Can Biochar Link Forest Restoration with Commercial Agriculture?

Economic Evaluation of a Forest-to-Farm Biochar Paradigm

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John Campbell

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Dan Leavell  
John Bailey

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Agricultural Research Service

Oregon State University  
College of Forestry

Sessions et al., Journal of Biomass and Bioenergy (in review)
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 caused 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?
Does a forest-to-farm biochar paradigm pair the needs of forest restoration and agriculture?
Study Area: Klamath Basin of Oregon
Is it economical to reduce fuel loads on steep slopes?

A shift level productivity study using steep slope harvesting technology was used to develop a model of tethered harvest.
Is it economical to reduce fuel loads on steep slopes?

• 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.

• Model calculated average harvest and transport cost to each plant

<table>
<thead>
<tr>
<th>Cost per green ton</th>
<th>No Firewatch</th>
<th>TT</th>
<th>TU</th>
<th>UT</th>
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<tbody>
<tr>
<td></td>
<td>With Firewatch</td>
<td>TT</td>
<td>TU</td>
<td>UT</td>
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<tr>
<td>$26.84</td>
<td>$23.63</td>
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<td>$27.04</td>
<td>$23.80</td>
<td>$21.55</td>
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<table>
<thead>
<tr>
<th>Wardon, OR</th>
<th>Yreka, CA</th>
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</thead>
<tbody>
<tr>
<td>Harvest and Transport (Per BDT)</td>
<td>$50</td>
</tr>
</tbody>
</table>

Josh Petitmermet et al., (in preparation)
BIOCHAR PRODUCTION PROCESS

Scenario 1
Biochar Production
- 18,000 tons/year

Scenario 2
Heat Recovery
- 50,000 BDT of forest restoration logs / year

Scenario 3
Electricity generation
- 18,000 tons/year

Scenario 4
Liquid Recovery

Milling
Microwave Pyrolysis
Thermal Pyrolysis

Chipping
Drying
Complexity of plant does not increase price

Capital Costs

Biochar Production Cost
Critical Economic Factors

• Plant location
  • Influences delivered log costs

• Electricity rates
  • Higher in California and for microwave production

• Plant Complexity
  • Recovery of energy and condensable liquids adds capital and operating costs but in the end, offsets the production cost

• 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
Harvest and Transport Impact Biochar Production Costs

Biochar Production Cost without Harvest and Transport

Biochar Production Cost with Harvest and Transport
Can Farmers Afford Forest-Origin Biochar?

<table>
<thead>
<tr>
<th>Crop</th>
<th>Area Harvested (ha)</th>
<th>Total Production (Mg)</th>
<th>Value ($ Mg⁻¹)</th>
<th>Value ($ ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oats</td>
<td>823</td>
<td>3,167</td>
<td>$207</td>
<td>$795</td>
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<tr>
<td>Potatoes</td>
<td>3,359</td>
<td>129,138</td>
<td>$160</td>
<td>$6,168</td>
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<tr>
<td>Barley</td>
<td>6,635</td>
<td>33,086</td>
<td>$124</td>
<td>$618</td>
</tr>
<tr>
<td>Hay (excluding alfalfa and barley)</td>
<td>6,798</td>
<td>34,347</td>
<td>$190</td>
<td>$960</td>
</tr>
<tr>
<td>Wheat</td>
<td>7,274</td>
<td>32,790</td>
<td>$136</td>
<td>$615</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>20,236</td>
<td>189,750</td>
<td>$184</td>
<td>$1,722</td>
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Can Farmers Afford Forest-Origin Biochar?

Conventional Crops

Claire Phillips: PNW Biochar Atlas Session 1C Wed 9:45
Can Farmers Afford Forest-Origin Biochar?

**Organic Crops**

<table>
<thead>
<tr>
<th>Crop</th>
<th>Wholesale Price, IBI 2014</th>
<th>Wholesale Price, This Study</th>
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**IBI Estimate**

This Study

**Maximum Biochar Cost ($ ha⁻¹)**

Yield Increase (%)
Can Farmers Afford Forest-Origin Biochar?

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*Assume 2-ton acre amendment rate
Summary

• The production of biochar from forest residues has the potential to
  • Reduce fire risk
  • Store forest-origin carbon in agricultural soils
  • Lower the price point for biochar products

• Our economic analysis determined that:
  • Microwave pyrolysis is more costly than thermal pyrolysis
  • Electrical generation from this process adds a significant capital cost but lowers overall price point
  • Local commodity markets are not enough to support a biochar industry
Acknowledgments

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Collaborators: Karr Group; BSEI Inc.; Green Diamond; Miller Timber
## Char Properties

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<thead>
<tr>
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<td>Fixed C</td>
<td>Ash</td>
<td>C</td>
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<tr>
<td></td>
<td>%</td>
<td>%</td>
<td>%</td>
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<tr>
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<td>82</td>
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<tr>
<td>Thermal</td>
<td>14</td>
<td>73</td>
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<table>
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<tbody>
<tr>
<td></td>
<td>Acetone</td>
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<tr>
<td></td>
<td>mg/kg</td>
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<tr>
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<td>BMDL</td>
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