Using Manure to Produce Biofuel on PA's Mined Lands

Experiments and Economics

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Goals for renewable biofuel production in PA exceed the capacity of agricultural land to generate needed plant oils and biomass.

Mined lands in PA are a potential resource for biomass production, but…

- limited productivity
- expensive to restore

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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

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Soil amendments to overcome these limitations

Lime and fertilizer

Biosolids

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- 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?

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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?

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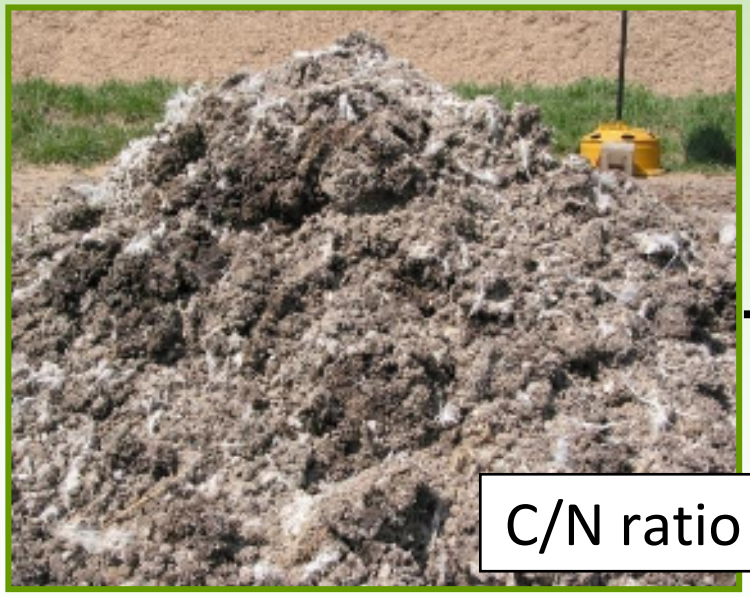
We have investigated two possible approaches:

1

2



+

C/N ratio adjustment

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Preliminary greenhouse experiment

- Columns of mine soil amended with
  - Compost at 15, 30, 45 T/A
  - PMS+layer manure at C/N of 20, 30, 40:1
- Planted with switchgrass
- Leached intensively

