Warm-Season Grass Production on Two Mine Soils Amended with Spent Mushroom Compost

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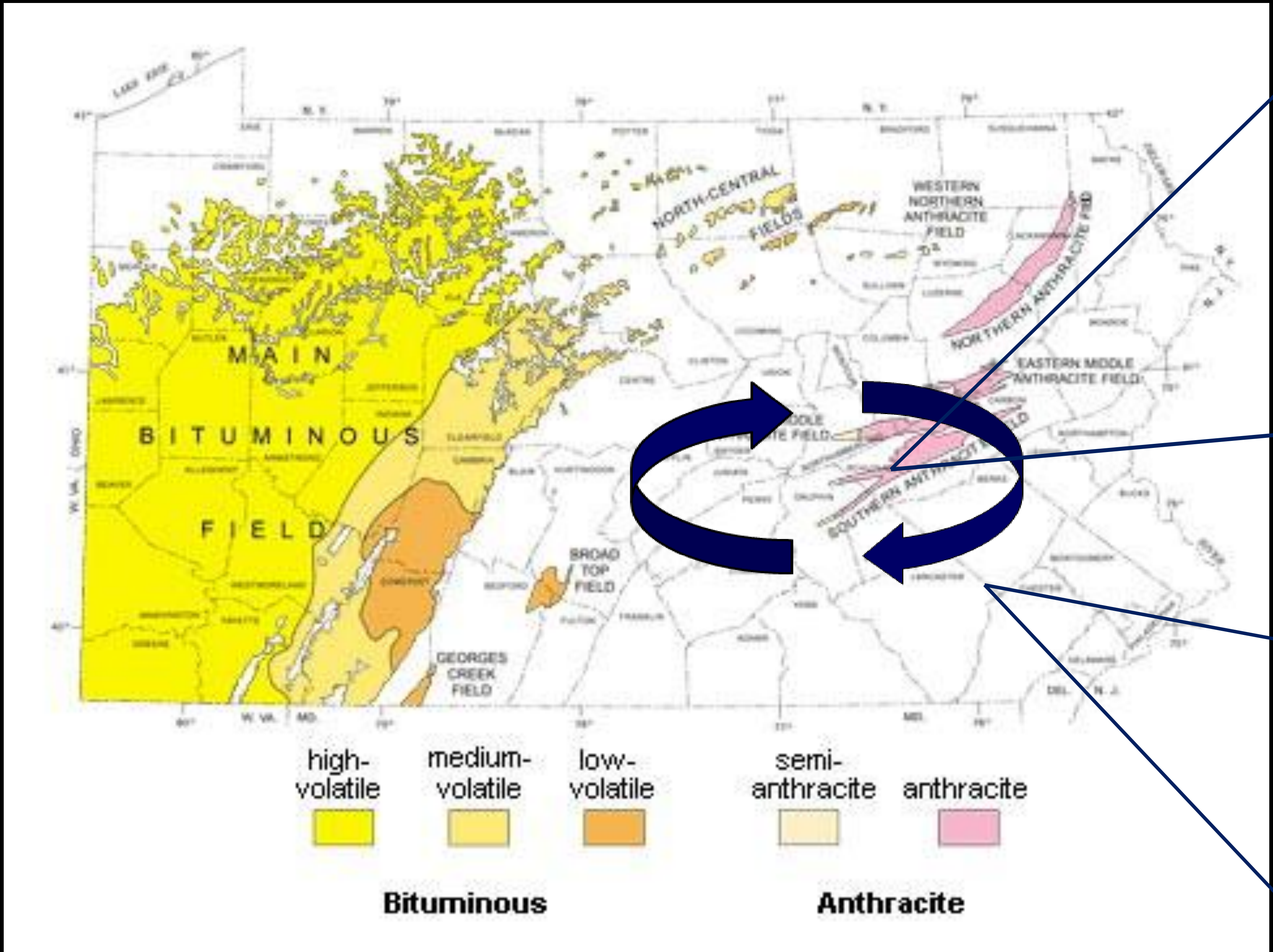
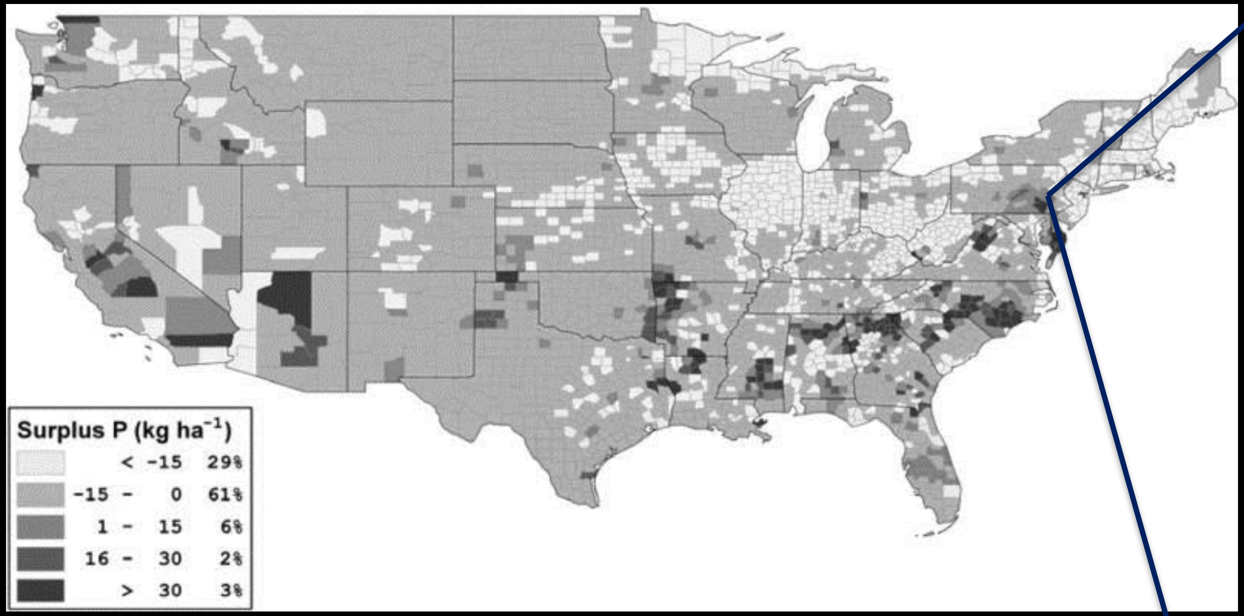


