

# Shrub Establishment Trials & Tribulations

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# Wyoming Big Sagebrush



Sagebrush is difficult to establish.  
But, it can be done.



# Wyoming Coal Mine Reclamation

## Shrub Establishment

25 years of trials

Numerous techniques, methods, and equipment used. There is more than one way.

# Wyoming

## Coal Mine Reclamation

**Pre-1980:** No sagebrush reclamation.

**1980-1989:** Mines started adding sagebrush to their seed mixtures, using various techniques with their own equipment. Some successful, some not.

**1990-1999:** Sagebrush establishment techniques were becoming standardized. Mines contracting out reclamation. But, success still marginal and intermittent. A lot of research occurring.

**Post-2000:** Mines standardizing and optimizing methods and techniques. Several new innovative techniques emerging. Mines applying for bond release on 10-20 year old reclamation.

# SUMMARY

- Sagebrush reclamation success has shown a consistently improving trend.
- We know a lot more than we did a few years ago.
- Successful proven techniques and practices do exist to grow sagebrush.

# HOWEVER

- Success is not guaranteed.
- Seed germination is substantially limited by water stress.
- The successful establishment of big sagebrush has typically been correlated with favorable precipitation (snow cover).

# Same seed mix – Different year



Several emerging techniques to overcome these limitations and allow for greater and more consistent establishment.

# HOWEVER

These techniques may provide a niche for cheatgrass establishment.

and

Wildlife predation is also showing a negative impact that may limit long-term success.

# Proven Techniques

- Use good quality locally adapted seed (yellow tagged source identified).
- Use “good” topsoil.
- Broadcast seed (or drill into very firm seed bed). Sage needs light to germinate.
- Seed-soil contact critical.
- Substantially reduce competitive grass seed rate.
- Enhance soil moisture (several techniques).

# Emerging Techniques

- No mulch or cover crop – Use surface roughing.
- Micro-topography.
- Compact subsoil OK.
- Diverse seed mixtures & lower rates.
- Time seeding to snow fall.
- Grazing management.

# Questionable Techniques

- Irrigation??
- Fertilizing.
- Mycorrhiza fungi inoculation??

# Shrub Establishment Techniques

The first consideration is  
site grading

# Site Grading

- Topographic reconstruction – macro-topography.

**BLM definition of “reclamation”?**

**Site stability vs. reconstruction**

- Micro-topography.

**Create (or leave) micro-sites for seed protection and germination**

Little macro-topographic  
landform diversity  
not a lot to work with



More topographic landform diversity  
Grade the site to restore these conditions  
Also more micro-topography



Cool moist north facing slope – now that's macro-topography. What about micro-topography?



Cool moist north facing slope  
for a seed the size of a pin head.



# Micro-topography



# Micro-topography Not just for shrubs



# Micro-topography Rockpiles



# Small Depressions and swales



The second consideration is  
subsoil preparation

# Subsoil Preparation

## Two contradictory techniques

- 1) Rip the compacted subsoil to promote root penetration and water infiltration before reapplying topsoil?
- 2) Place topsoil directly on compacted subsoil. Water infiltration only through topsoil, then pools in root zone.

# Rip spoil/subsoil

(along contour)

Only on slopes to prevent soil slippage



# Compacted subsoil rip or not?



# Compacted surface To rip or not? disc? topsoil?



# Disc subsoil



The third consideration is  
topsoil replacement

# Topsoil Salvage & Replacement

- Maintain soil structure and moisture to the maximum extent possible.
- Minimize stockpiling.
- Working with frozen soil is good.
- Two very different methods of preparing soil for seeding.

# Topsoil salvage

## Dry soil - loss of structure



# Topsoil Stockpiling

- Stockpiling topsoil is not beneficial.
- Temporary vs permanent reclamation.

# Topsoil Replacement

## Again two contradictory techniques

# Topsoil Replacement & Preparation

## Prepare firm friable seedbed

- **Disking** – pulverize lumps, 2 passes different direction.
- **Harrowing** – spike-tooth, spring-tooth, tine-tooth. Creates fine loose soil.
- **Cultipacking** – Firms the seed bed. Often several passes.
- **Seed** – Drill, broadcast, or hydroseed.
- **Mulch** – grass or straw.
- **Cover crop** – annual grain
- **Nurse crop** – annual grain
- **Rolling** – Seed soil contact with broadcasting.

# Intensive Soil Preparation



# Various Tillage Equipment



# Various combinations of implements



# Disc/roller/disc/harrow



# Cultipackers & Rollers

Firm seed bed critical if drill seeding  
and also critical if broadcasting.



< 1/4 in. footprint  
Time the moisture  
Ready for seeding



# Seedbed? Not for Sagebrush



# Prepared Seedbed



# Alternative Technique

## Minimal Seedbed Preparation

- Not conducive to drill seeding.
- Broadcast seed right in rough, unprepared soil surface.
- Conserves soil structure.
- Maintain micro-sites for seed germination.
- Control erosion and water retention.
- Rough surface will “melt down” in a few years.

# No or Minimal Soil Preparation Ready for seeding?



# Ready for seeding?



Match the soil preparation to  
your seeding technique or  
implement.

