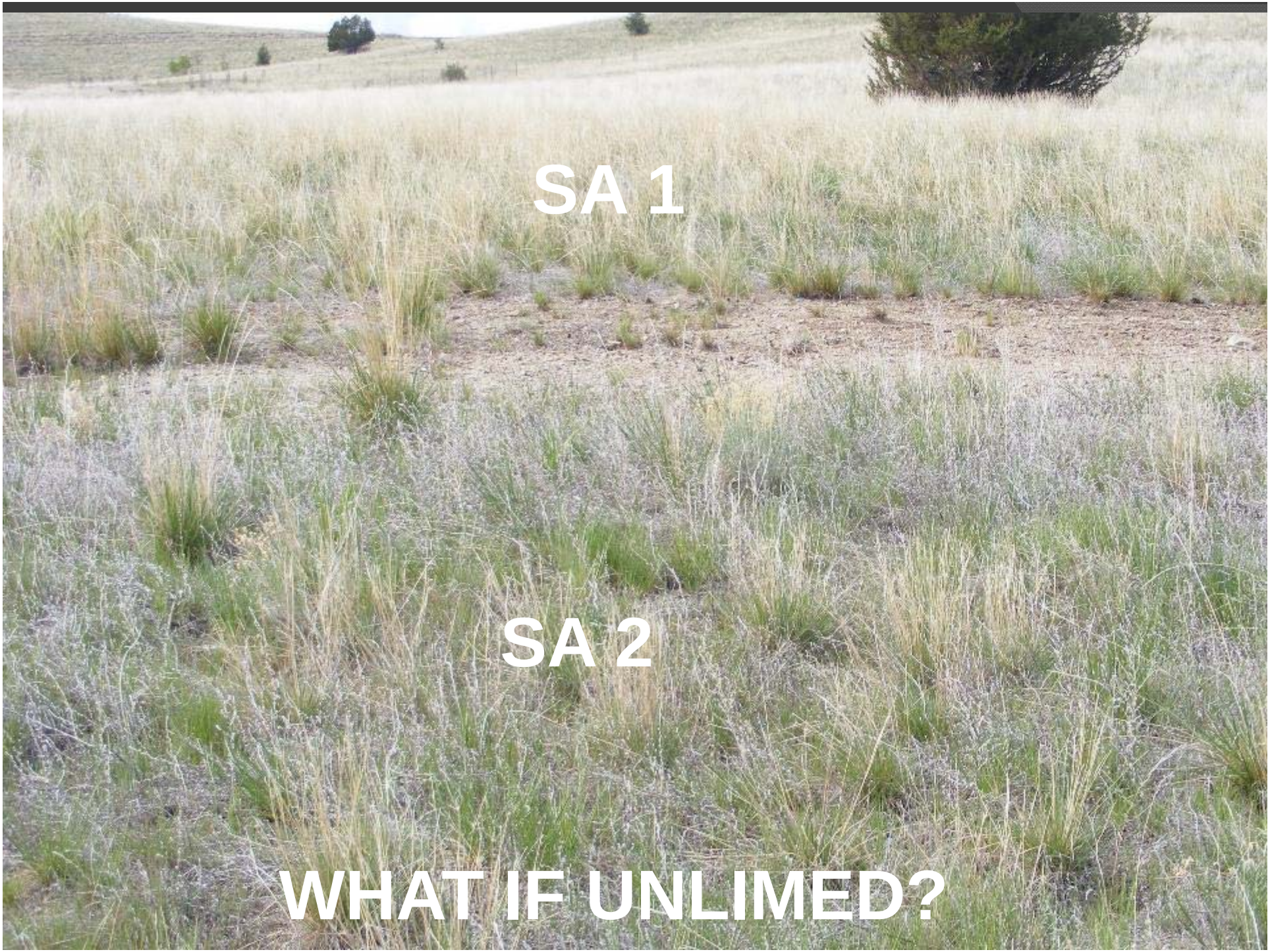
- OWSR 2012-1 =47.3 ACRES @ 20.0 T/AC AND 12" TILLAGE DEPTH
- OWSR 2012-2 = 22.3 ACRES @ 20.0 T/AC AND 6" TILLAGE DEPTH
- OWSR 2012-3 = 23.2 ACRES @ 32.5 T/AC AND 12" TILLAGE DEPTH
- MONITOR WELL VEGETATED = 0.9 ACRES - NO REMEDY REQUIRED