Map source: PA DCNR

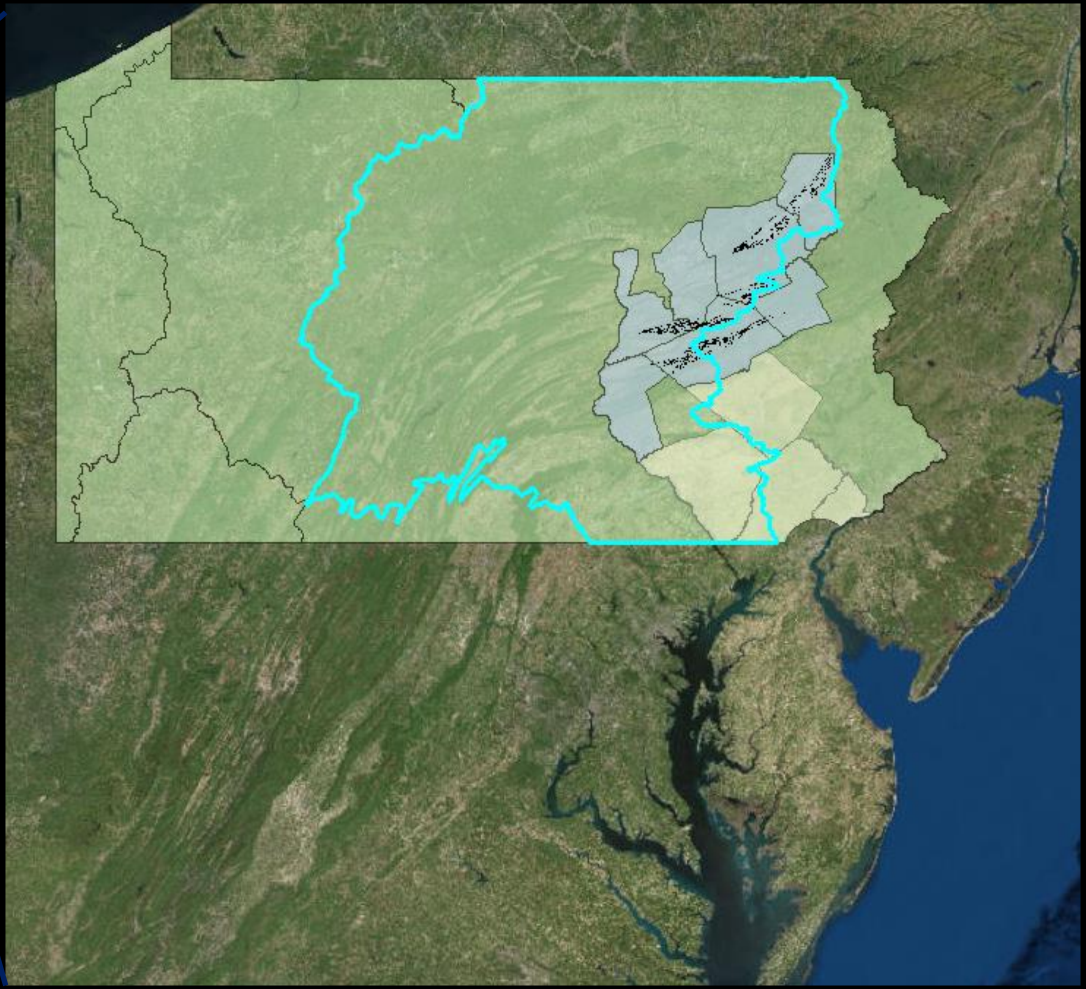
What is Spent Mushroom Compost (SMC)?

- Mix of recycled agricultural/municipal waste
- Single-pass use
- Nutrient rich
- Disposal issues

