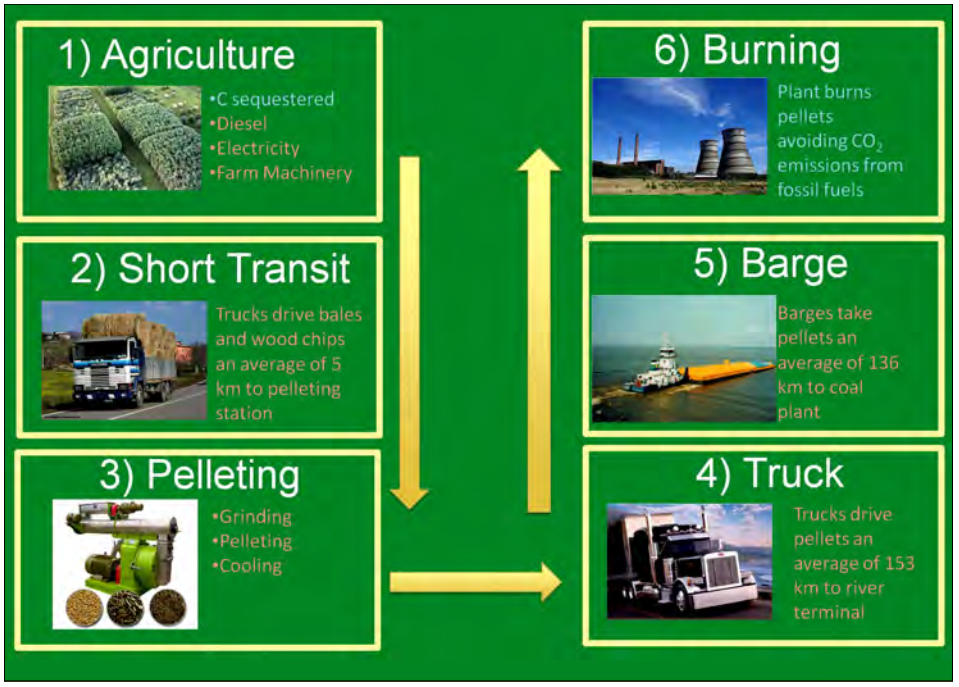
Assessment of Carbon Lifecycle for Growing Crops for Biofuels Around Pike County, Kentucky

Katie Young, Department of Civil and Environmental Engineering, Virginia Tech
Faculty Mentors: James Fox (University of Kentucky), Alice Jones (Eastern Kentucky University), Elliott Campbell (University of California, Merced)
NSF-Research Experience for Undergraduates, Appalachian Headwaters Program 2010

Purpose

The state of Kentucky is in need of renewable, low carbon emission energy sources. The purpose of this study is to explore using reclaimed mine sites as biofuel production plots by projecting future fuel-to-energy ratios and carbon savings associated with growing biofuel specific crops on mountaintop coal mining and valley fill sites.



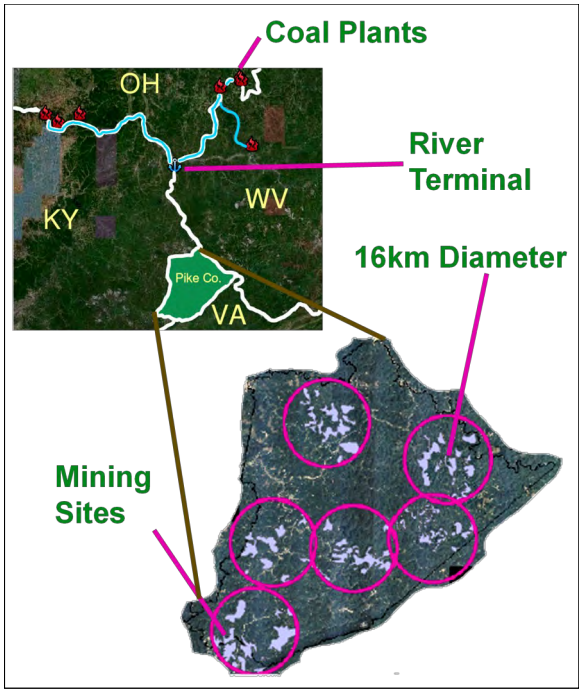
Overview and Methods

In the projected model, crops would be grown on reclamation sites and assumed to produce 65% of fertile land yield. Biomass would be pelletized and then burned at coal fired plants for electricity. The main carbon losses of this method would be CO_2 emissions from production of pellets and carbon not sequestered if uptake rate is less than the reclaimed site rate. The main carbon benefits of this method would be CO_2 emissions avoided from fossil fuels and carbon sequestered, if uptake rate is greater than reclamation site uptake rate (1.30 t/ha yr). The net carbon savings will be the calculated carbon benefits less carbon losses.

The carbon uptake rate of these crops is unknown, so three rates (0.5, 1.30, and 2.06 t/ha yr) are used for a low-, mid-, and high-range estimate.

Sites of Interest

An existing experimental biofuel test plot located on a reclaimed mine site in Pike County, Kentucky was used for this analysis. Crops on this site include corn, switchgrass, miscanthus, cottonwood, sycamore, and black locust, which were all planted nine months prior to study. Carbon density of the site was found by collecting soil samples and analyzing their isotopic signatures. These carbon estimates were then applied to all mountaintop mine reclamation sites in Pike County to estimate potential market scale production. This area was selected because of the numerous mine reclamation sites (see map) and an existing rail and waterway infrastructure for transporting coal to regional power plants, which could be adapted easily for pelletized biofuels in existing plants.