NRDP
STUCKY RIDGE
2011 REVEGETATION PROJECT

SA3 2012
REMEDIATION
AREA

PIONEER
TECHNICAL SERVICES, INC.
200 E. BROADWAY, SUITE 3
HELENA, MONTANA 59601
(406) 457-8372

SHEET
1


SA 1
SA 2
WHAT IF UNLIMED?

CONFIRMATION SAMLING POSTREMEDIATION ACIDITY

22 SAMPLES IN 2013
MEAN pH 7.2
2 samples had pH 6 or less
One adjacent to a lime pile!

MEAN METALS AND OTHER SOIL PROPERTIES 0-6”

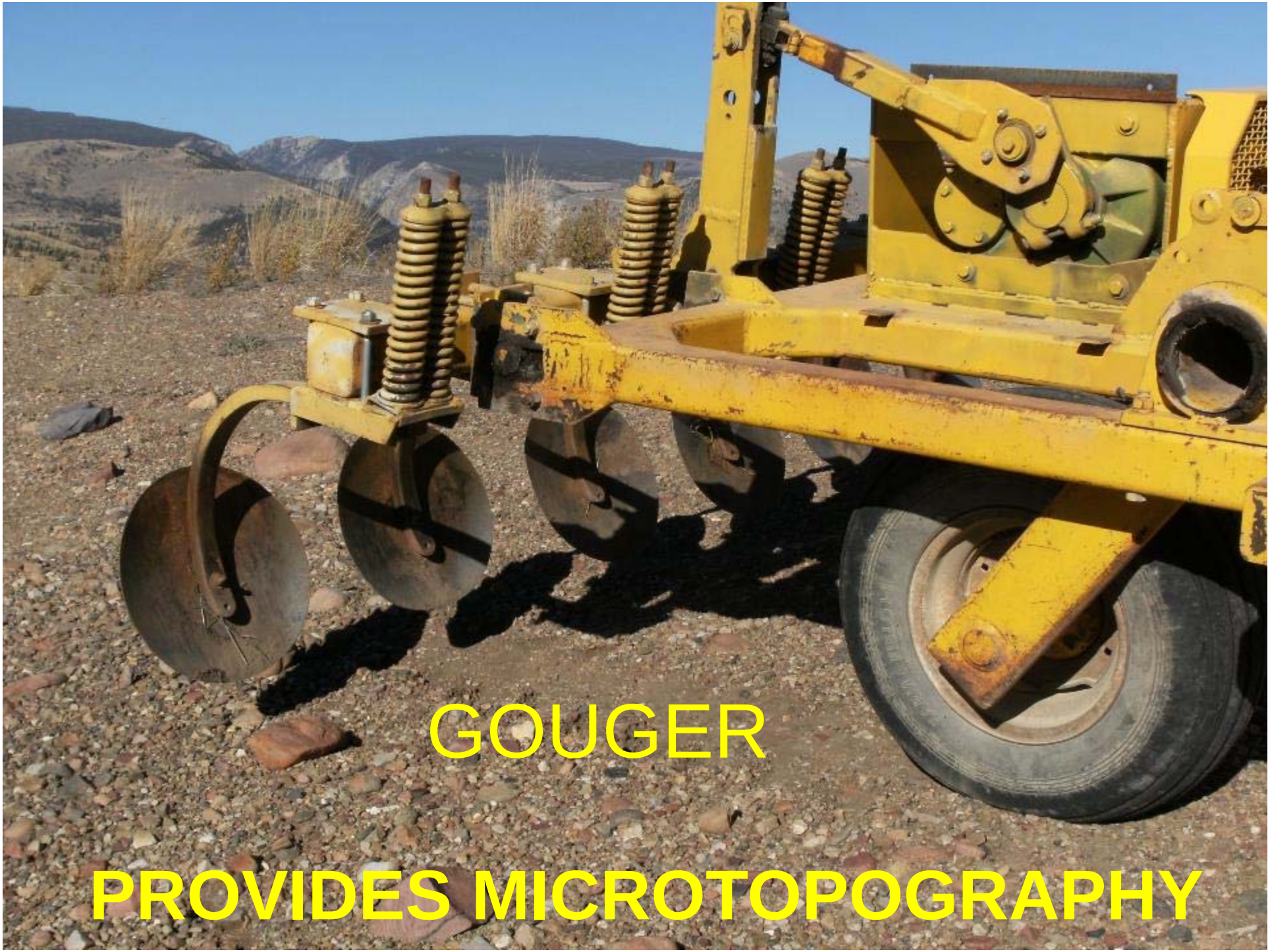
	PREREMED	POSTREMED
OM	2.3%	2.9%
As	200 ppm	185 ppm
Cd	2.7 ppm	3.1 ppm
Cu	1,480 ppm	1,390 ppm
Pb	67 ppm	68 ppm
Zn	250 ppm	375 ppm