Drill vs Broadcast

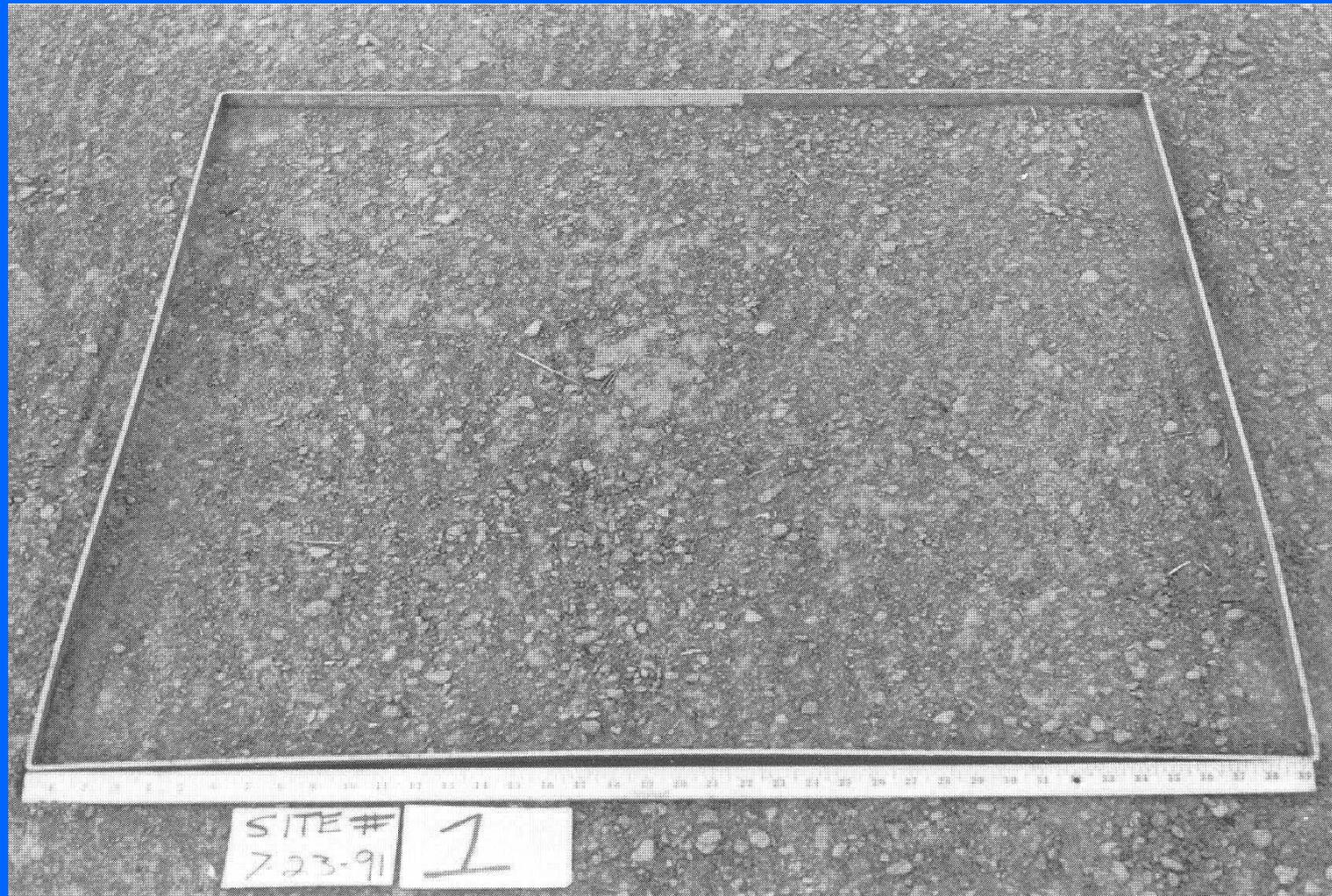
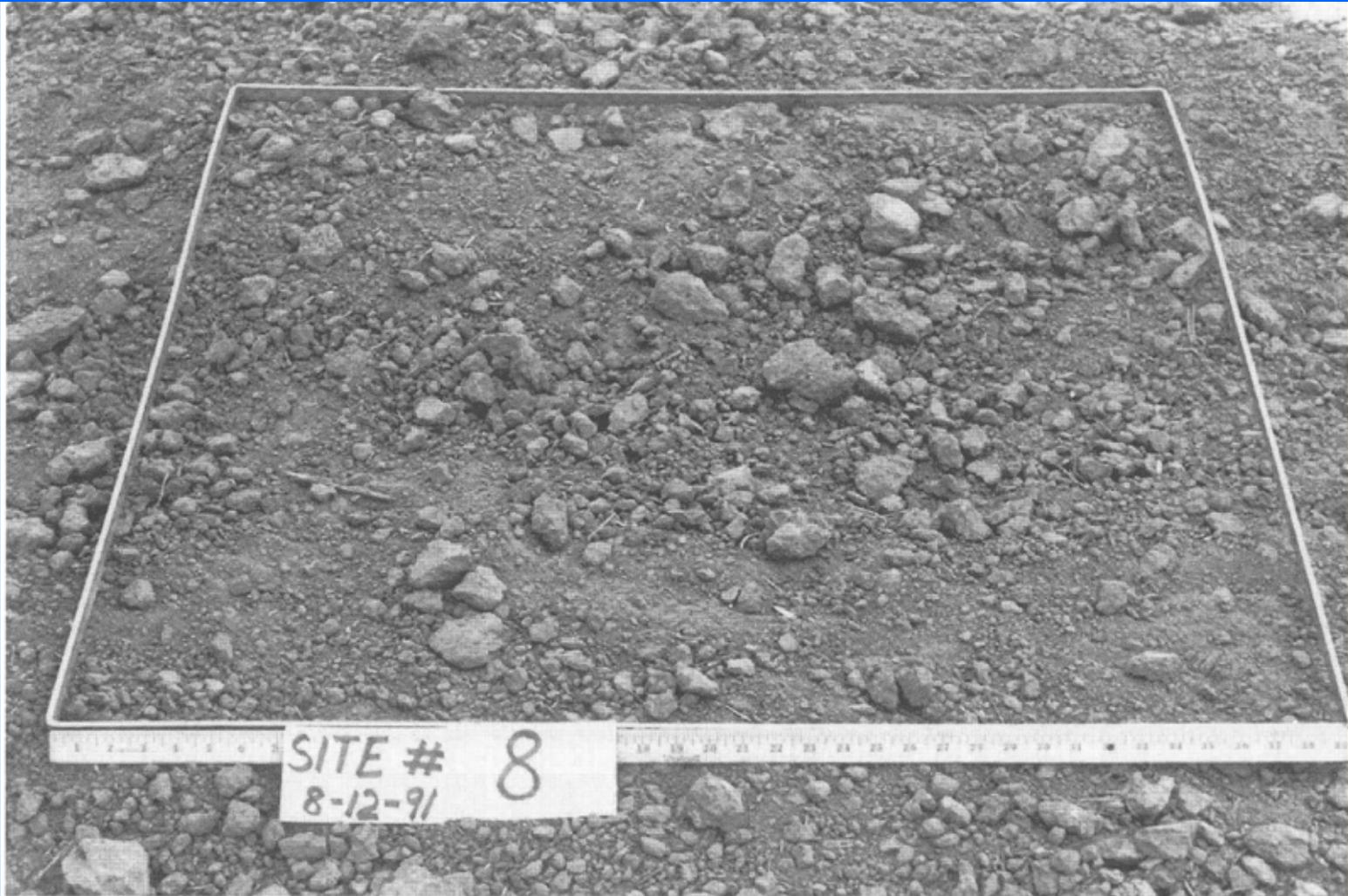


