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?

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Economic Analysis: Method

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

K is the capital cost for a biochar system;
C is operating cost for a biochar system, including labor, biomass feedstock, etc;
ΔCO_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 α 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.

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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

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Massachusetts Biochar Potential

Best candidate land:

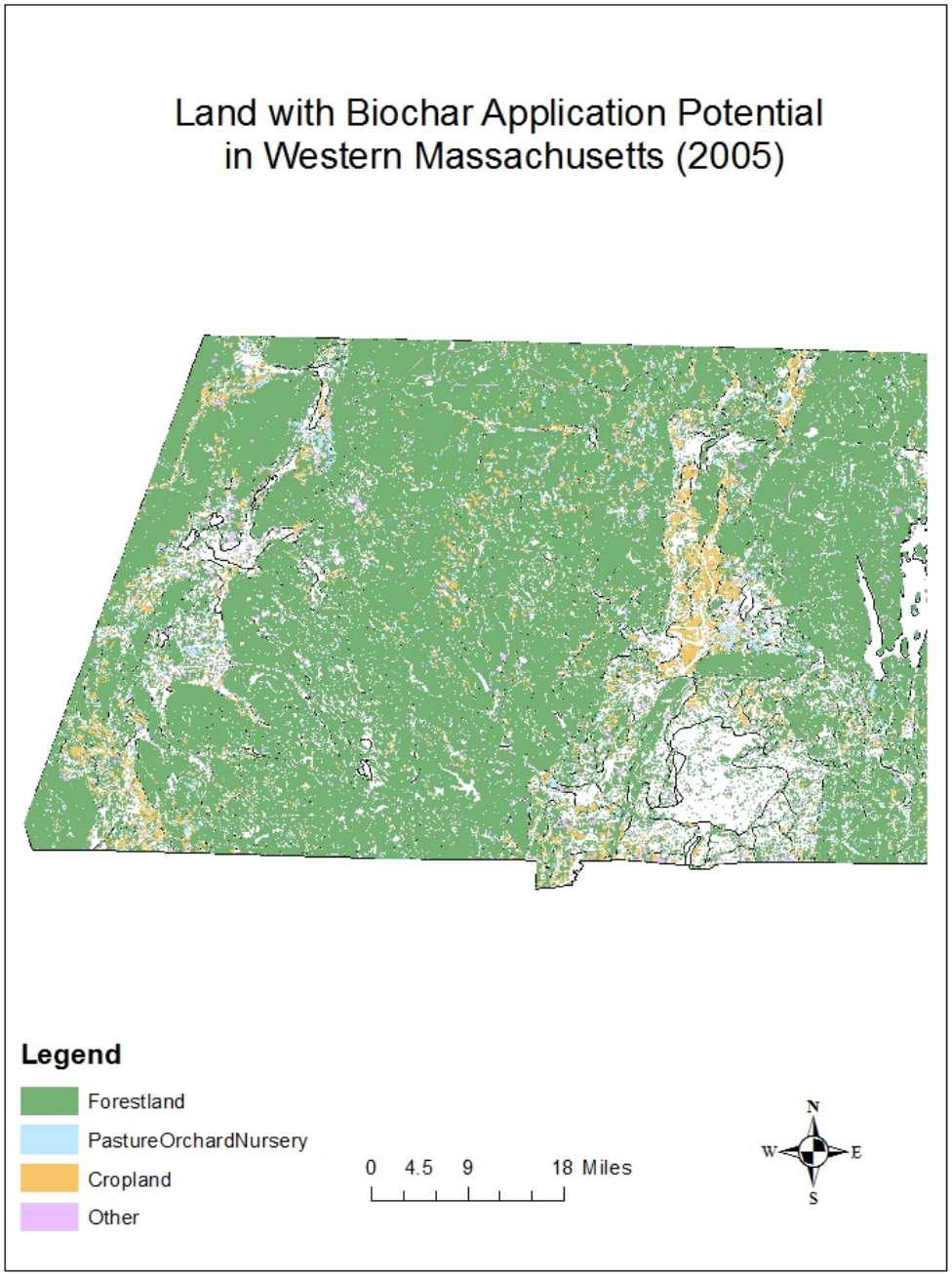
- tilled cropland
- acid soil
- poor soil nutrients
- excessive drainage

