Soil Health & Biotic Soils via 5 Fundamentals for Sustainable & Cost Effective Mine Closure

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Overview

• Quick Glance at “The 5 Fundamentals”
• Overview of Soil Health
• Summary of Biotic Soil Technologies
• Project Examples
• Cost Example
• Q & A
The Five Fundamentals

Understand Your Substrate: Test the soil or substrate for agronomics

Plant Species Selection: Pick plant materials compatible with project goals

Erosion Control Materials: Select the most effective control measures for your site

Proper Installation: Ensure guidelines and specifications are followed

Inspection and Maintenance: Coordinate plan to ensure success

Fundamentals must be integrated into a process that entails proper planning and execution
What is our ultimate site restoration goal?
Sustainable Vegetation

Climax Community
Sustainability Comes From Nutrient Cycling

Requires a **healthy soil** as the infrastructure to support and nurture vegetation.
What is Soil Health?

The continued capacity of the soil to function as a vital living ecosystem that sustains plants, animals, and humans

- Nutrient cycling
- Water (infiltration & availability)
- Filtering and Buffering
- Physical Stability and Support
- Habitat for Biodiversity

Most of the Soil Health concepts presented here stem from discussions and references provided from USDA-NRCS and Cornell Soil Sciences
But Why are We Talking About Soil Health?

It is the foundation of a successful project!

Healthy Soil
• Alive with microbes
• Storing water
• Cycling nutrients
• Attractive animal habitat

Sustainable Vegetation
• Dense coverage
• Diverse species
• Prolific roots
• Aesthetically appealing

Long-Term Erosion Control
• Minimal cost
• Low maintenance
• Habitat enrichment
• Water quality enhancement
Key Elements of Healthy Soil

- **Minerals:** Clay, sand and silt
- **Organic Matter:** Needed for microorganisms to break down to humus
- **Biological Activity:** Bacteria, fungi, protozoa, nematodes, worms, etc.
- **Water:** Carrier of nutrients, all living things require water
- **Air:** Critical for plant and microbiological activity
Keys to Improving Soil Health

• Increasing OM and Biological Activity are the keys to improving Soil Health
• We can track this by measuring pre and post levels of OM and Soil Respiration
Organic Matter & Biological Activity

- Organic Matter (OM) is the foundation for all biological life in the soil
- Key words in the OM foundation is “Biological Life”
- Without biological life, the OM is not capable of building a solid foundation
- Target will vary based on region
- Typical would be 2-5%
Biological Activity: Soil CO$_2$ Respiration

Measures soil respiration
- Rate of CO$_2$ released from decomposition of OM by soil microbes
- Indicates the level of microbial activity
- Correlates to the nutrients contained in OM in forms available to plants
Soil Respiration Activity

The target Soil Respiration value is 1000 mg CO$_2$ / kg soil / week

<table>
<thead>
<tr>
<th>Deficient Soil Activity</th>
<th>Low Soil Activity</th>
<th>Medium Soil Activity</th>
<th>Ideal Soil Activity</th>
<th>High Soil Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>mg CO$_2$ / kg soil / week</td>
<td>&lt; 300</td>
<td>300 – 500</td>
<td>500 – 1000</td>
<td>1000 – 2000</td>
</tr>
<tr>
<td></td>
<td>&gt; 2000</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Reference: USDA-NRCS, Soil Respiration – Soil Quality Kit – Guide for Educators
No Quality Topsoil — What Then?

• Next best alternative?
  - Use subsoil and hope for the best?
    (One of the primary causes of project failures)

  - Haul in and spread topsoil or compost?
    (Common but often expensive)
Topsoil and Compost Problems

- Many specifications for topsoil and compost do not call for specific agronomic requirements.
- Neither topsoil or compost can be effectively placed on steep slopes and both can actually increase erosion potential.
- Trucking in materials adds time and cost to projects and has a negative environmental impact.
- Quality topsoil is hard to find and expensive when you find it.
- Quality compost is oftentimes an oxymoron
  - “Allowable tolerances” of harmful bacteria are sometimes enough to literally make you sick.
- So what do you do?
Biotic Soil Technologies (BST)
## Compare: BST vs. Topsoil vs. Compost

<table>
<thead>
<tr>
<th>Considerations</th>
<th>BST</th>
<th>Topsoil</th>
<th>Compost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consistent Product</td>
<td>✓</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Decreased Hauling Costs</td>
<td>✓</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Readily Available / Easy Delivery</td>
<td>✓</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Easy On-Site Storage</td>
<td>✓</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Fast, Uniform Application</td>
<td>✓</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>No Substrate Mixing Required</td>
<td>✓</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Steep Slope Applications</td>
<td>✓</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Introducing Concentrated OM</td>
<td>✓</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>Readily Renewable</td>
<td>✓</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>Application on Toxic Substrates</td>
<td>x</td>
<td>✓</td>
<td>x</td>
</tr>
</tbody>
</table>
How Does BST Build Healthy Soils?