Figure C-1. Random roughness,  $R_t$ , of 0.25 in, site 1



Fig

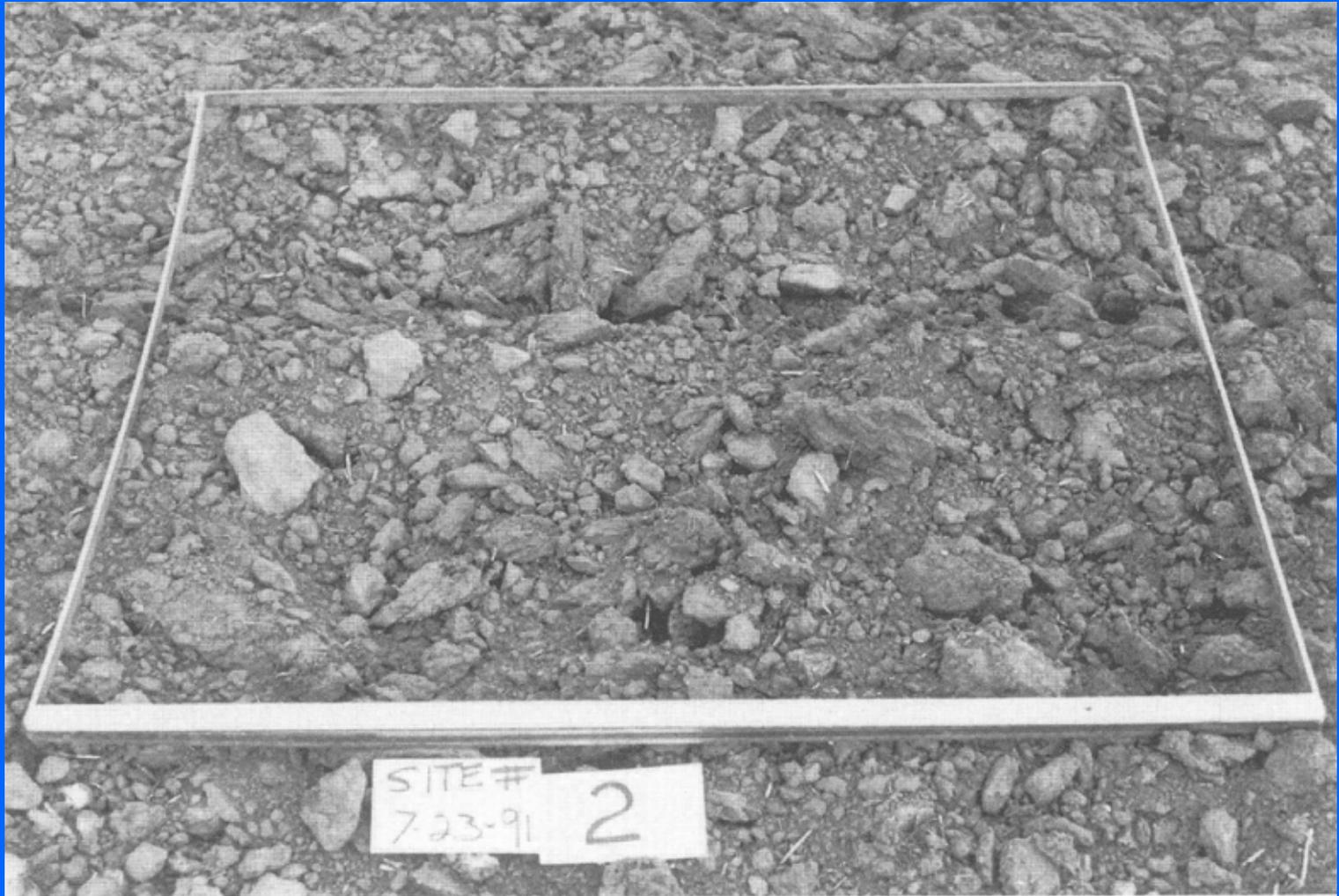


Fig.



Fig 1



Fig. 1



Fig.



Fig



Fig.



Fig. C-9. Random roughness,  $R_t$ , of 2.15-inches, Site 4

## Common Seed Bed Preparation.

Ready for **drill** seeding, then should do something to hold moisture (mulch?). But, then will there be enough light for germination of sagebrush?



# To Mulch or Not to Mulch?

- Mulching creates shade, it keeps the soil temperature down which helps conserve water.
- Mulching creates a rough surface which interrupts wind flow and speed. Again, conserving moisture as well as holding the seed.
- Erosion control – limits rain drop impact and soil displacement.

# To Mulch or Not to Mulch?

- Mulch is dry and can act as a wick, sucking up the moisture where the wind then evaporates it.
- Applying mulch works the soil, causing loss of soil structure and micro-sites.
- Mulch is expensive to purchase and apply.

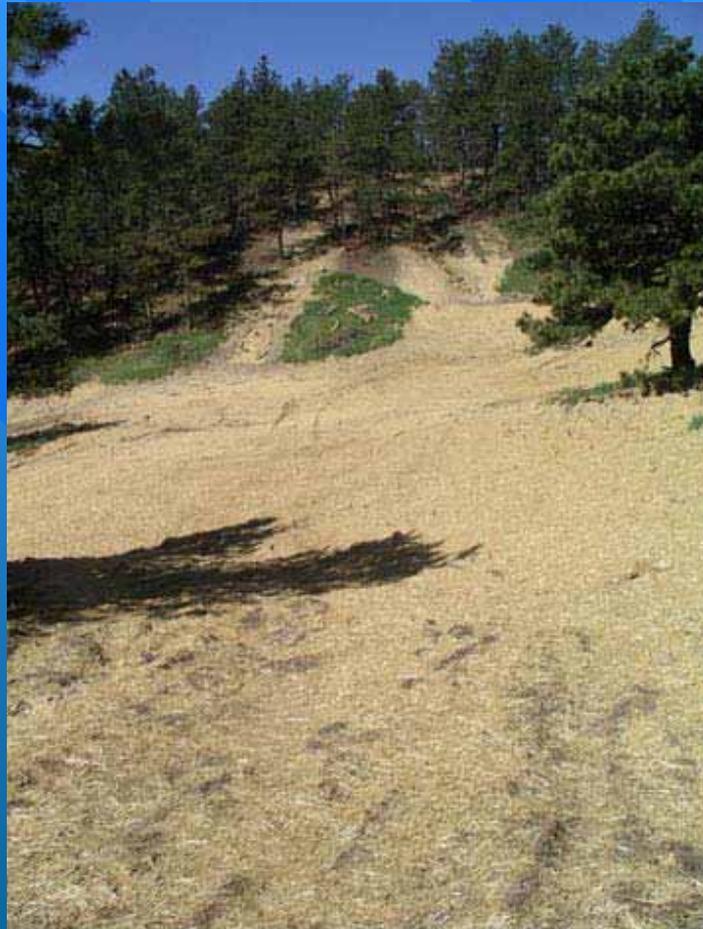
# Mulching

- Straw mulch or grass (wetland) mulch.
- Recommended Rate @ 2 ton/acre.
- Must crimp in ground.
- Seed most species before mulching,
- But, seed (broadcast) sagebrush on top of mulch. Sagebrush needs light to germinate.

# Mulching Con's

- Expensive.
- Over works the soil, need to crimp.
- Must seed sagebrush on top of mulch and other species under it.
- May introduce weeds.

# Straw Mulch at 2 ton/ac



# Straw Blower



# Straw Crimper



# Alternatives to Mulching

- **Cover Crop** – seed an annual grain a year before reclamation seeding. Then mow it and seed into the stubble.
- Some of the same problems as mulch. Expensive, over worked soil, wick for evaporation. Adds an extra year.
- Advantages – Quick green cover, aesthetics, the cows like it.

# Inter-seeding into cover crop



# Alternatives to Mulching

- **Nurse Crop/Companion Crop** – Similar to cover crop, annual grain (Re-green), but seed it while seeding the reclamation mix.
- **Problem** – competition for moisture and nutrients.

# Nurse crop/Cover crop



# Nurse crop



# Natural Nurse Crop



# Tumble weed – Russian Thistle



# Nurse Crop



# Nurse Crop



# Nurse Crop Tumbleweed and Kochia sometimes Halogeton



# Kochia & Tumbleweed



# BLM Slide

## “WEED CONTROL AND SEEDING”



# Aesthetics

Do we want a quick green vegetative cover?



Or do we want shrublands  
and plant diversity?





If we want shrubs and diversity.

It isn't going to happen quick.

We need to be patient.

We need to accept non-competitive,  
non-noxious annual weeds.

# Tumbleweed



Tumbleweed, "Russian thistle" caught on a barbed wire fence.

# Alternatives to Mulching

## Alternative seedbed preparation

- **Surface Roughening** – Similar benefits, controls erosion and conserves soil moisture.
- Creates shade, it keeps the soil temperature down which helps conserve water.
- Creates a rough surface which interrupts wind flow and speed. Again, conserving moisture as well as holding the seed.
- Erosion control achieved by rough surface.

# Surface Roughening

Various techniques and implements depends on specific soil condition.

- Just leave after topsoil replacement.
- Rip replaced topsoil with blade or dozer.