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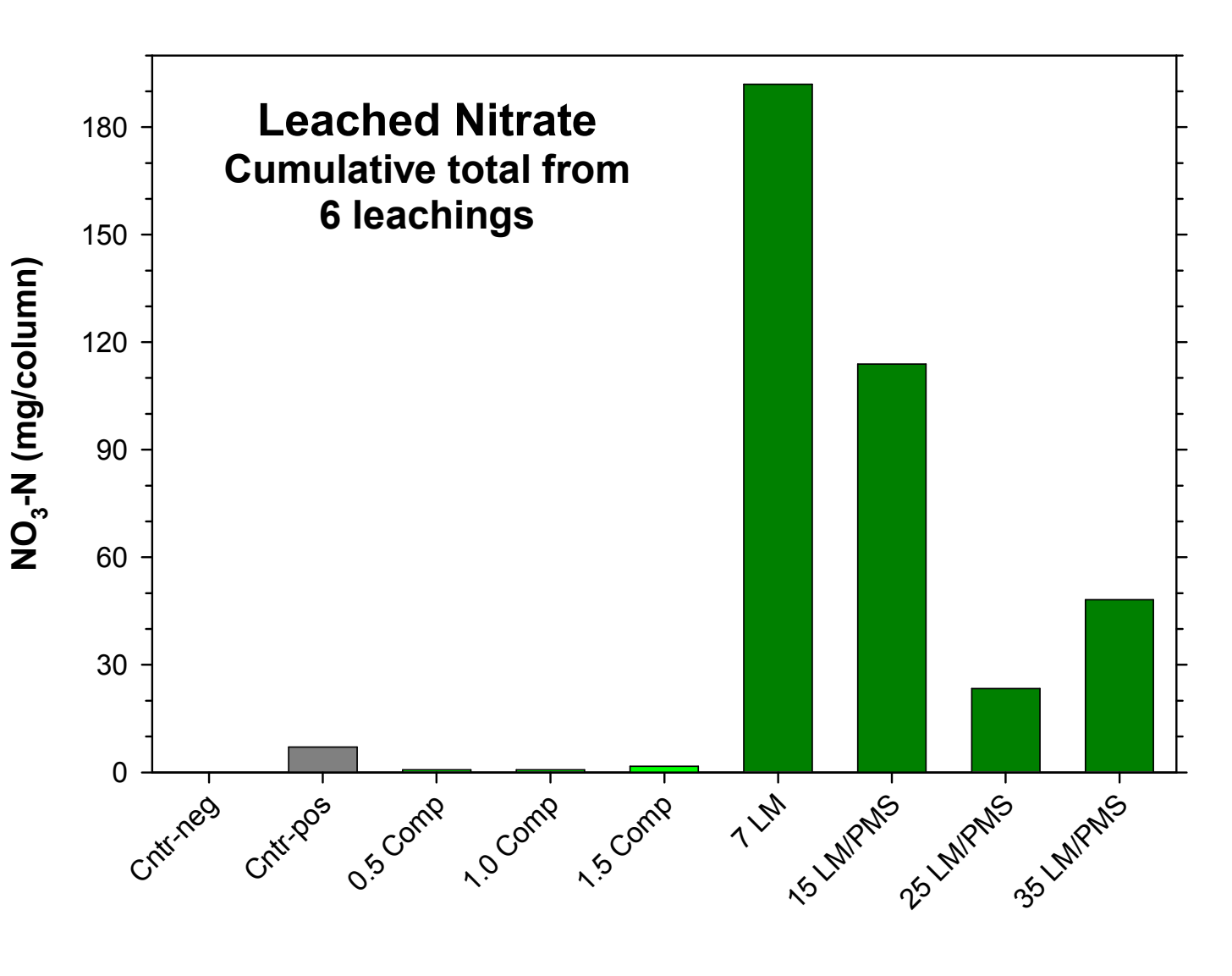