Nutrient Loading in Chesapeake Bay and Nutrient Deficient Mined Land

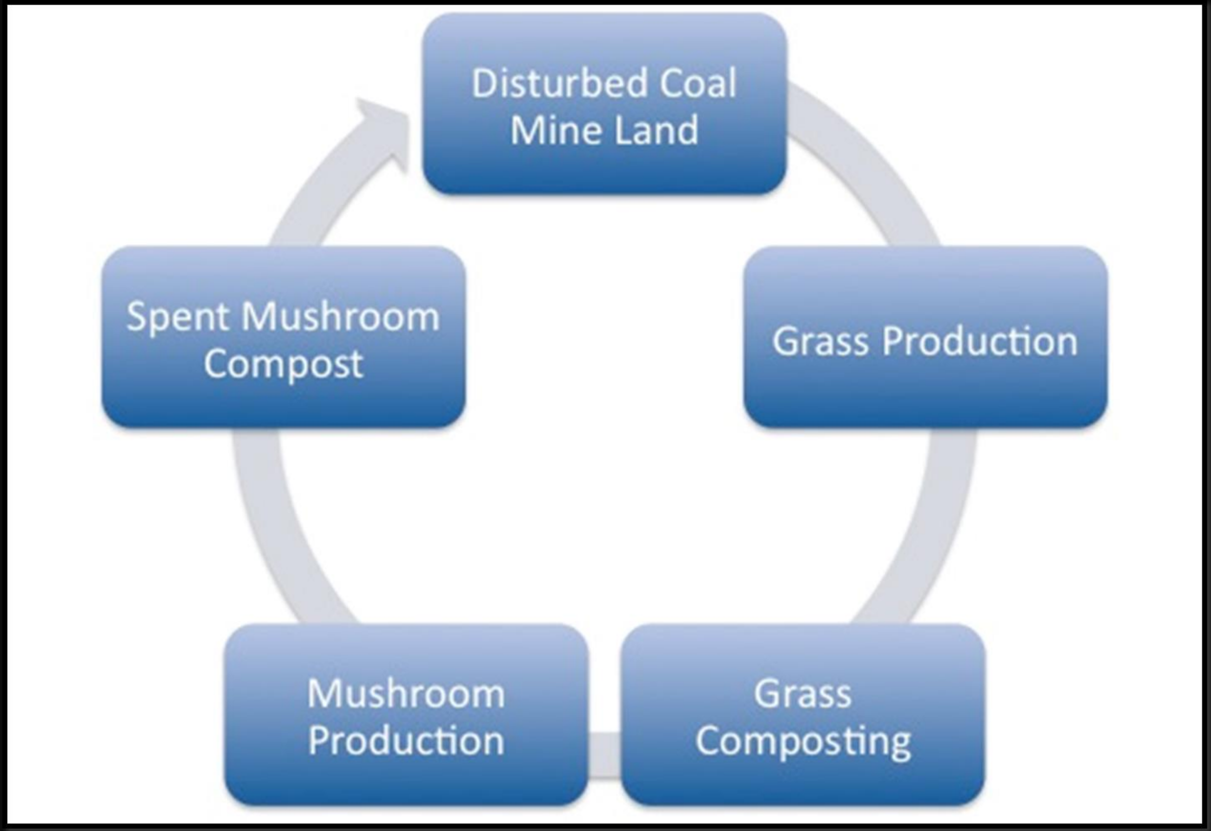


Map source: Maguire et al. 2007



Map source: ESRI 2014; PASDA 2014

System & Research Questions



- Goal: a regional semi-cyclical system (Baur, 2011)
- Can we amend mined soils with SMC for the production of grass biomass?
- Is it economically feasible? Is it agronomically feasible?

Southern Anthracite Field

- Shallow and deep coal seams
- Sandstone colluvial parent material
- Acidic soils, coal fragments (Ciolkosz et al., 1985)

Barry Site

- Former strip mine
- RCB Split-Plot with Switchgrass
  - Main plot (2006): Lime & fertilizer vs. organic reclamation amendments
  - Split-plot (2011-2014): N-based SMC rates (0, 34, 67 Mg ha^{-1})

Photo credit: Penn Pilot; NAIP 2013

Barry Site (2006)

Lime and Fertilizer

Compost

Recommended: Manure + Paper Mill Sludge, C:N 20:1
(Man+PMS 20:1)

Blackwood Site

- Mine refuse pile from underground coal mine
- Initial rate of 158 Mg ha^{-1} SMC and 26 Mg ha^{-1} lime kiln dust over whole experiment; L+F side experiment

Photo credit: Penn Pilot; NAIP 2013

Blackwood Site (2011)

RCB Split-plot

- Main plot: SMC (0, 34, 67 Mg ha^{-1})
- Split-plot: 5 grass species (timothy, orchardgrass, tall fescue, switchgrass, miscanthus)

SMC Nutrient Content & Properties

Parameter measured	**Giorgi Project (2011-2014)**		**Fidanza et al. (2010)**
	(n=5)		(n=30)
pH	7.05		6.62
Carbon:nitrogen ratio	13.3:1		12.79:1
Soluble salts (mmho/cm)	10.8	<	13.3
		----------%----------	
Organic Matter	45.57	>>>	25.86
Carbon	21.1	>>>	14.29
Total nitrogen	1.59	>>	1.12
Organic nitrogen	1.53	>>	1.1
Ammonium nitrogen	0.04		0.03
Phosphorus	0.45	>>	0.29
Potassium	1.13		1.04
Other			
Bulk density (kg m^{-3})	478.2		341
CaCO3 Equivalence	8.95%		NA


