Can biochar link forest restoration with commercial agriculture?

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Catastrophic fire threatens Oregon’s forests

- 4 million ha. are at high risk of wildfire in Oregon

- Most of the risk is due to decades of fire suppression and a lack of funds to support fuel reduction treatments

- Limited demand for forest harvest residues restricts the ability of foresters to fund restoration projects.
Drought threatens Oregon’s crops

- In 2015 drought resulted in over >$1.2 billion in crop losses
- Biochar has the potential to improve water availability in agricultural soils, but limited supplies means costs are high.
- Does a forest-origin biochar strategy pair these reciprocal needs of forest restoration and agricultural productivity?
Does a forest-to-farm biochar paradigm pair the needs of forest restoration and agriculture?
## Char Properties

### Chemical Characteristics

<table>
<thead>
<tr>
<th>Source</th>
<th>pH</th>
<th>cmol-C/kg</th>
<th>Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microwave</td>
<td>8.23</td>
<td>7.34</td>
<td>0.25</td>
</tr>
<tr>
<td>Thermal</td>
<td>9.34</td>
<td>6.05</td>
<td>0.27</td>
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</table>

### Proximate

<table>
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<tr>
<th>Volatile</th>
<th>Fixed C</th>
<th>Ash</th>
<th>%</th>
<th>%</th>
<th>%</th>
<th>%</th>
<th>%</th>
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</thead>
<tbody>
<tr>
<td>Microwave</td>
<td>13</td>
<td>82</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Thermal</td>
<td>14</td>
<td>73</td>
<td>12</td>
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### Ultimate

<table>
<thead>
<tr>
<th>C</th>
<th>H</th>
<th>N</th>
<th>O</th>
<th>S</th>
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<tbody>
<tr>
<td>88</td>
<td>2</td>
<td>0.5</td>
<td>5</td>
<td>0.089</td>
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<tr>
<td>83</td>
<td>2</td>
<td>0.5</td>
<td>5</td>
<td>&lt;0.005</td>
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</table>

### VOCs

<table>
<thead>
<tr>
<th>Acetone</th>
<th>2-Butanone</th>
<th>Benzene</th>
<th>Toluene</th>
<th>Ethylbenzene</th>
<th>m,p-Xylenes</th>
<th>o-Xylene</th>
<th>4-Isopropyltoluene</th>
<th>Naphthalene</th>
<th>Semi-volatiles</th>
</tr>
</thead>
<tbody>
<tr>
<td>mg/kg</td>
<td>mg/kg</td>
<td>mg/kg</td>
<td>mg/kg</td>
<td>mg/kg</td>
<td>mg/kg</td>
<td>mg/kg</td>
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<tr>
<td>Microwave</td>
<td>62</td>
<td>21</td>
<td>8.8</td>
<td>11</td>
<td>2</td>
<td>4.4</td>
<td>2.6</td>
<td>5.7</td>
<td>2.6</td>
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<tr>
<td>Thermal</td>
<td>38</td>
<td>BMDL</td>
<td>2.6</td>
<td>1.8</td>
<td>BMDL</td>
<td>BMDL</td>
<td>BMDL</td>
<td>BMDL</td>
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</table>
Does a forest-to-farm biochar paradigm pair the needs of forest restoration and agriculture?
Klamath Basin of Oregon: where irrigated cropping systems, water scarcity, and high fire-hazard forests share the same landscape
BIOCHAR PRODUCTION PROCESS

50,000 BDT of forest restoration logs / year

Scenario 1
Biochar Production
18,000 tons/year

Scenario 2
Heat Recovery

Scenario 3
Electricity generation

Scenario 4
Liquid Recovery

Chipping
Drying
Milling

Microwave Pyrolysis

Thermal Pyrolysis

Klamath Falls
Yreka
Preliminary Cost Estimates

**Preliminary Capital Costs**

**Preliminary Biochar Production Cost**

![Graph showing cost estimates for different processes and locations.](image-url)
Critical Economic Factors

- **Plant location**
  - Influences delivered log costs

- **Electricity rates**
  - Higher in California than Oregon
  - Higher usage for microwave technology

- **Plant Complexity**
  - Recovery of energy and condensable liquids adds capital and operating costs

- **Seasonality**
  - Influences raw material and finished product inventory
  - Log deliveries limited to summer months
  - Product sales limited to spring and fall months
  - Plant operates year round to maximize asset utilization
Summary

- Biochar-based products utilize low-value biomass from forest restoration projects. Simultaneously, biochar can:
  - Prolong the storage of soil water
  - Sequester carbon in soils
  - Improve plant productivity
- Our economic analysis determined that:
  - Microwave pyrolysis is more costly than thermal pyrolysis
  - Electrical generation from this process adds a significant cost
- Further analyses will determine if these extra costs can be offset.
Acknowledgments

Economic Evaluation of a Forest-to-Farm Biochar Paradigm

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Agricultural Research Service

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College of Forestry
• A shift level productivity study using steep slope harvesting technology was used to develop a model of tethered harvest.

• Used decision support models to optimize treatments and transport from forest to plant.

• The cost of tethered machines on tethered operations (TT) and untethered operations (TU), and the cost of untethered machines on untethered operations (UT) were estimated.

<table>
<thead>
<tr>
<th></th>
<th>No Firewatch</th>
<th>With Firewatch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost per green ton</td>
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<td></td>
</tr>
<tr>
<td>TT</td>
<td>$26.84</td>
<td>$27.04</td>
</tr>
<tr>
<td>TU</td>
<td>$23.63</td>
<td>$23.80</td>
</tr>
<tr>
<td>UT</td>
<td>$21.38</td>
<td>$21.55</td>
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</table>
Biochar Plant Design Assumptions

• Log supply:
  • 50,000 bdt/year
  • Low-grade logs from restoration treatments on National Forests

• Plant Location
  • Existing wood processing sites in Oregon and California

• Primary Technology
  • Thermal and Microwave pyrolysis reactors from commercial suppliers

• Other Technology
  • Size reduction and material handling systems from commercial suppliers