FERTILIZE BASED ON UPPER SIX INCHES. NO ROCK DISCOUNT

ADD:
45 POUNDS/ACRE ACTUAL N
30 POUNDS/ACRE ACTUAL P
K NONE IN PLACES, 100 POUNDS/ACRE POTASH IN OTHERS

PRE- AND POST-REMEDIATION SOIL FERTILITY 0-6”

	PREREMED	POSTREMED
NO_3^-	5 ppm	30 ppm
NH_4^+	3 ppm	6 ppm
Ol P	20 ppm	60 ppm
Am Ac K	440 ppm	510 ppm


GOUGER
PROVIDES MICROTOPOGRAPHY


Great Plains

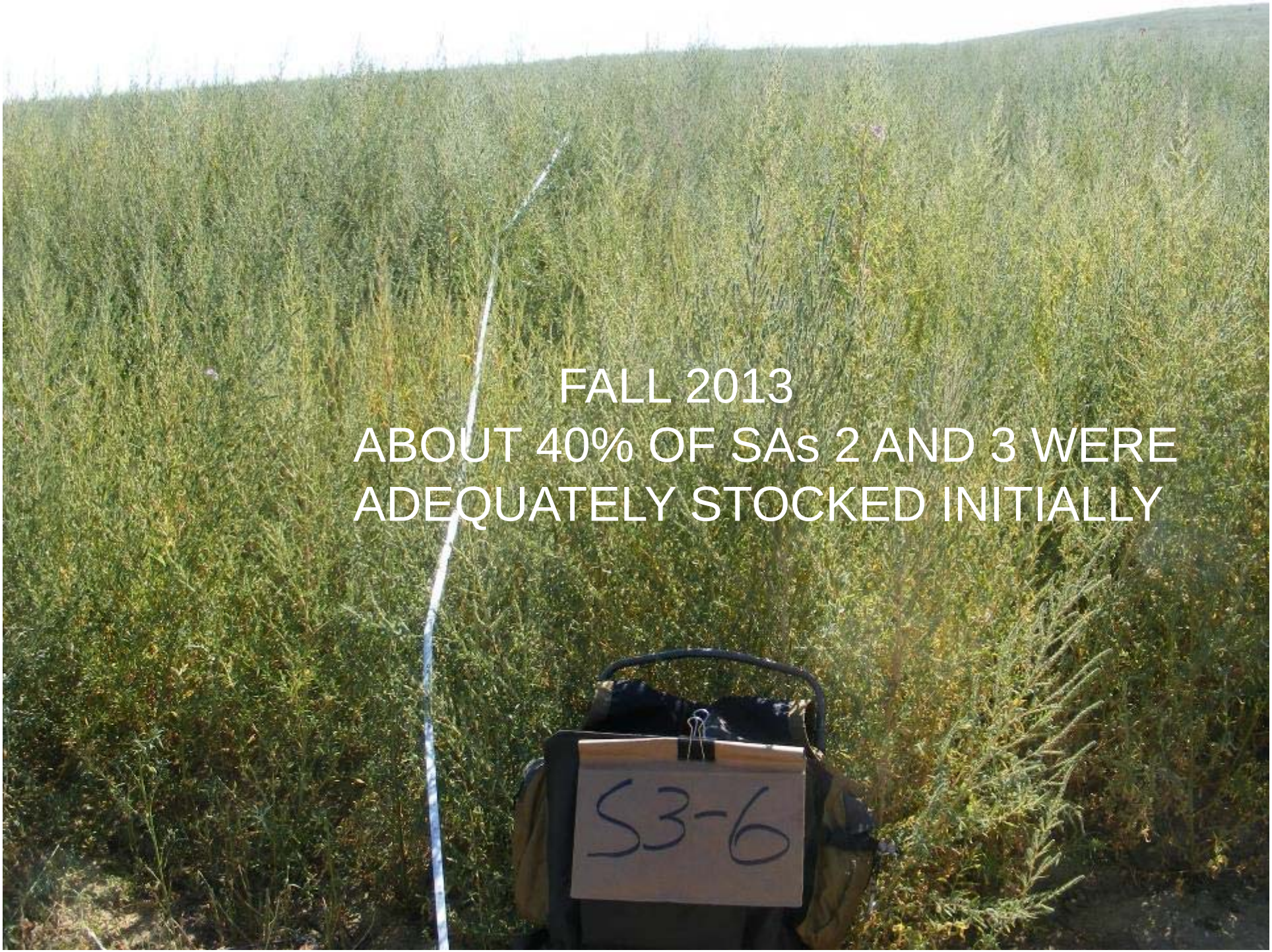

2011

SUBAREA 1
PERMANENT SEEDING
FALL 2011 – SPRING 2012


SUBAREA 1
SA2-11

SUBAREAS 2-3

PERMANENT SEEDING
FALL 2012 -- SPRING 2013


FALL 2013
ABOUT 40% OF SAs 2 AND 3 WERE ADEQUATELY STOCKED INITIALLY
S3-6


INTERSEEDING REQUIRED
2014 SA 1


2013


Kochia auto-suppressed to provided 4% Relative Cover in 2016


Copperhead Slender
Wheatgrass 29%
relative cover in 2016
PHOTO 2014


2015
Opportunity
Nevada bluegrass 35%
Relative cover in 2016


Washoe Basin Wildrye
13% Relative Cover in 2016
2015

SILVER BOW CREEK REVEG PERFORMANCE STANDARD UPLANDS: 60% PERENNIAL CANOPY COVERAGE

DON'T COUNTY NOXIOUS WEEDS

STUCKY MEAN IN 2016 = 63.8 +- 5.8% CANOPY COVERAGE

11 OF 16 TRANSECTS PASSED THE STANDARD

We seeded a diverse mix of growth forms:

- 10 species of grasses
- 3 shrubs
- 9 forbs or “flowers”

Few plants were able to handle the Cu concentrations.

3/4s OF RELATIVE PLANT COVER CAME FROM JUST THREE GRASSES


UPLIFTED TERTIARY FLUVIAL DEPOSITS
SIT UNCONFORMABLY ON RENOVA-AGED MUDS.
MATRIX ERODED AWAY LEAVING A LAG OF COBBLES.


CAT
D5C