Using Manure to Produce Biofuel on PA's Mined Lands

Experiments and Economics

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- Significant conversion to bio-based energy sources will require large increases in biomass production.
- While much of the increase can come from agricultural and forest lands, existing markets for products from these sectors will compete with emerging biomass markets.

Mined lands in PA are a potential resource for biomass production, but…
- limited productivity
- expensive to restore

Mine soil limitations to high levels of biomass production

- Little to no real topsoil
- Low organic matter levels
- Limited plant nutrients
- Low pH and acidity
- Droughty
- Extremely rocky/stony
- Steep slopes
- Compaction

Soil amendments to overcome these limitations

Lime and fertilizer

Biosolids

- PA has excess manure in watersheds with intensive animal agriculture.
- Much of the manure must be moved off the farms on which it is produced (1.5 million tons/yr).

Could this manure be used to restore high levels of productivity to the soils of mined lands?

Potential problems with use of manure for mine soil amendment

- Low C/N ratio means
  - Unstable material
  - Potential for significant nutrient loss at application rates needed
  - Contains relatively small amounts of organic matter in relation to nutrient content
- Odor
- Attracts flies
- High moisture content and bulky

Is there a way to overcome these problems?

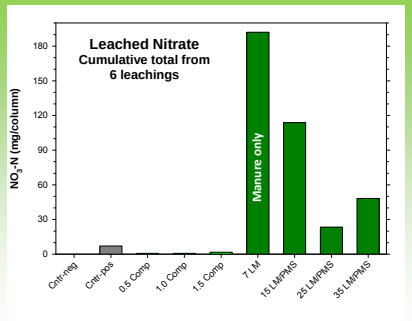
We are investigating two possible approaches:

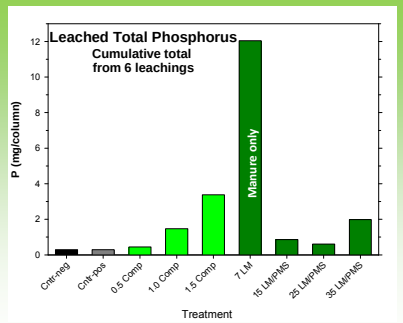
1. Composting

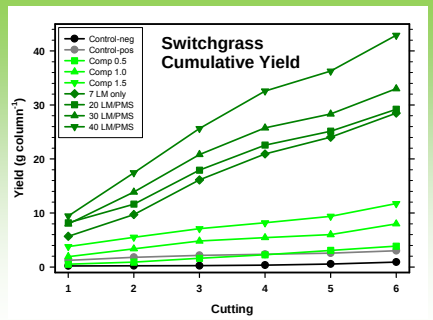
2. C/N ratio adjustment (manure + paper mill sludge)

Preliminary greenhouse experiment

- Columns of mine soil amended with
  - Compost at 15, 30, 45 T/A
  - Layer manure+PMS at C/N of 20, 30, 40:1
  - Total N application approx 800 lb/acre for 15 T/A compost and all manure+PMS treatments.
- Planted with switchgrass
- Leached intensively







Field experiment on AML site in Schuylkill County

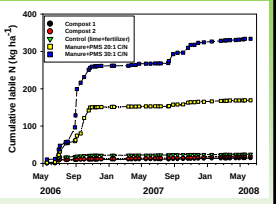
Five soil amendment treatments applied Spring of 2006

	Treatment	Total Application		Fresh Manure Equiv.	C	N	P_2O_5
		Dry wgt	Fresh Wgt				
		tons/acre				lb/acre	
1	Control (lime + fert)	6	6		–	125	400
2	Compost	30	65	38.5	10	1620	1842
3	Compost	60	130	77.0	20	3240	3684
4	Man + PMS (20:1 C:N)	63	162	38.5	16	1620	1839
5	Man + PMS (30:1 C:N)	101	266	38.5	24	1620	1839

Nitrogen leaching losses from field experiment in Schuylkill County

Cumulative N leaching loss over 3 years.

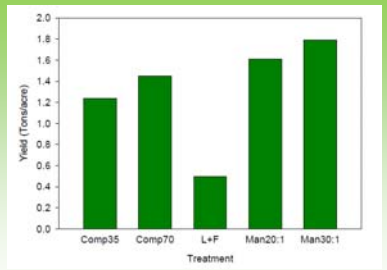
Amendment	N loss (lb N/acre)
Compost 1	14
Compost 2	19
M+PMS (20)	153
M+PMS (30)	303
No-till corn	160



Quantity of soil total N and C prior to amendment application and after 3 years after amendment application. Letters that are different indicate significance at α = 0.10.