NEW HOLLAND
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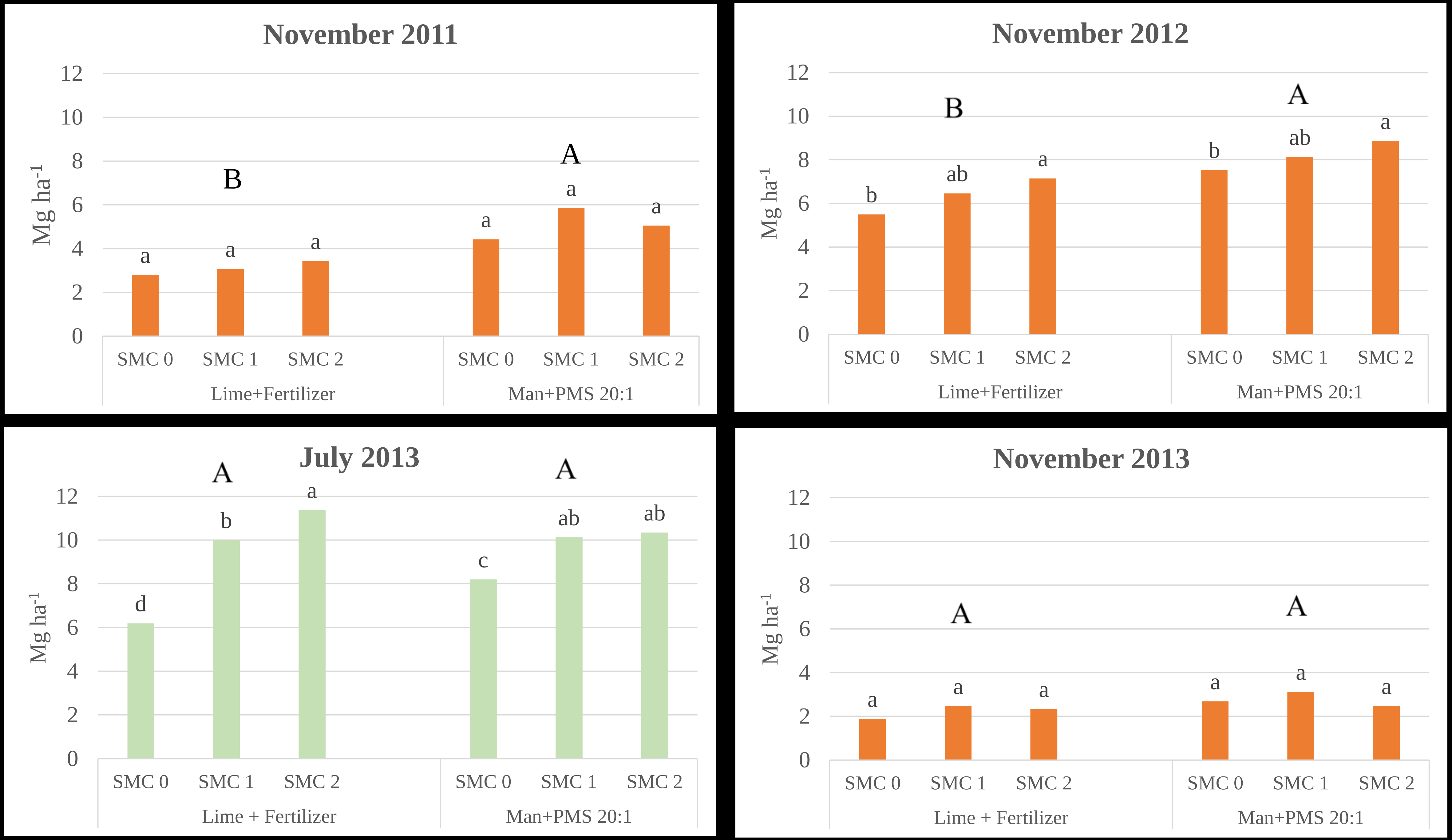
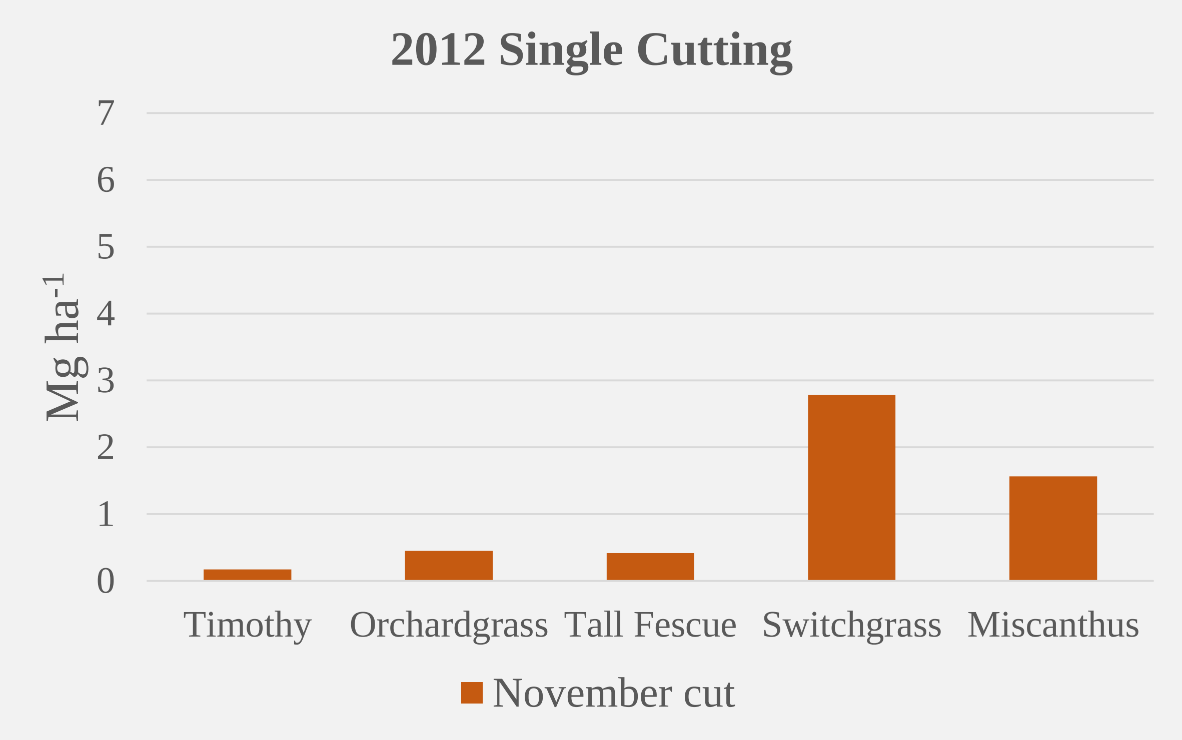
Data Collection