• BST’s improves soil chemistry — which later improves soil structure / texture — with increased organic matter and biological activity combined with plant establishment and subsequent nutrient cycling

• Helps O & A horizons to regenerate faster by creating a “revegetation platform”

• While the soil chemistry is improving, the media provides a more ideal growing environment

• Provides rapid growth establishment and sustains long-term vegetation
Projects Using 5 Fundamentals &
Tracking Soil Health Parameters
Heading towards Mine Closure

Increasing OM and Biological Activity are keys to improving soil health and achieving sustainable vegetation.

We can track this by measuring pre and post levels of OM and Soil Respiration:

- Oil & Gas Pad in Western CO
- Mine Reclamation in SE USA
- Colorado Mine Site
Oil & Gas Pad Site and Road Access – Western Colorado
General Project Location
Site Pad and Road
# Pad & Road Site Soil Test Problems

<table>
<thead>
<tr>
<th></th>
<th>pH</th>
<th>Organic Matter (OM)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Optimal Range</strong></td>
<td>6.3 – 7.4</td>
<td>3% – 5%</td>
</tr>
<tr>
<td><strong>Site Values</strong></td>
<td>8.4</td>
<td>1.6%</td>
</tr>
</tbody>
</table>
Custom Grass Seed Mix: 33.2 lb/acre
Saltbush: 4-Wing

4-WING SALTBUSSH
Lot: ATCA-10084

Pure: 92.30%
Crop: 0.13%
Inert: 7.48%
Weeds: 0.17%

Germ & Hard: 49%
Germination: 49%
Hard/Dormant: 0%
Net Wt.: 8.0 #
Tested: NOV 2012
Origin: UT

ENCANA SITE P-15

THIS BAG CONTAINS APPROX. 3.50 PLS LBS

Sharp Bros. Seed Co.
Not the Biggest... Simply the Best!
Fertilizer: 2000 lb/acre
pH Modifier -
Sulfur: 1000 lb/acre for this site
BST: 4000 lb/acre  BFM Cover at 2500 – 3000 lb/acre
Road is prepared – Ripped with tractor, fairly rocky with log placement for more natural look
Applying Saltbush by hand
Organic Matter Change

- Background OM
- Untreated/Disturbed OM
- BST-Treated OM (35 mo.)
Soil Respiration

- Soil is on the right track for improved biological activity – Soil Health is at or above ideal for region
- Significant increase in Soil Respiration (406% increase)
Soil Bacteria Level

Significant increase in beneficial Bacteria (304% increase)
Soil Fungi Level

Significant increase in Fungi (867% increase)

![Graph showing significant increase in Fungi levels with bars for Background Reference, Untreated / Disturbed Fungi Level, and BST-Treated Fungi Level (35 mo.).]
Mine Reclamation – SE USA
# Mine Site Soil Test Problems

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<td>Optimal Range</td>
<td>6.3 – 7.4</td>
<td>3% – 5%</td>
</tr>
<tr>
<td>Site Values</td>
<td>5.0</td>
<td>0.6%</td>
</tr>
</tbody>
</table>

![Mine Site Soil Test Problems Image]

![Mine Site Soil Test Problems Image]
Installation - April

- 5,000 lbs/acre of BST™ applied
- 3,500 lbs/acre of HP-FGM Lime & BioStimulants applied
Timeline — August

Site inspection mid-August 2016. Completed reclamation release on September 1, 2016.
Timeline — 18 Months after Installation

Follow-up inspection: sustainable vegetation/climax community.
Organic Matter Change

Organic Matter (OM) %

- Background OM: 1.50%
- Untreated/Disturbed OM: 0.60%
- ProGanics-Treated OM (18 mo.): 2.00%
Soil Respiration

- Soil is on the right track for improved biological activity – Soil Health is improving
- Significant increase in Soil Respiration (271% increase)

![Graph showing Soil Respiration (SR) comparison between Ideal USDA-NRCS SR, Untreated / Disturbed SR, and ProGanics-Treated SR (18 mo.).]
Soil Bacteria Level

Significant increase in beneficial Bacteria (345% increase)
Soil Fungi Level

Significant increase in Fungi (142% increase)
Mine Site – Ouray, CO
## Mine Site Soil Test Problems