Or Create It

- Land Imprinter.
- Pitter gouger.
- Large construction disc.
- Extreme surface roughening

# No or Minimal Soil Preparation Ready for seeding?



# Ready for seeding?



Ripped topsoil – ready for broadcast seeding followed by packing.





# The type of seeder is critical for these seedbeds.

- Sagebrush seed must be distributed on surface. It needs light to germinate.
- Some sort of broadcast seeder.
- But, also need seed-soil contact.
- Some sort of packer/roller to press seed into soil.

Create a rough seedbed.  
Various implements

# Land Imprinter



# Imprinter



# Dixon Land Imprinter



# Imprinter with seeder



# Imprinting



Disc with Broadcast seeder and drag.  
This would not work well for sagebrush.



# Gouger



Pitter-Gouger similar to previous implement in a swale with hand broadcasting.



# Lawson Aerator with seeder



# Extreme Surface Roughening

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- Trackhoe shovel to dig, poke, and/or push to create basins
- Dozer basins
- Microbasins 1½ to 2 feet deep by 4 feet wide
- Placed in a random overlapping pattern

# Extreme Surface Roughening Can be done when taking out roads







1990



1994

*Extreme Surface Roughening*

Another alternative to traditional  
straw mulch.

Rocks



*surface roughening and rocks in reclamation*



*Surface roughening and rocks*

The next consideration is  
purchase of the seed.

# Sagebrush Seed Purchase

- Locally collected vs SE United States?
- Wildland collection vs farm raised?
- **Pure Live Seed (PLS)**, purity + germination
- Short shelf life
- Weed free seed (cheatgrass)
- Mix or individual seed?
- Granite Seed vs Wind River Seed?

# Big Sagebrush Seed

- 2,500,000 seeds/pound
- Seed cost = \$35/PLS pound (highly variable)
- $\$35/2,500,000$  seeds = \$0.000014/seed

## Cool Season Grass Seed

- 150,000 seeds/pound
- Seed cost = \$3/PLS pound
- $\$3/150,000$  seeds = \$0.00002/seed

For small-seeded species, fewer pounds per acre are required because of the greater number of seeds per pound.

# Big Sagebrush Seed

- Short shelf life (1-5 years low humidity, low temperature)
- But maintains viability in soil 4 years
- Light fluffy trashy seed
- Needs light to germinate
- Needs soil contact
- Needs correct moisture

# Wind River Seeds' farm grown Big Sagebrush



# Wildland collection



Purchase sagebrush seed  
separately?  
or  
Buy it in a mix?

Depends on seeding equipment  
and technique.

<b>Big Sagebrush Shrubland Seed Mixture</b>				<b>Total seeds per acre=</b>	<b>871,200</b>
				<b>PLS Seeds per square foot=</b>	<b>20.0</b>
<b>Common Name</b>	<b>Desired Species %</b>	<b>No. of Seeds per Pound</b>	<b>No. of PLS in Mix for Desired Blend</b>	<b>PLS Pounds Required per one acre</b>	<b>PLS per Square Foot</b>
<b>Grasses</b>					
Little bluestem	3.0	225,000	26,136	0.116	0.60
Bluebunch wheatgrass	2.0	145,000	17,424	0.120	0.40
Blue grama	3.0	711,000	26,136	0.037	0.60
Sandberg bluegrass	3.0	925,000	26,136	0.028	0.60
<b>Grass Total:</b>	<b>11.0</b>		<b>95,832</b>	<b>0.301</b>	<b>2.20</b>
<b>Forbs</b>					
Yarrow	1.0	4,124,000	8,712	0.002	0.20
White prairie clover	1.0	275,000	8,712	0.032	0.20
Purple prairie clover	1.0	275,000	8,712	0.032	0.20
Blazingstar	1.0	63,000	8,712	0.138	0.20
Lewis flax	1.0	285,000	8,712	0.031	0.20
Prairie coneflower	1.0	1,032,000	8,712	0.008	0.20
Munroe globemallow	1.0	750,000	8,712	0.012	0.20
American vetch	1.0	33,000	8,712	0.264	0.20
Hairy vetch	1.0	20,000	8,712	0.436	0.20
<b>Forb Total:</b>	<b>9.0</b>		<b>78,408</b>	<b>0.954</b>	<b>1.80</b>
<b>Shrubs</b>					
Silver sagebrush	10.0	846,000	87,120	0.103	2.00
Big sagebrush	40.0	2,520,000	348,480	0.138	8.00
Rubber rabbitbrush	10.0	693,000	87,120	0.126	2.00
Fringed sagewort	10.0	1,000,000	87,120	0.087	2.00
Winterfat	10.0	123,000	87,120	0.708	2.00
<b>Shrub Total:</b>	<b>80.0</b>		<b>696,960</b>	<b>1.162</b>	<b>16.00</b>
<b>Mix Total:</b>	<b>100.0</b>		<b>871,200</b>	<b>2.418</b>	<b>20.00</b>

# Shrubland seed mix



# Shrubland seed mix



# Seed Rate

Use PLS/ ft<sup>2</sup>

not

Pounds/acre

# Number of PLS/Ft<sup>2</sup>

- General recommendation is 20 PLS/ft<sup>2</sup> when drill seeding.
- 40 PLS/ft<sup>2</sup> when broadcasting.

How many plants per square foot  
do you want?

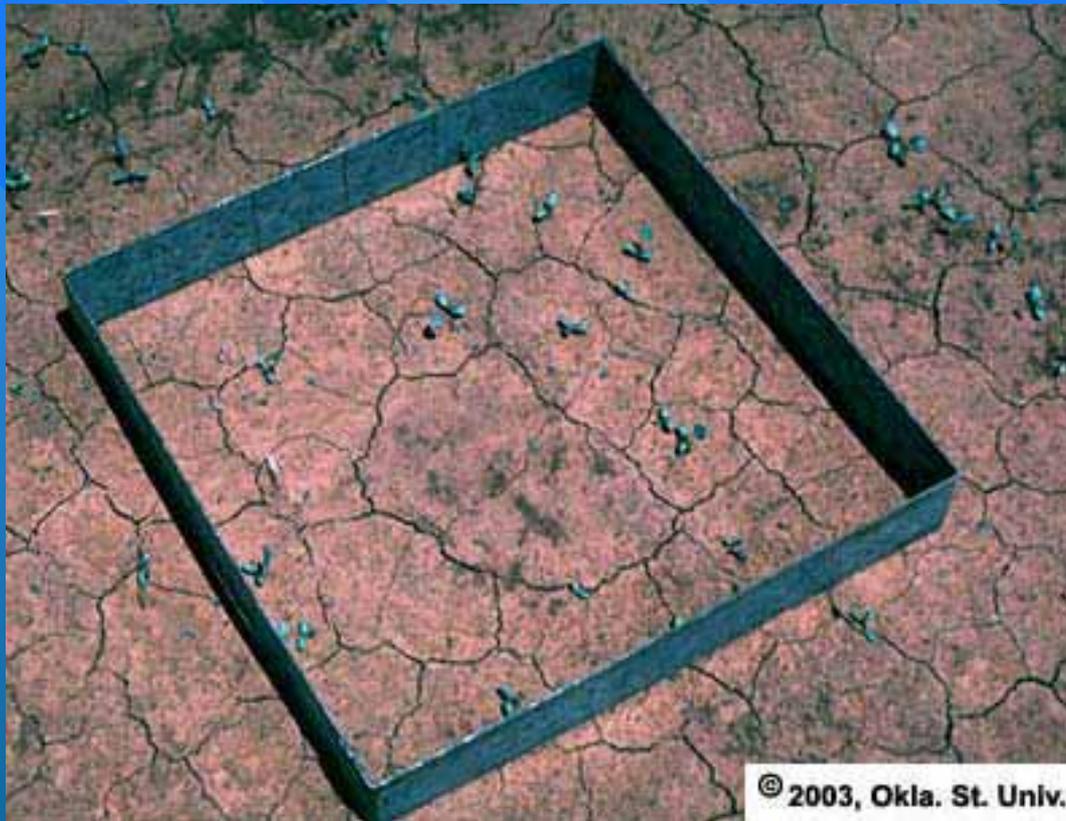
Number of PLS to achieve it?