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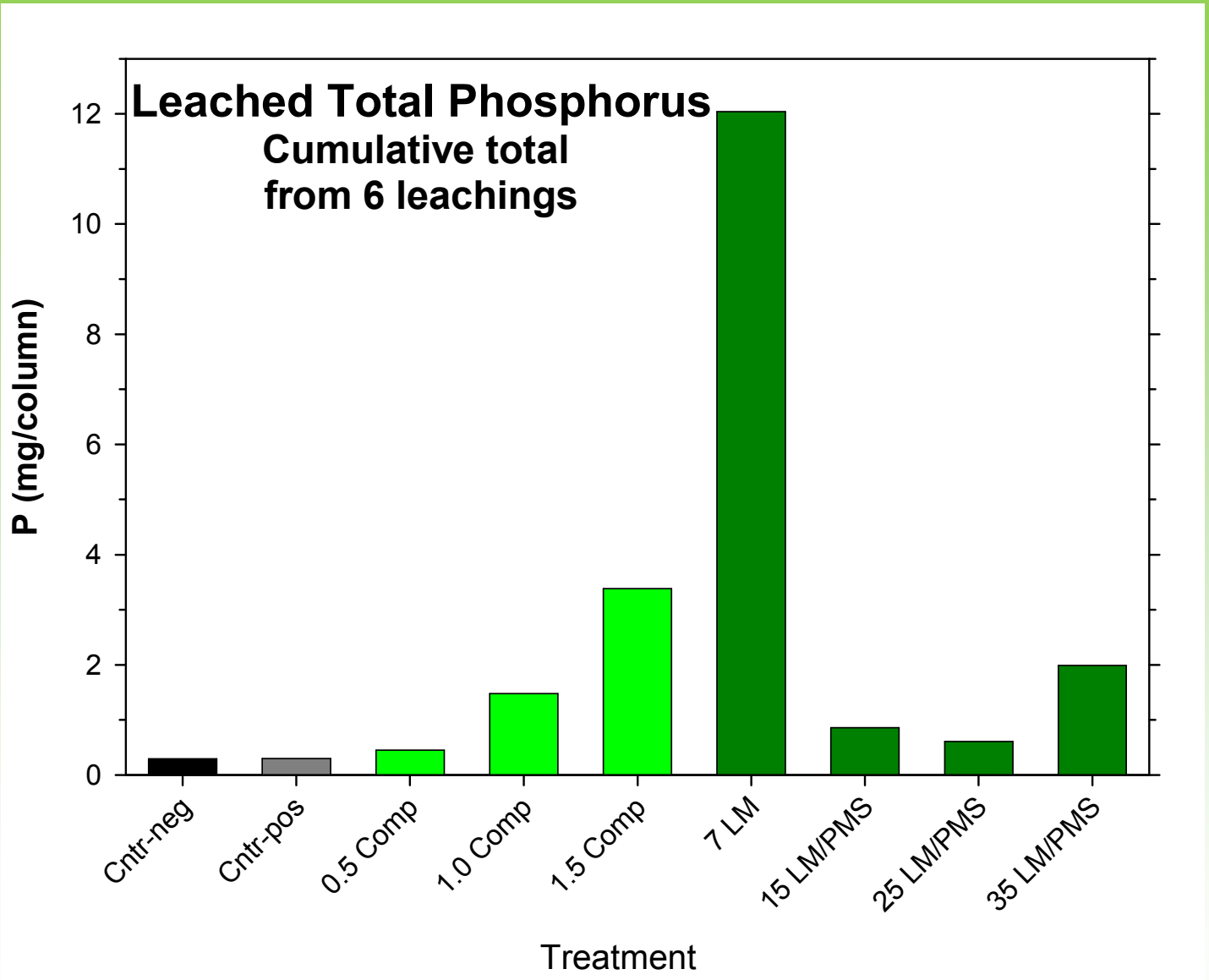