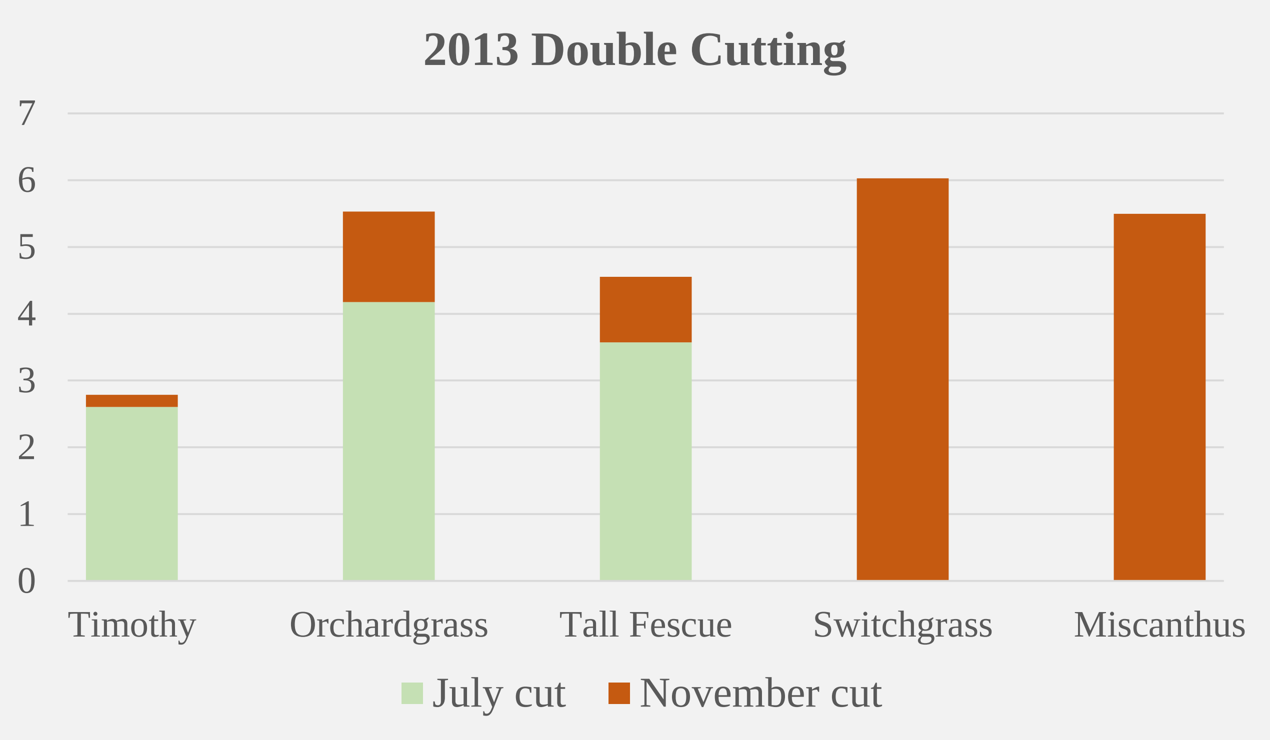
Site	Barry			Blackwood		
Year	2011	2012	2013	2011	2012	2013
Yield	✓	✓	✓		✓	✓
Soil Macronutrients		✓	✓		✓	✓
Soil Micronutrients			✓			✓
Tissue Analysis			✓			✓