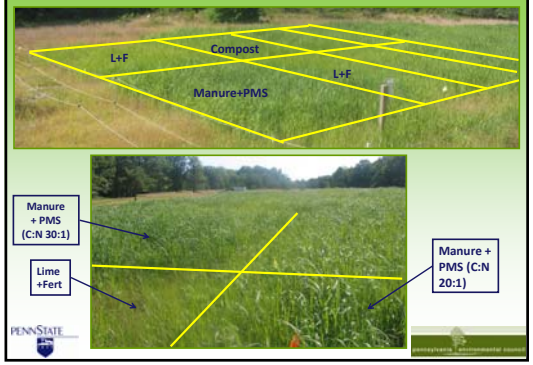
Treatment	Soil N		Soil C	
	Initial	Final	Initial	Final
	kg ha^{-1}		Mg ha^{-1}	
Lime+fertilizer	790a	1150c	28.4a	31.2b
Compost 1	790a	2880b	25.1a	39.6b
Compost 2	767a	4780a	30.3a	55.7a
Manure+PMS 20:1	835a	1940bc	27.2a	40.5b
Manure+PMS 30:1	812a	2060bc	33.6a	41.3b

2008 Switchgrass Yield*



*2nd year stand, harvested October, 2008
Plots were inadvertently mowed on June 26, 2008.

Switchgrass stand at Schuylkill AML on July 14, 2009. Third year growth.



Full-scale demonstration at active mining sites in Clearfield County

- 30 acres total at 3 sites
- Approximately half amended with compost, half amended with PMS+manure.
- Planted with
  - Switchgrass
  - Atlantic Coastal Panic Grass
  - Big Bluestem
  - 3 grasses mixed
  - 3 grasses+2 legumes mixed

Lower Emigh mine reclamation site, Morrisdale, Clearfield County

Mixed grass/legume seeding on manure+PMS amended mine soil.
Amendments applied and chiseled September, 2008
Planted May 13, 2009. Photo taken June 22, 2009

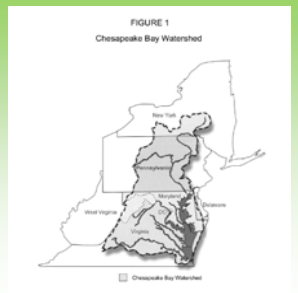
Reclamation Operations for manure based biomass production

- Site preparation (grading, spreading topsoil) same as conventional reclamation.
- Deliver and spread paper mill sludge ~110 T/A (costs covered by paper mill, DEP permit needed)
- Deliver and spread manure (~35 T/A, target 1,000 lb N/A)
  - Cost for delivery of manure covered by nutrient trading
  - Cost for spreading manure is additional cost
  - Must be timed so manure is not stockpiled more than 2 days
- Incorporate PMS and manure (chisel or disc plow)
  - Cost covered by paper mill
  - May need additional tillage or secondary tillage to smooth surface for good seeding and future harvest activity
- Seeding
  - Seeding operation same as conventional reclamation
  - Warm season grass seed more expensive than conventional reclamation mixes (switchgrass ~
- No limestone or fertilizer needed.

Economics of Manure on Mined Lands

- Supply of poultry manure and paper mill sludge in PA
- Geography of manure and paper mill sludge sources versus reclamation sites
- Are there incentives in the PA nutrient trading program and the paper industry waste disposal regulations to offset the cost of transportation of material to and reclamation of mine sites?
- Can reclaimed sites produce an annual cash crop and environmental credits?

Cheseapeake Bay Watershed



Nutrient Trading Background

- Bay State Stakeholders have agreed to reduce to 175 million lbs. annually by 2010
- Pennsylvania's obligation is to reduce nitrogen loading to Chesapeake Bay from 109 million lbs. to 72 million lbs.
- Phosphorous from PA to be reduced from 3.6 million lbs. to 2.5 million lbs.
- 183 WWTPs in Bay Watershed subject to 6.0 mg N/l and 0.8 mg P/l discharge limits
- New developments and WWTP expansions require offsets

Source: PA Chesapeake Bay Tributary Strategy, PA DEP, 2004

Manure Production vs. Mine Reclamation

- Manure export from qualified farms eligible for credit generation
- Nutrient trading could potentially deliver ~115,000 tons of manure per year
- 900 acres of AML reclaimed in 2008 by DEP BA (31,500 tons)
- 2008 Stage 1 reclaimed on operating mines – 5,967 acres (208,000 tons manure)
- 2008 Stage 2 - 3,152 acres (110,000 tons manure)

Nutrient Trading Economics

- WWTP upgrade costs: $5 - $40 per pound of N removed
- N credit price – historic range $3.81 to $10, weighted average $5.40, 42,694 N credits traded to date
- Transportation cost - $0.20 - $0.50/ton/mile
- Distance between poultry farm and mine
- Distance between paper mill and mine
- Landfill tipping fee - $25 - ?/ton
- Application of manure within Bay Watershed Boundary: what % of N and P is "removed"?

redbarn www.redbarntrading.com/

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