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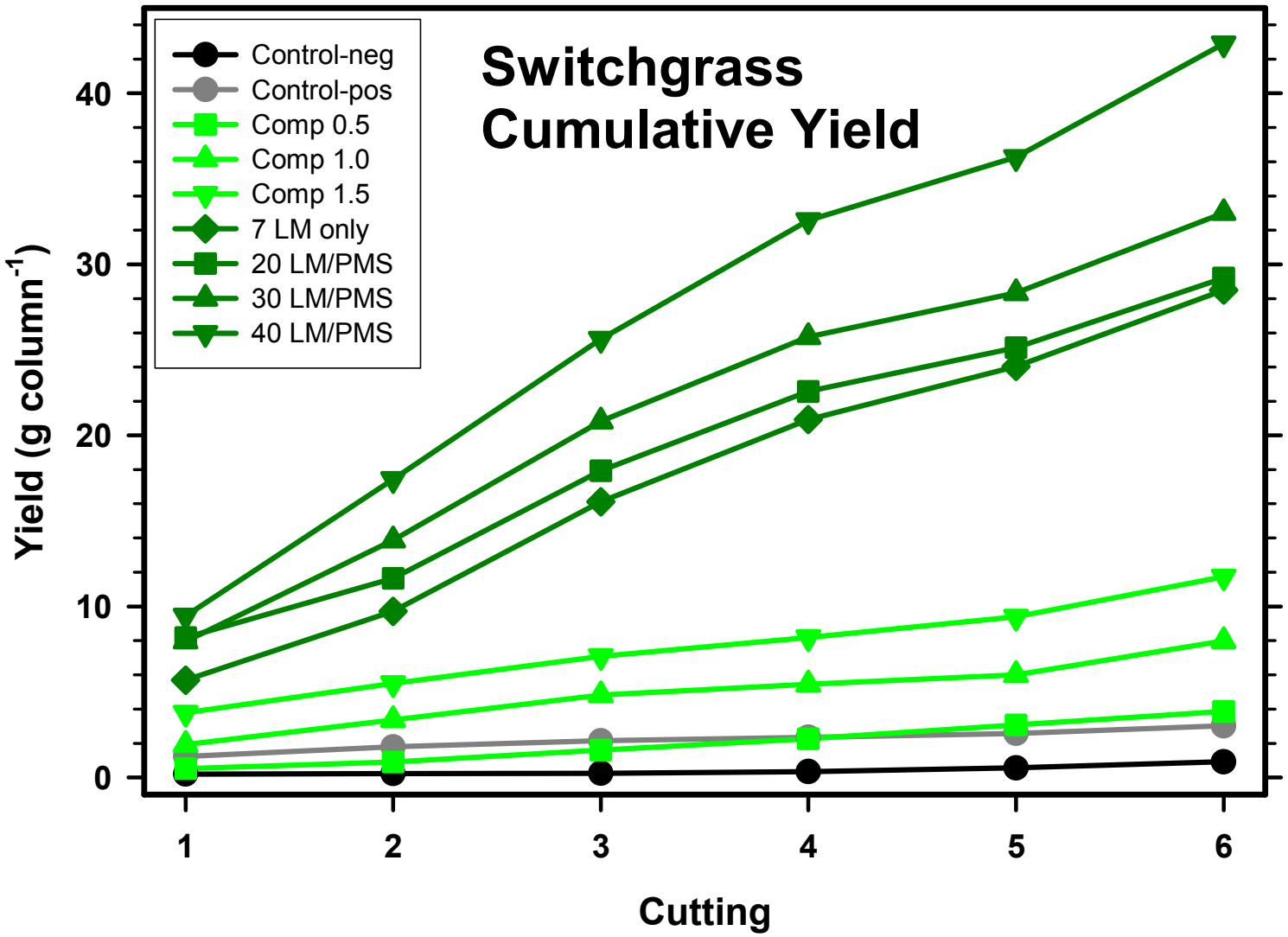

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Field experiment on AML site in Schuylkill County

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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

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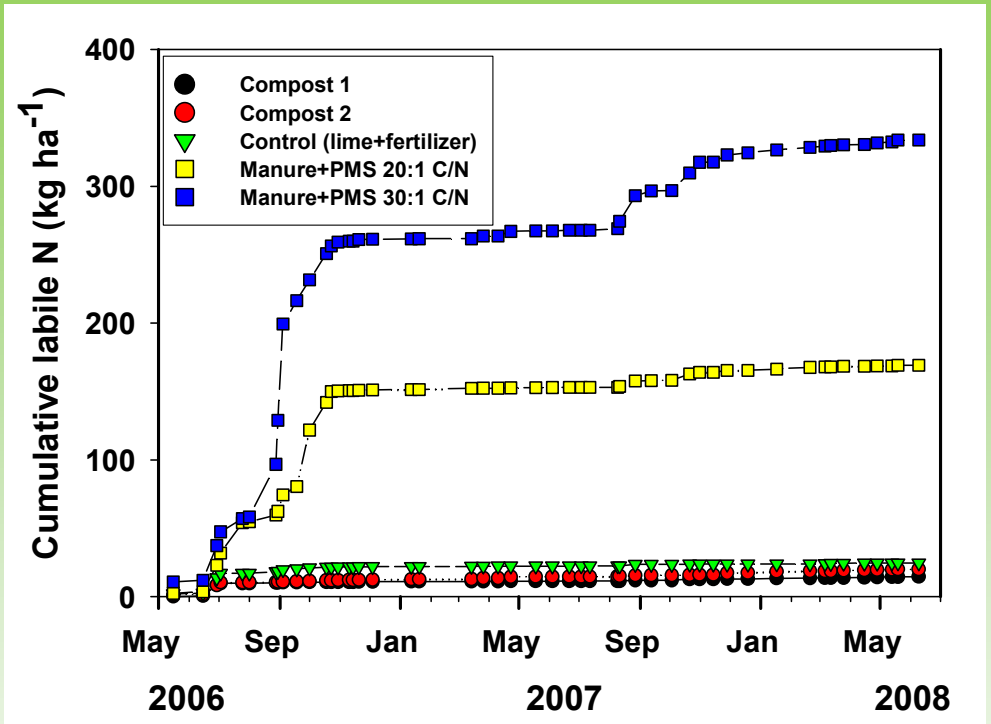
Nitrogen leaching losses from field experiment in Schuylkill County