November 2011
November 2012
July 2013
November 2013
Mg ha-1
0
2
4
6
8
10
12
SMC 0
SMC 1
SMC 2
Lime+Fertilizer
Lime + Fertilizer
Man+PMS 20:1
A
B
a
ab
b
c
d

- Yields comparable to switchgrass growth on marginal or reclaimed land in region (Skousen et al., 2013; Adler et al., 2006)

Blackwood Yields





- Cool-season grasses established ground cover quickly on SMC-applied areas vs. L+F side experiment
- Miscanthus performed well where established; spot replanting required

Soil Properties in 2013 (0-5 cm)

Properties	pH	CEC	P#	K	Mg	Ca	Al	Base Sat. (%)
Treatment								
No amendment*	6.56	8.8	197	22	58	972	392	61.30
Depth 0-5 cm								
L+F SMC 0	6.84c	12.7d	100c	161b	121b	1954b	597a	85.9b
L+F SMC 1	7.37ab	16.1bc	264b	281a	272a	2680b	283b	100a
L+F SMC 2	7.33b	17.2abc	415a	237a	292a	2836b	249b	100a

Man+PMS SMC 0	7.69a	16.4c	484b	117b	138b	5340a	93.3c	100a
Man+PMS SMC 1	7.66ab	18ab	599ab	208a	297a	8514a	52.4c	100a
Man+PMS SMC 2	7.5ab	18.4a	673a	270a	331a	6758a	33.9c	100a
LSD (0.05)	(0.30)	(1.80)	(80.7)	(45.8)	(40.5)	(2255)	(65.2)	(6.26)

Letters denote significance at (*P*<0.05)

*Composite sample (n=10) taken from adjacent unreclaimed soil for comparison.

Letters denote significance for SMC treatment only; Man+PMS and L+F treatments differed significantly

Soil Properties in 2013 (5-10 cm)

Properties	pH	CEC	P#	K	Mg	Ca	Al#	Base Sat.(%)
Treatment								
No amendment*	6.56	8.8	197	22	58	972	392	61.30
Depth 5-10 cm								
L+F SMC 0	6.54c	12.9c	89c	123b	84b	1726b	727a	73.9c
L+F SMC 1	7.04b	14.7abc	224b	260a	193a	2387b	478b	94.1b
L+F SMC 2	7.17b	13.4bc	244a	250a	202a	2217b	466b	99.9a
			----				---	
Man+PMS SMC 0	7.61a	15.8ab	359b	104b	87b	3971a	300a	100a
Man+PMS SMC 1	7.56a	16.2a	434ab	187a	199a	5147a	196b	100a
Man+PMS SMC 2	7.50a	16.7a	495a	252a	209a	4435a	198b	100a
LSD (0.05)	(0.28)	(2.49)	(144)	(53.4)	(67.1)	(1625)	(152)	(5.43)

Letters denote significance at (*P*<0.05)

*Composite sample (n=10) taken from adjacent unreclaimed soil for comparison.