% Germination?

% Field Emergence?

% Survival

Alfalfa drill seeded at 4 PLS lbs/acre  
(200,000 seeds/lb = 18.4 seeds/ft<sup>2</sup>)  
18 emerged seedlings/ft<sup>2</sup>



Alfalfa drill seeded at 10 PLS lbs/acre  
(200,000 seeds/lb = 46 seeds/ft<sup>2</sup>)  
40 emerged seedlings/ft<sup>2</sup>



Alfalfa drill seeded at 20 PLS lbs/acre  
(200,000 seeds/lb = 92 seeds/ft<sup>2</sup>)  
90 emerged seedlings/ft<sup>2</sup>



Seed rate should be calculated from an expected field emergence for each species and the desired number of plants per unit area.

For example, **field emergence** for small seeded grasses and forbs is around 52% if the germination is greater than 80%, and 33% if germination is between 60% and 80%.

Expect around 30-50% field emergence.

Twenty PLS per ft<sup>2</sup>, with an expected field emergence of 50%, produces approximately 10 plants per ft<sup>2</sup> on the seeded area.

Can your soil support 10 mature  
plants per ft<sup>2</sup>?

In addition to expected field emergence, the competitive ability of each seeded species must be evaluated to determine species seeding rates.

In general, grasses are more competitive than forbs, forbs are more competitive than shrubs, and shrubs are more competitive than trees.

Among grasses, the naturalized species are usually more aggressive than native species.

Within native species on the Northern Great Plains and Great Basin, cool-season grasses are more competitive than warm-season grasses.

# *Diversity @ 40 PLS/ft<sup>2</sup>*



5 lbs per acre slender wheatgrass out  
of 22 lbs seed mix/acre.



What species do we want in that square foot?

The seeding will thin naturally during the first few years.

Aggressive, early germinating species may restrict later species.

The soil has limited moisture, nutrients, and light.

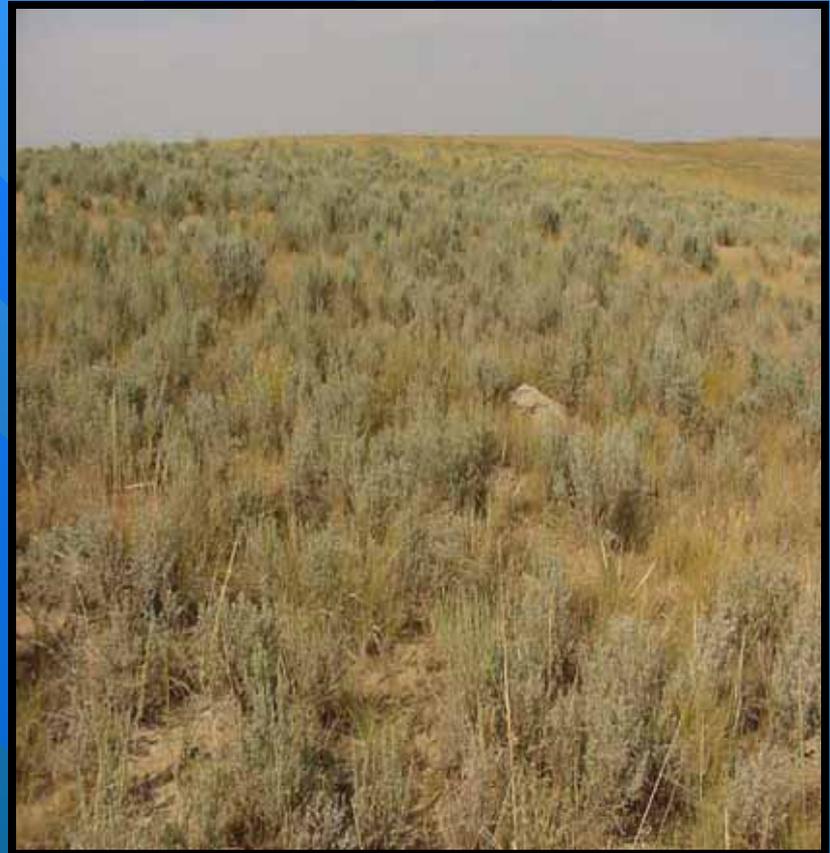
# To establish Sagebrush

- Substantially reduce or eliminate aggressive cool season grasses.
- Seed bunch grasses over rhizomatous (sod forming) grasses
- Include warm season grasses and forbs.
- Include legumes.