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

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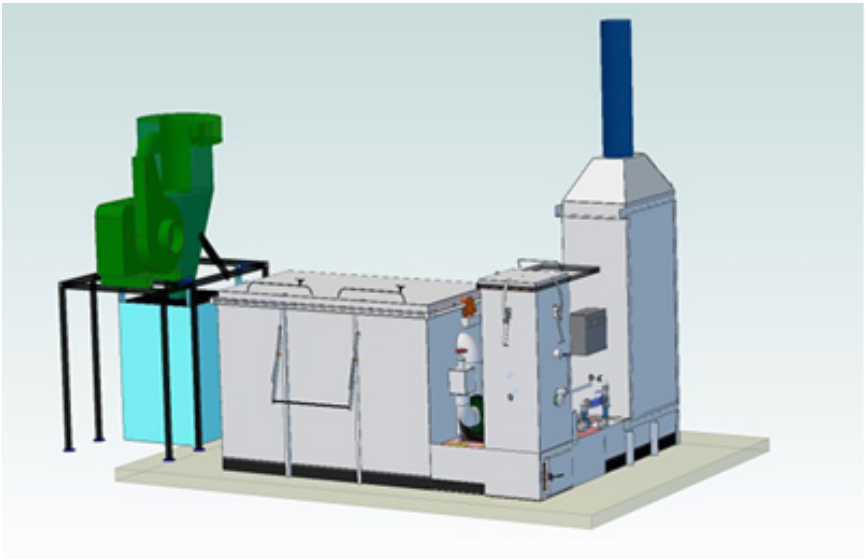
Production Method:

New England Biochar

Eastham, MA



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Production Method:

NextChar

Amherst, MA

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Production Method:

Roberts Energy Renewables

Ashfield, MA

Results:
Cost of Carbon Sequestration

CharCone: **$83/Mg CO_2**

NE Biochar: **$92/Mg CO_2**

Modified boiler: **$114/Mg CO_2**

NextChar: **$82/Mg CO_2**

Roberts/Biogen: **$119/Mg CO_2**

Table 6-1. Cost Carbon Sequestration with Biochar: Massachusetts Case Studies

	Char-cone	New England Biochar retort	Modified biomass electric plant	NextChar CHAB processor	Biogen G1300 gasifier
Plant size (input Mg/day, 40% MC)	0.06	9	367	101	63
hours per day	3.5	24	24	24	24
days per year	75	330	330	330	336
Biomass Mg/year @ 40% MC	4.1	2,831	121,208	33,333	21,000
Biomass Mg/year, dry weight	2.5	1,699	66,664	20,000	12,600
Plant capital cost	$549	$558,000	$3,152,908	$3,500,000	$7,800,000
plant life, years	20	20	20	20	20
average return on capital	10%	10%	10%	10%	10%
Annualized capital cost	$64	$65,542	$370,339	$411,109	$916,185
Biomass fuel costs					
biomass input @ 40% MC	4.1	2,831	7,362	33,333	21,000
biomass price/Mg, 40% MC	-	$(28)	$25	$25	$25
Total biomass fuel cost per year	-	$(79,279)	$184,055	$833,333	$525,000
Plant annual operating costs					
labor cost	-	$150,000	-	482,380	$482,380
maintenance, % of capital cost	0.0%	5.0%	5.0%	5.0%	5.5%
annual maintenance cost	-	$27,900	$157,645	$175,000	$430,000
utilities, supplies, and other costs	$80	$31,100	-	-	-
Total plant operating cost	$80	$209,000	$157,645	$657,380	$912,380
Total annual cost	$144	$195,263	$712,040	$1,901,822	$2,353,565
Electricity production, MWh	-	-	not included	-	16,128
Electricity value, $/MWh	-	-	not included	-	$85
Total electricity value per year	-	-	-	-	$1,370,880
Heat production per hour, MMBtu	-	1.50	-	18.00	10.00
Heat utilization rate		50%		50%	75%
Net utilized heat, MMBtu/hour		0.75		9.00	7.50
Heat value, $/MMBtu	-	$9.01	-	$9.01	$9.01
Total heat value per year	-	53,668	-	642,082	544,797
Net annual cost	$144	$141,595	$712,040	$1,259,740	$437,888
Biochar yield, percent dry weight	22%	30%	3%	25%	10%
Annual biochar production, tons	0.54	510	2,133	5,000	1,260
Biochar production cost per ton	$268	$278	$334	$252	$348
Biochar distribution cost per ton	-	$14	$14	$14	$14
Biochar ag value per ton	$57	$57	$57	$57	$57
Net cost biochar per ton	$211	$235	$291	$209	$304
Biochar carbon content	79%	79%	79%	79%	79%
Recalcitrant carbon portion	97%	97%	97%	97%	97%
Carbon sequestered per Mg biochar	77%	77%	77%	77%	77%
~~Cost of sequestration per Mg C~~	~~$303~~	~~$337~~	~~$418~~	~~$300~~	~~$437~~
Cost of sequestration/Mg CO_2	$83	$92	$114	$82	$119

Minimizing Cost of a Fully Renewable Energy System

Energy options :

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