

Case Histories

Natural landscapes modified by mining

- Paschke, M.W., K. Topper, R.B. Brobst and E.F. Redente. 2005. Long-term effects of biosolids on revegetation of disturbed sagebrush steppe in northwestern Colorado. *Restoration Ecology* 13(3):545-551.



Piceance Basin, Colorado



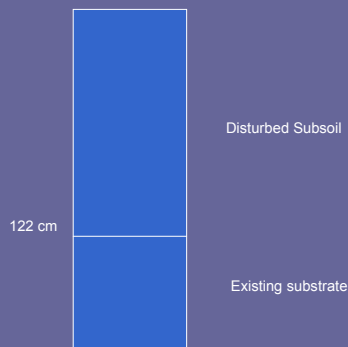
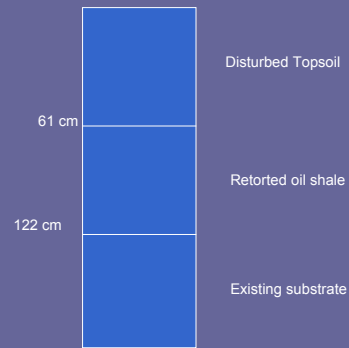
Oil shale



Retort

- Study conducted in Piceance Basin, 65 km NW of Rifle, Colorado
 - Elevation 2030 m
 - Semiarid, 280 mm/y precip, half snow
 - Sagebrush

- Oil shale excavated, taken to retort, pulverized, treated with steam to separate oil (Paraho method).
- Experimental restoration was performed on two disturbed byproducts of the mining of oil shale.



• Treatments:

- Biosolids
- Wood waste
 - Both applied to surface and roto-tilled in
- Plots were drill-seeded in 1977 with grasses, shrubs and forbs.

• Treatment levels:

Biosolids	Wood waste
Mg/ha	Mg/ha
56	0
112	22.4
224	44.8
Control	

Results

- 24 years after treatments, there were significant differences between treatments and controls (esp. on subsoil plots)
- On treatment plots:
 - pH lower
 - More OM
 - C/N ratio lower
 - More nitrates
 - More Cu and Zn

- Vegetation responses:
 - Sagebrush absent on all amended plots
 - Saltbush high in amended topsoil plots
 - Grasses high in amended subsoil plots
- If goal is to re-establish a sagebrush community like control, cut back on bio-solids, because they favor other forms.

- Bio-solids had an overall positive effect:
 - Lowered pH
 - Supplied phosphorus, OM, trace elements
 - Succession linked to higher N
 - Biosolids did not provide N
 - Biosolids provided OM, which facilitated cycling and nutrient pool development.

- Walker, R.F. 2002. Responses of Jeffrey pine on a surface mine site to fertilizer and lime. *Restoration Ecology* 10(2):204-212.



Tailings



- Leviathan mine, Alpine County, California
 - Open pit, former sulfur mine, opened in 1863 to extract copper sulfate for processing silver ore.
 - Converted to open pit sulfur mine in 1954.
 - Acid mine drainage has resulted in fish kills as far as 10 miles downstream.
 - Superfund site

- In Jeffrey pine dominated forest of eastern Sierra Nevadas
 - Surface mines in forest regions pose challenges for return to forest
 - Nutrient deficiencies
 - Toxic substrates
 - Harsh micro-climates
 - Droughty soils

- Sierra Nevada site poses additional climate constraints:
 - Semi-arid climate
 - Little growing season moisture
- Jeffrey pine is common in area and is tolerant of infertility and aridity.

Site

- Open pit sulfur mine, inactive since 1962
- 100 ha
- Elevation 2,200 m
- Spoil material is from steam-altered rock
- Precipitation 50 cm/y, mostly snow
- Former cover *Abies concolor*, *Pinus contorta*, *Pinus jeffreyi*

- Soils:
 - 70% sand, 19% silt, 11% clay
 - OM 0.4%
 - pH 4-4.5
 - Low N (741 µg/g)

Strategy

- Use soil amendments to make site more habitable.
- Amendments must not impair water relations.
- Controlled-release fertilizer has been used successfully with forestry nursery stock.
- Toxicity (metal availability) function of pH
 - Lime historically used to raise pH in agriculture

Experiment

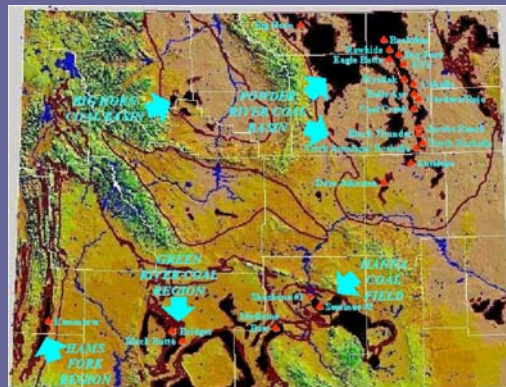
- Apply different levels of slow-release fertilizer.
- Apply lime
- Plant 2-0 bare root Jeffrey pine seedlings

- Slow release fertilizer applied as packets (0, 1 or 2) in augered backfill material.
- 30 g finely ground dolomitic limestone applied to backfill material in lime treatments.
- 1000 seedlings planted into 50 plots (stock from USFS nursery).

Results

- Seedling survival affected negatively by both fertilizer and lime
 - Lime killed more (25-30% more)
 - After 3 seasons fertilizer resulted in increased growth.
 - Lime continued to suppress growth.

- Williams, M.I., G.E. Schuman, A.L. Hild and L.E. Vicklund. 2002. Wyoming big sagebrush density: effects of seeding rates and grass competition. *Restoration Ecology* 10(2):385-391.





Wyoming big sagebrush



Belle Ayr coal mine



- Belle Ayr Coal Mine, Gillette, Wyoming
- Largest producing coal mine in U.S.
- Open pit/ shovel/ truck
- 7 year old topsoil stockpile was spread 56 cm deep over 70 m of spoil.

- Post-mining land in Wyoming is required to have one shrub per m² on 20% of land
 - Establishment has been spotty
 - Grass, forbs and shrubs are planted together
 - To provide soil stability
 - Wildlife habitat
 - Livestock forage
 - There is often inadequate shrub establishment; it is suspected grass limits shrub seedling establishment.

Experiment

- Three sagebrush seeding rates
- Seven grass seeding rates
- Site:
 - 1460 m elevation
 - 376 mm/y precipitation
 - Initially seeded spring 1998 with *Hordeum vulgare* (barley) cultivar
 - Mowed in summer and fall

- Sown December 1998.
- Grasses drill seeded to 2 cm depth
 - *Pascopyrum smithii*
 - *Elymus lanceolatus*
 - *Elymus trachycaulus*
- Wyoming big sagebrush broadcast with cracked corn as carrier.

- Grass seeding rates:

Kg/ha	Plants/m ² (pls)
0	0
2	187
4	374
6	561
8	750
10	935
14	1309

- Sagebrush seeding rates:

Kg/ha	Plants/m ² (pls)
1	350
2	700
4	1400

Results

- Total grass density did not vary among seeding rates.
- Sagebrush density after 1 y exceeded the 1 shrub per square meter standard for all sagebrush seeding levels.
- Greater sagebrush seeding levels resulted in higher sagebrush seeding densities.

- Sagebrush seedling survival dropped through the growing season, but establishment the next year exceeded previous season mortality.
- There was no interaction between grass seeding rate and sagebrush establishment.
 - Other authors have found that grass suppresses sagebrush at higher seeding rates.