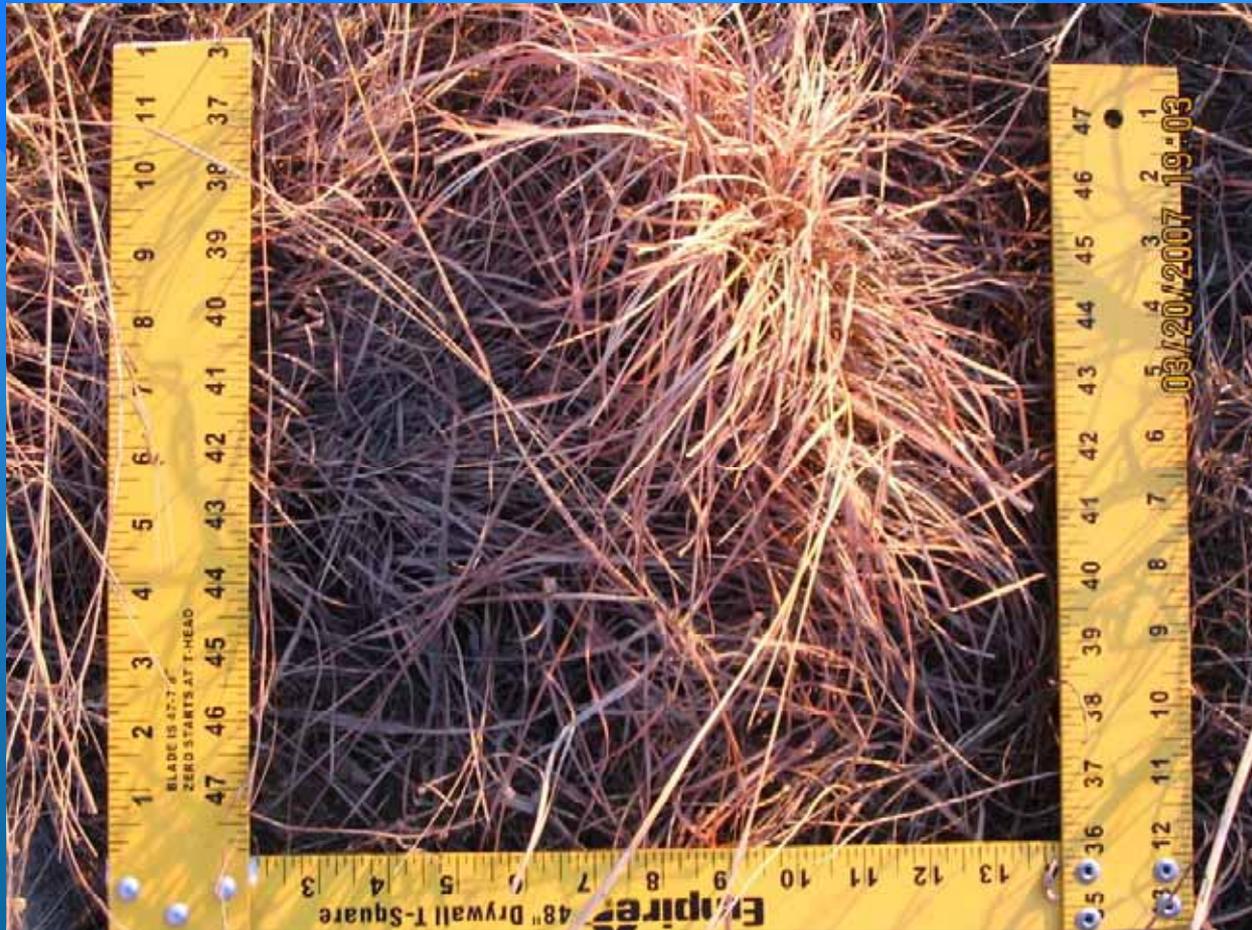
# Native # plants/ft<sup>2</sup>



# Reclamation # plants/ft<sup>2</sup>?



# 10 year old Little bluestem - 1 plant



# Grazed crested wheatgrass pasture 5 plants



# 7 year old heavily browsed sagebrush



# 3 year old sagebrush



Before formulating and ordering  
a seed mix – Give it some  
thought.

What is your goal?

How many plants per ft<sup>2</sup> do you  
want?

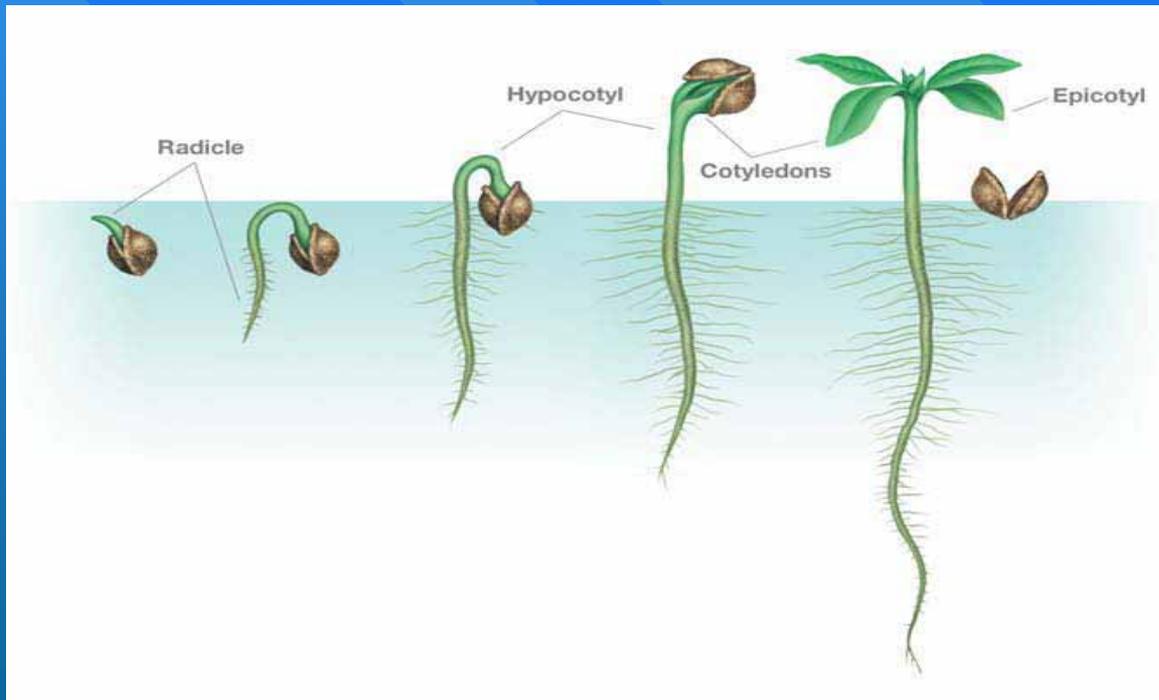
What plants do you want?

# Seeding method and equipment.

# Seeding Methods

- Hydro seeding
- Drill seeding
- Broadcast seeding

Big sagebrush seed needs to be on the surface (not below it) but it also needs seed/soil contact and moisture (preferably snow cover)



# Hydro seeding



# Hydro seeder



Hydro seeder – good shrub establishment where seeder drove.



# Drill Seeding

- Big sagebrush seed must be on the surface. Depth bands.
- Must have a firm seedbed and seed-soil contact. Press wheels/cultipacker.
- Follow contour of land.
- Big sagebrush seed will not flow through many seed boxes (techniques to overcome this).

# Grain Drill



# No Till Drill



# Drill Seeder



# Seed box aggressive agitator and picker wheel critical



# Big Sagebrush Drill Seeding



# Broadcasting seed

- Hand broadcasting
- Whirlybird broadcasters
- Air broadcasters
- Modified rangeland drills
- Grass drill seeders
- Grasslander
- Home-made seeders.

# Hand Broadcasting

## Good techniques for shrubs



# Rolling seed in is preferable to dragging it



Or hand seed right on top of  
snow have it melt in.

Hand seed right before  
snowstorm.

# Whirlybird Broadcasters

Most cannot handle fluffy seed  
and hard to regulate seed rate.



# Broadcaster

Most cannot handle fluffy  
sagebrush seed.