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



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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

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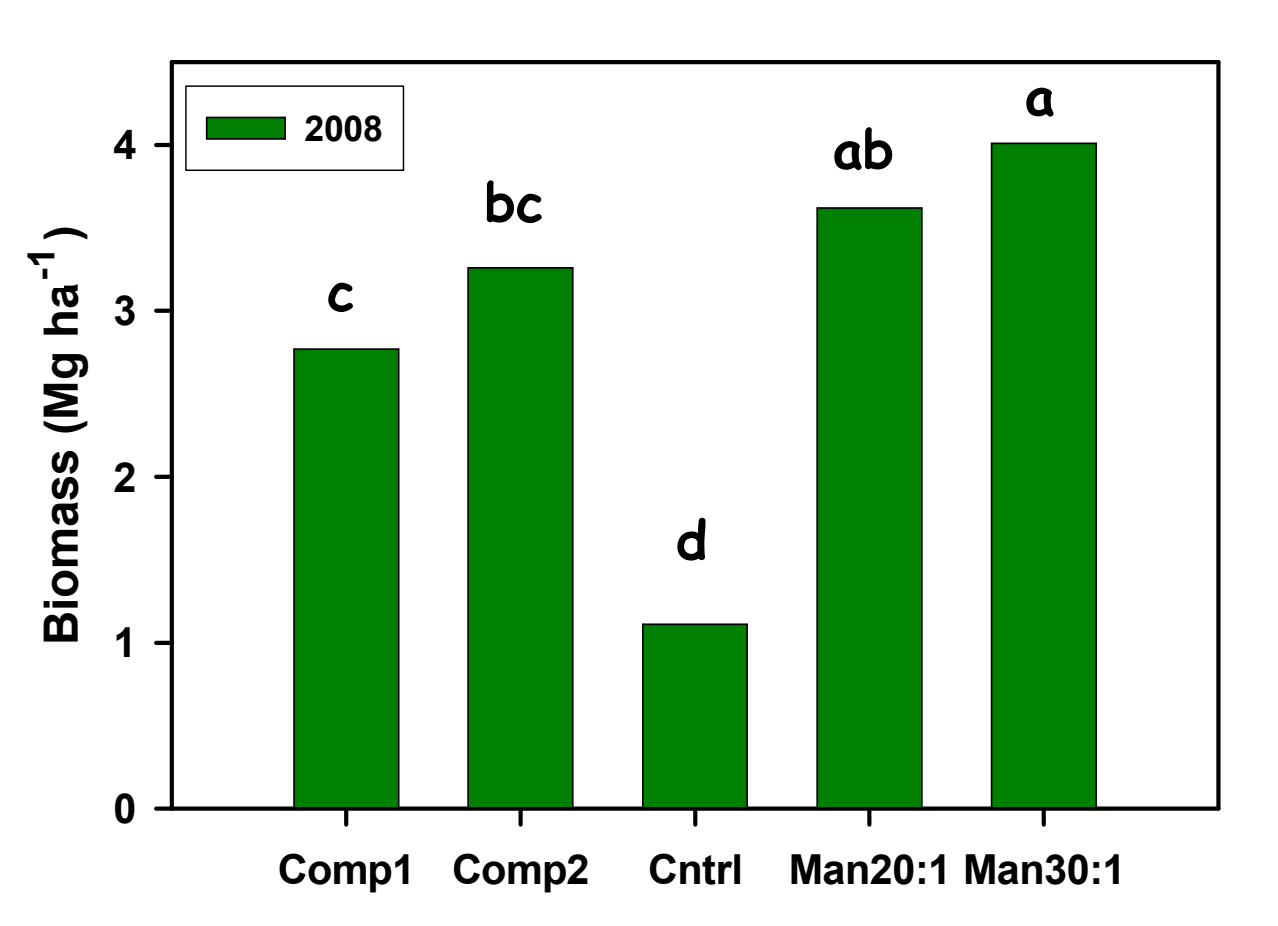
2008 Switchgrass Yield*



