The Economics of Biochar Carbon Sequestration in Massachusetts

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Potential Benefits of Massachusetts Biochar Production

- Improve crop yields
- Produce renewable energy
- Sequester carbon

Research Questions:

- How much does it cost to produce biochar?
- What is the value of increased crop yields?
- What is the value of energy produced?
- What quantity of biochar can be produced in Massachusetts?
- How much biochar could be applied in Massachusetts?
- What is the net cost of sequestering carbon using biochar?
Economic Analysis: Method

\[
\text{Biochar sequestration cost} = \frac{(K\alpha + C)}{\Delta CO_2} - B_a - B_c
\]

K is the capital cost for a biochar system;
C is operating cost for a biochar system, including labor, biomass feedstock, etc;
\(\Delta CO_2\) is the change in atmospheric CO_2, which equals the amount of CO_2 sequestered;
\(B_a\) is the biochar benefit in agricultural use;
\(B_c\) is the benefit of biochar coproducts: pyroligneous acid, thermal energy, electricity, etc;
and \(\alpha\) is a capital recovery factor:

\[
\alpha = \frac{r(1 + r)^T}{(1 + r)^T - 1}
\]

where:

\(r\) is an annual discount rate; and
\(T\) is the number of years the capital investment is expected to last.
Potential Agricultural Benefits of Biochar

- Liming agent
- Phosphorous and potassium additions
- Nutrient retention
- Water retention
- Increased microbial activity

**Slow Pyrolysis**
- More biochar
- More porous structure
- Increased CEC
- Byproduct: pyroligneous acid

**Fast Pyrolysis**
- More energy
- Byproduct: bio-oil
- More stable carbon

Also differences based on:
- Application practices
- Biomass feedstock
- Soil characteristics
- Years since initial application
Estimate of Biochar Agricultural Value in Massachusetts

Biochar metastudy result: 10% yield increase (Jeffery et al. 2011)
Massachusetts evidence: Much anecdotal
  Little in controlled studies

Assumed biochar application rate: 18 tons/acre
Massachusetts relevant agricultural production value: $117 M (USDA, 2014)
First-year value: $11 M

Years of benefit: 25
Discount rate: 6%
Present value of increases: $150 M

Average value of biochar: $56.76/ton applied
Massachusetts Biochar Potential

Best candidate land:
- tilled cropland
- acid soil
- poor soil nutrients
- excessive drainage

Possible demand and supply:
Using 18 tons/acre: 3.8 M tons
Production: 0.27 M tons/year
Carbon sequestration: ≈1% of current emissions
Production Method: CharCone

Easthampton, MA
Production Method:
New England Biochar

Eastham, MA
Production Method:
NextChar

Amherst, MA
Production Method: Roberts Energy Renewables
## Results:

### Cost of Carbon Sequestration

- **CharCone:** $83/Mg CO₂
- **NE Biochar:** $92/Mg CO₂
- **Modified boiler:** $114/Mg CO₂
- **NextChar:** $82/Mg CO₂
- **Roberts/Biogen:** $119/Mg CO₂
Minimizing Cost of a Fully Renewable Energy System

Energy options:
- solar photovoltaic
- wind power
- hydropower, run-of-river
- pumped hydro energy storage
- biomass/biochar?