# Air seeder

## Problem with fluffy seed



# Drop seeder, fertilizer spreader



# Fluffy seed flow



# Modify existing seeders for fluffy seed.



# Olathe seeder/roller



# Tye rangeland drill



# Rangeland Seeder



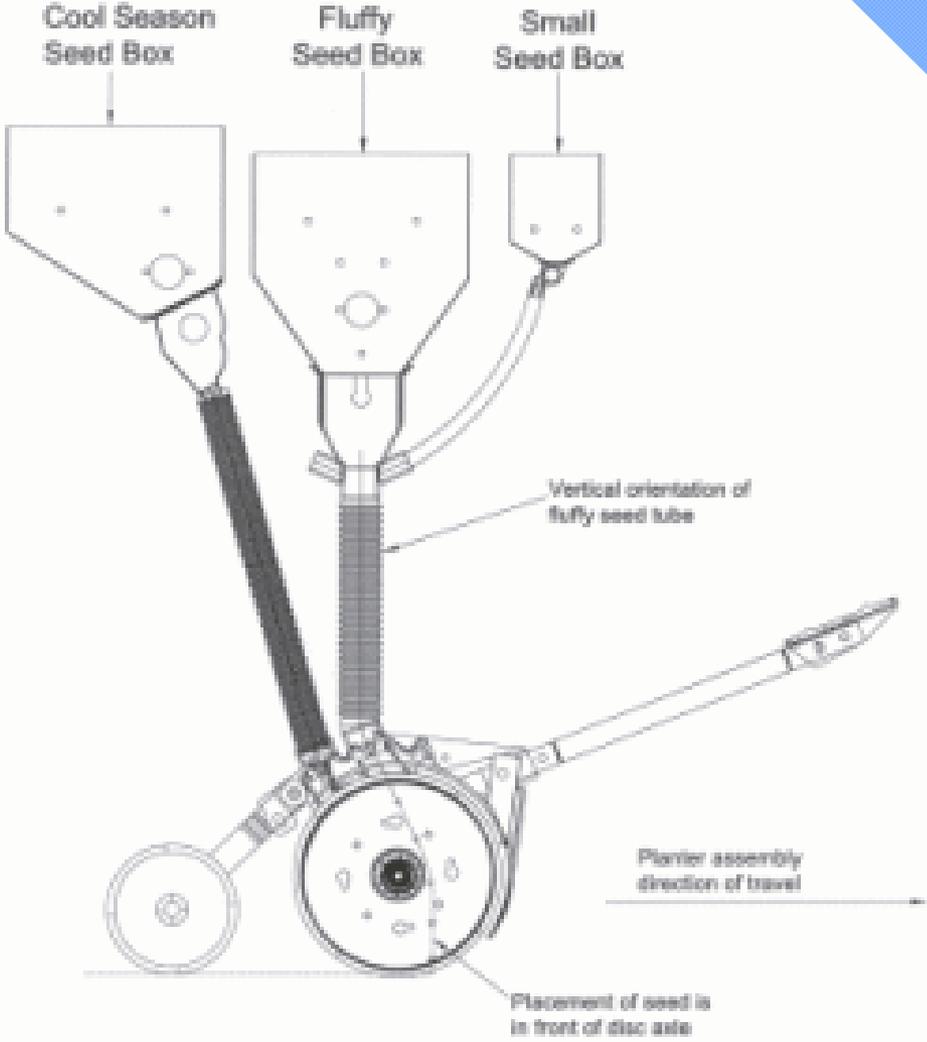
# Truax Trillion



# Truax Rough Rider Drill



# Truax Seed Delivery System



# Truax fluffy seed box





# Press wheels



# Brillion Grass Drill



# Brillion



# Grasslander



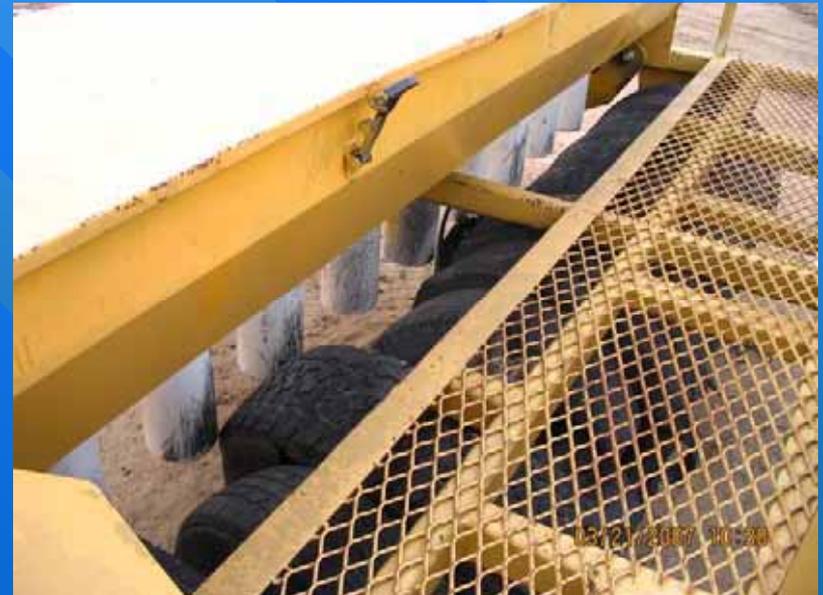
# Grasslander



# Grasslander



# Grasslander seed boxes



# Broadcast Seeding w/aerater





# Dixon Land Imprinter with seeder



# Disc/Imprinter/Broadcaster



Lawson Pasture Aerator purchased by Anadarko Petroleum



WGFD

Inter-seeding falcata alfalfa and other forbs while aerating the soil.



# Seeding Time

- **Late Fall** (October-November)
- **Winter**, when the upper few inches of soil is thawed. Time before storm or seed right on top of light snow cover.
- **Spring to Early Summer** (March-May). Warm season grasses and diversity.

**Anytime EXCEPT June-September**

# Planting Containerized Seedlings

Expensive

Labor Intensive

“Mother Plant” approach

# Bitterroot Native Growers



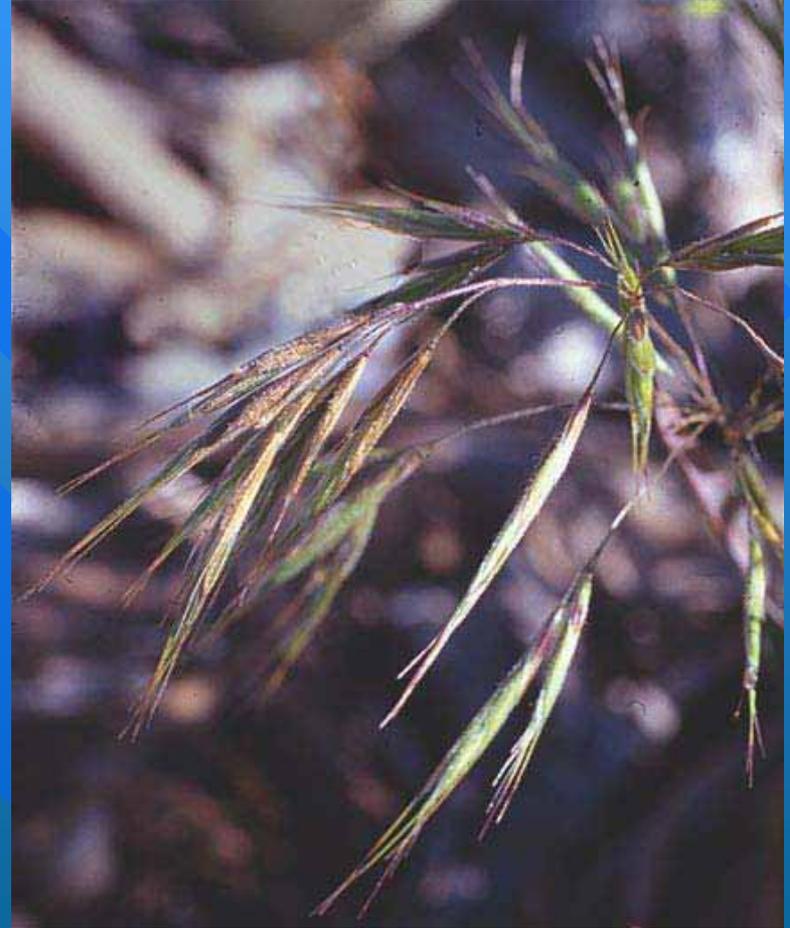


Another consideration is  
Management of Reclamation  
(Husbandry Practices)

# Irrigation

- Not routinely practiced by mining industry.
- Impractical for very large acreage.
- Concern that emerged vegetation will be dependant on additional water and once discontinued will die.
- May have applicability for O&G if used sparingly.