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<td>7.3</td>
<td>1.1%</td>
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![Mine site soil test results](image-url)
Initial Growth/Germination

- Promising Start at 9800’
- Will Continue to track over time
Organic Matter Change

- **Background OM**: 3.20%
- **Untreated/Disturbed OM**: 1.10%
- **BST-Treated OM (11 mo.)**: 2.20%
Soil Respiration

- Soil is on the right track for improved biological activity – Soil Health is at ideal for region

- Significant increase in Soil Respiration (329% increase)
Soil Bacteria Level

Significant increase in beneficial Bacteria (240% increase)
Soil Fungi Level

Significant increase in Fungi (1800% increase)

![Bar graph showing significant increase in fungi levels]

- Background Reference
- Untreated / Disturbed Fungi Level
- BST-Treated Fungi Level (11 mo.)
What’s the Cost of BST?

• Cost of obtaining, hauling and placing topsoil can be significant
• Compare the cost of BSTs to topsoil or compost for any project site

Online BST Calculator
### BST Calculator

**Site Example**

<table>
<thead>
<tr>
<th>Material</th>
<th>Depth in Inches</th>
<th>Cubic Yards Needed</th>
<th>Cost Per Cubic Yard</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topsoil</td>
<td>4</td>
<td>1,452</td>
<td>$16.00</td>
<td>$23,232.00</td>
</tr>
<tr>
<td>Compost/Other</td>
<td>0</td>
<td>0</td>
<td>$20.00</td>
<td>$0.00</td>
</tr>
<tr>
<td><strong>Total Material</strong></td>
<td>4</td>
<td>1452</td>
<td></td>
<td><strong>$23,232.00</strong></td>
</tr>
</tbody>
</table>

**Traditional Volume-Based Topsoil and/or Compost**

**MATERIAL COST**

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<td><strong>Total Material</strong></td>
<td>1452</td>
<td></td>
<td><strong>$23,232.00</strong></td>
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</tbody>
</table>

**TRANSPORTATION & INSTALLATION COST**

<table>
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<tr>
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<th>Cubic Yards Material</th>
<th>Cost Per Cubic Yard</th>
<th>Total Cost</th>
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<tr>
<td>Topsoil</td>
<td>1,452</td>
<td>$8.00</td>
<td>$11,616.00</td>
</tr>
<tr>
<td>Compost/Other</td>
<td>0</td>
<td>$8.00</td>
<td>$0.00</td>
</tr>
<tr>
<td><strong>Total Transportation &amp; Installation Cost</strong></td>
<td></td>
<td></td>
<td><strong>$16,896.00</strong></td>
</tr>
</tbody>
</table>

**Total Cost**

**$40,128.00**

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1. **Cost Per Mile** based on a round trip from topsoil borrow pit or compost/other location to job site. Enter zeros in mileage and cost per mile if you have a delivered Cost. If you have a flat rate hauling cost per truckload, make sure you add it to your material cost.
## BST Calculator

### Site Example

<table>
<thead>
<tr>
<th>Material</th>
<th>Application Rate (lb/ac)</th>
<th># Bags Needed</th>
<th>Cost Per Bag</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>BST</td>
<td>5,000</td>
<td>270</td>
<td>$75.00</td>
<td>$20,250.00</td>
</tr>
<tr>
<td>Transportation</td>
<td>Number of Pallets^2</td>
<td>Cost per Pallet^3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BST</td>
<td>7</td>
<td>$50.00</td>
<td>$350.00</td>
<td></td>
</tr>
<tr>
<td>Installation(^4)</td>
<td>Acres</td>
<td>Cost per Acre</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BST</td>
<td>2.7</td>
<td>$3,000.00</td>
<td>$8,100.00</td>
<td></td>
</tr>
</tbody>
</table>

**Total BST Cost**  
$28,700.00

**BST Cost Savings**  
28.5%  
$11,428.00

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2. **Number of Pallets**: Forty, 50lb bags of BST per pallet = 2,000 lb/pallet  
3. **Cost per Pallet**: Based on LTI freight rates per 2,000 lb pallet or full truckload pricing for 22 pallets = 880 bags. If you have a delivered BST cost, enter zero in your freight cost per pallet.  
4. **Installation**: BST is hydraulically applied with complementary soil amendments and seed in one convenient and time-saving application.
Summary & Conclusion

- Confirmed with multiple project sites that utilizing the 5 Fundamentals in conjunction with BST’s can rebuild soil health and allow for sustainable vegetation in challenging areas and save money versus conventional techniques.
Questions
Soil Health & Biotic Soils via 5 Fundamentals for Sustainable & Cost Effective Mine Closure

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