Letters denote significance for SMC treatment only; Man+PMS and L+F treatments differed significantly

Switchgrass Tissue Nutrient Content

Harvest Time	Summer (July)					Fall (November)			
Parameter	**P**	**K**	**Mg**	**S**		**P**	**K**	**Mg**	**S**
Treatment					-----%-----				
L+F SMC 0	0.28	1.8	0.19	0.13		0.12	0.27	0.14	0.09
L+F SMC 1	0.32	2.2	0.20	0.14		0.13	0.38	0.13	0.09
L+F SMC 2	0.35	2.5	0.22	0.15		0.13	0.40	0.13	0.09
Man+PMS SMC 0	0.32	2.0	0.21	0.13		0.14	0.32	0.13	0.09
Man+PMS SMC 1	0.33	2.2	0.22	0.15		0.13	0.34	0.13	0.09
Man+PMS SMC 2	0.36	2.8	0.19	0.17		0.13	0.41	0.13	0.10

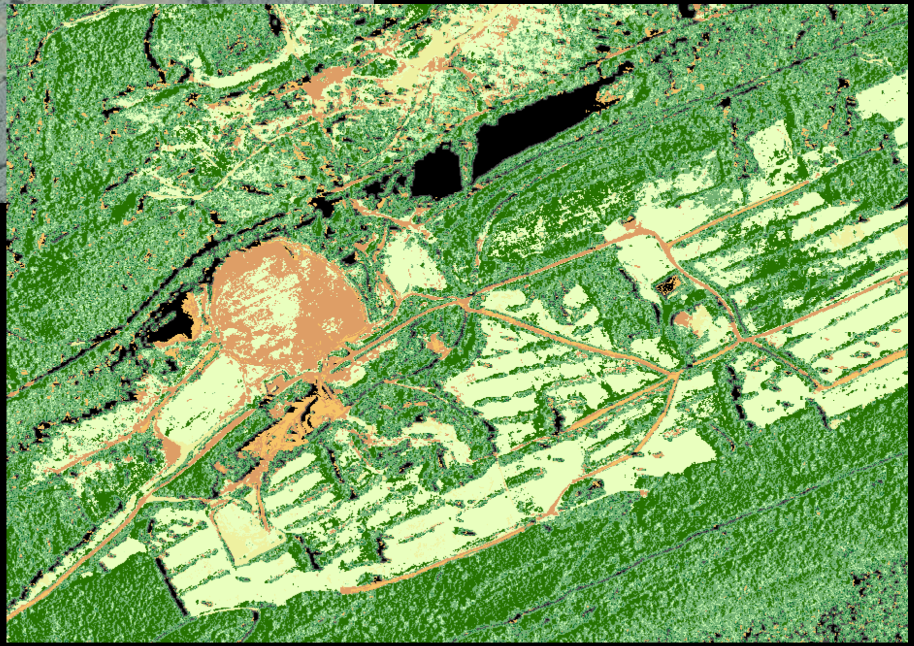
Estimated Switchgrass Nutrient Removal

Harvest Time	Summer (July)			Fall (November)		
SMC Rate	**0**	**1**	**2**	**0**	**1**	**2**
			---Kg ha^{-1}---			
P applied	0	68	136	0	68	136
P removed	25	34	36	11	13	13
Net P	**-25**	**34**	**100**	**-11**	**55**	**123**
K applied	0	231	463	0	231	463
K removed	160	225	278	25	36	42
Net K	**-160**	**6**	**185**	**-25**	**195**	**421**

*Assumes uniform yield between summer and fall

*Nutrient removal = (tissue content x dry matter yield)

Ongoing Work



- Phosphorus saturation?
- GIS analysis
- Economic analysis
- 2014 sampling

Conclusions

- SMC amendments can support:
  - agronomic warm-season grass production for biomass on two types of Anthracite mine soils.
  - cool-season ground cover establishment. However, economic incentive may be lacking.
  - build-up of soil nutrients for plant growth on mine soils with possible concerns about phosphorus loading.

Thanks to:

Giorgio
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Questions or Comments?

(James Banfill, jsb359@psu.edu)

Citations

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Map Sources

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