# Cheatgrass



# Cheatgrass

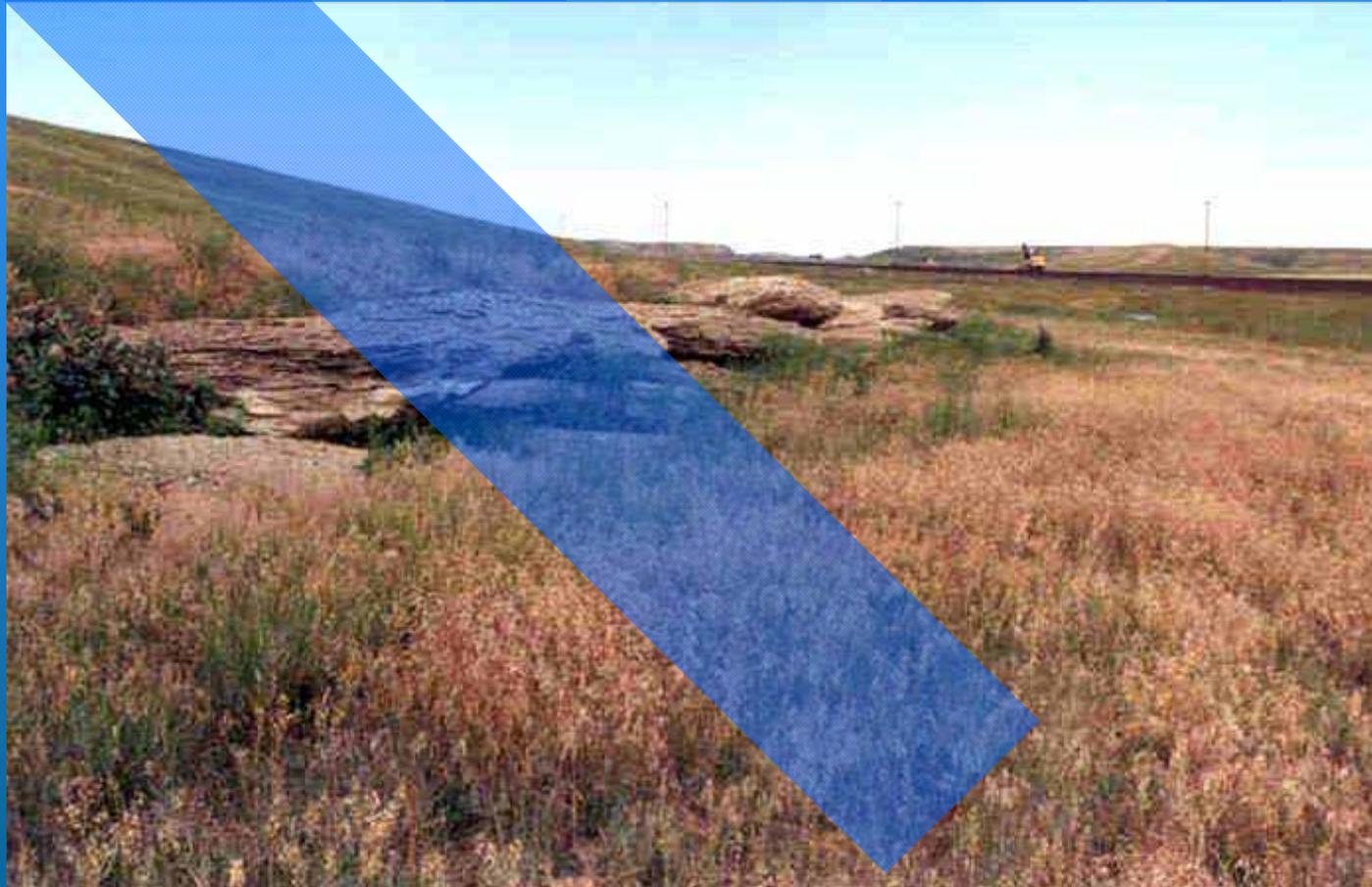
- Seeding these lower rates of aggressive cool season grasses allows a niche for cheatgrass.
- Cheatgrass can be a problem even with high CSG seed rates.
- Plateau being used to control cheatgrass. Will BLM allow it's use?
- Early Spring grazing can be used to manage cheatgrass.

# Native area cheatgrass



# Cheatgrass

## How much is acceptable in reclamation?



# How do you keep it out?



# Is it possible to keep it out?



# Do we really want diversity?



Even if there is some cheatgrass?





Or a cool-season grass monoculture?







# Diversity?



# Wildlife Predation on Shrub Establishment

# Core Hole Punch System 1998

2 year old Big Sagebrush  
“Mother Plant”



# Electric Fence



# Electric Fence



Woven wire exclosures erected in 2003, sagebrush is 9 years old and has been “unbrowsed” for 3 years



9 yr old sage fenced for past 3 years  
4 ft tall.



# 9 yr old sage not fenced 8 inches tall



# Fenced





# Wildlife/Livestock impact on sagebrush establishment?





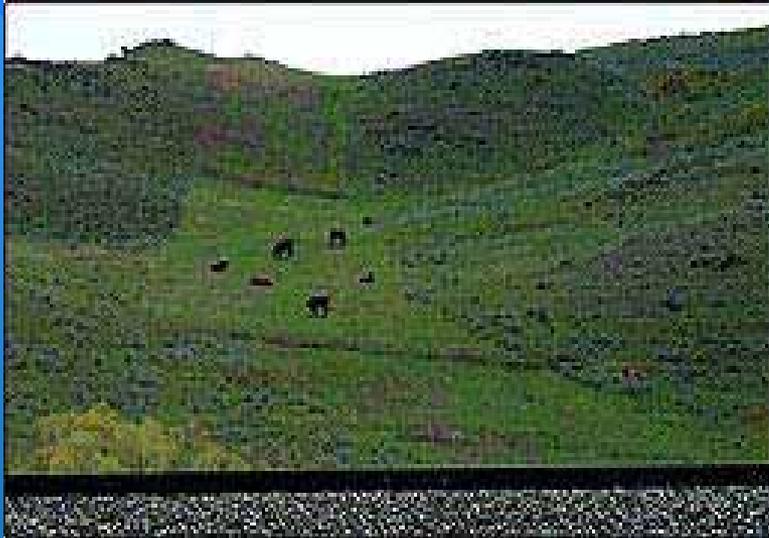






# Grazing Management

# Cows like reclamation



They may need to be managed.



But, they can also be used.



# My Recommended Techniques

1. Use good quality locally adapted (yellow tagged source identified) sagebrush seed.
2. Include sage seed in a diverse mixture including warm season grasses, forbs, legumes, subshrubs, and other shrubs and seed at 40 PLS/ft<sup>2</sup>.
3. Leave subsoil somewhat compacted.
4. Spread 6” of “live” topsoil.

5. If topsoil is rough and cloddy ('fist' size to 'boot' size), leave it and broadcast seed then cultipack/imprint.
6. If topsoil is loose-dry-light-fluffy, cultipack or roll it, then broadcast seed and cultipack/imprint.
7. If topsoil is compacted/settled, rip or disc it to make a cloddy seed bed then broadcast and cultipack/imprint.
8. I like the "Grasslander" seeder.

9. I like the “Dixon Land Imprinter/seedler”.
10. Seed in winter right before a snowfall.
11. Be patient, Russian thistle and kochia will be out competed in a few years.
12. Manage the reclamation. Over grazing, browsing, and cheatgrass invasion need to be controlled.

Thank You

Questions ?????

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