Eastern Kentucky Environmental Research Institute
Eastern Kentucky University
521 Lancaster Avenue • Moore B-18
Richmond, Kentucky 40475
(859) 622-6914 • www.eri.eku.edu

August 2010
RS10.026

Results

	Corn Stover (C)		Switchgrass (SG)		Miscanthus (M)		Cottonwood (CW)		Sycamore (SM)		Black Locust (BL)	
	Energy	CO_2	Energy	CO_2	Energy	CO_2	Energy	CO_2	Energy	CO_2	Energy	CO_2
(Units)	(MJ/t)	(kg/t)	(MJ/t)	(kg/t)	(MJ/t)	(kg/t)	(MJ/t)	(kg/t)	(MJ/t)	(kg/t)	(MJ/t)	(kg/t)
Agriculture	932.1	80.7	472.5	40.9	413.7	35.8	661.1	57.2	1198.8	103.8	1204.8	104.3
Short Transportation	20.3	1.5	20.1	1.5	20.1	1.5	7.7	0.6	8.7	0.6	9.0	0.7
Processing	364.7	29.7	364.7	29.7	364.7	29.7	1210.0	98.6	1210.0	98.6	1210.0	98.6
Truck Transportation	210.3	15.6	210.3	15.6	210.3	15.6	210.3	15.6	210.3	15.6	210.3	15.6
Barge Transportation	25.1	1.9	25.1	1.9	25.1	1.9	25.1	1.9	25.1	1.9	25.1	1.9
Total Inputs	1552.5	129.4	1092.7	89.6	1033.9	84.5	2114.2	173.9	2652.9	220.5	2659.2	221.1
Energy Content	7040.0	-	7040.0	-	7040.0	-	7040.0	-	7040.0	-	7040.0	-
Net Energy Value	5487.5	-	5947.3	-	6006.1	-	4925.8	-	4387.1	-	4380.8	-
Fuel-Energy Ratio	**4.5**	**-**	**6.4**	**-**	**6.8**	**-**	**3.3**	**-**	**2.7**	**-**	**2.6**	**-**

(Units)	(t/ha)	(t/ha)	(t/ha)	(t/ha)	(t/ha)	(t/ha)
Yield	5.0	9.9	11.3	7.1	3.9	3.9

(Units)	(kg/ha)	(kg/ha)	(kg/ha)	(kg/ha)	(kg/ha)	(kg/ha)
Total CO_2 Emissions	648.1	883.9	952.7	1225.7	859.8	857.7
CO_2 Emissions Avoided	2873.9	5661.7	6470.5	4044.1	2237.2	2225.7
C Savings w/o C sequestration	2225.8	4777.8	5517.8	2818.4	1377.4	1368.0
CO_2 % Reduction	**77%**	**84%**	**85%**	**70%**	**62%**	**61%**

Fuel to energy ratio and carbon savings without sequestration results.

Uptake Rate	Low End	Reclaimed Grassland	Reclaimed Forest
	0.50 t C/ha yr	**1.30 t C/ha yr**	**2.06 t C/ha yr**
Crop	kg CO_2/ha yr		
C	-707.5	2225.8	5012.5
SG	1844.5	4777.8	7564.5
M	2584.5	5517.8	8304.5
CW	-114.9	2818.4	5605.1
SM	-1555.9	1377.4	4164.1
BL	-1565.3	1368.0	4154.7

Calculated carbon savings with carbon sequestration.

Conclusion

The initial carbon density was found to be 11.6 mg/ha. These data indicate that, if the SOC uptake rate is at least 1.30 t/ha yr, biofuel crops have greater carbon benefits than losses. Fuel to energy ratios were projected to be much greater than one.

Because of higher yields, miscanthus and switchgrass have greater net energy values, greater fuel to energy ratios, and greater carbon savings.

Areas of Further Research

Results suggest promise for biofuel production on mountaintop coal mining and valley fill sites. However, further refined measurements and data are needed for conclusive results. This model relied heavily on estimates because of missing or inconclusive literature, including: yields, pellet processing, pellet energy content, and SOC uptake rate. Crop soil carbon density should continue to be measured yearly in order to determine carbon sequestration rates.

KATIE YOUNG is a junior majoring in civil and environmental engineering at Virginia Tech.

JAMES F. FOX is an assistant professor of water resources in the Department of Civil Engineering at the University of Kentucky and co-director of the Appalachian Headwaters Summer Research Program.

ALICE JONES is a professor of environmental planning in the Department of Geography & Geology at Eastern Kentucky University and co-director of the Appalachian Headwaters Summer Research Program.

The study was conducted as part of NSF Research Experience for Undergraduates and Research Experience for Teachers program: *Coal Mining's Impacts on Soil Carbon Storage and Erosion in Appalachian Headwater Stream Health* — a ten-week summer research program co-hosted by Eastern Kentucky University and the University of Kentucky.

Funded by the National Science Foundation, Division of Earth Sciences, Award No EAR-0754888, with co-funding from the NSF Experimental Program in Competitive Research (EPSCoR), and the Innovations in Environmental Education (EdEn) venture fund.