*2nd year stand, harvested October, 2008

Plots were inadvertently mowed on June 26, 2008.

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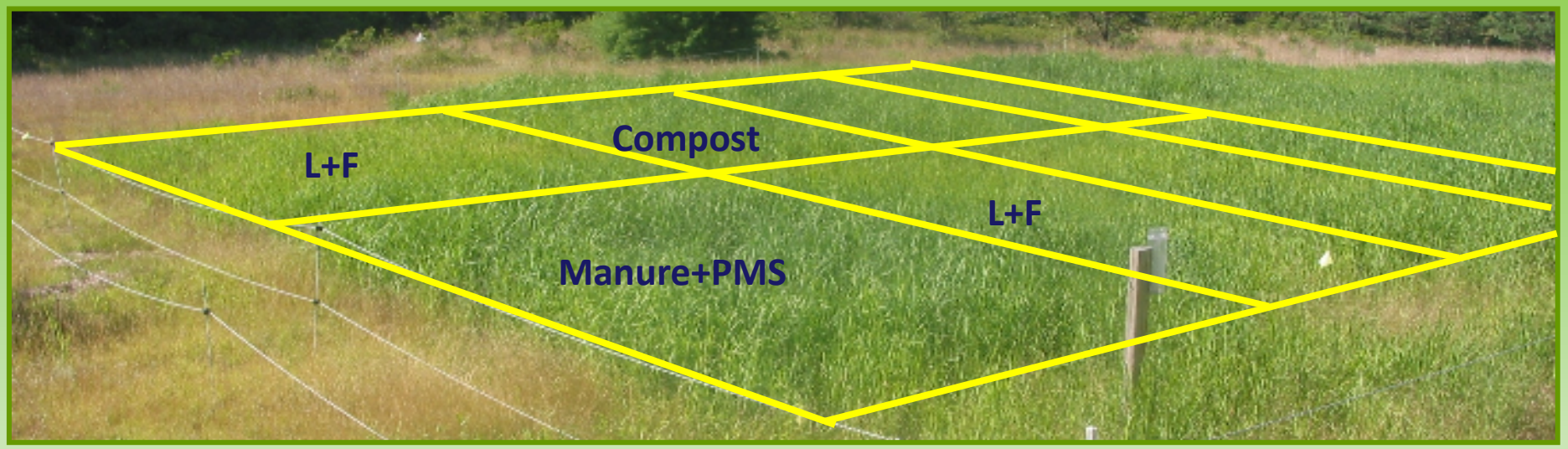
Switchgrass stand at Schuylkill AML on July 14, 2009. Third year growth.



Manure + PMS (C:N 30:1)

Lime +Fert

Manure + PMS (C:N 20:1)

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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

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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

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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?

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Manure on Mined Lands Business Model Research

- Duquesne Sustainability MBA Program team:

  Review data from Bureau of Mining, Bureau of Abandoned Mine Reclamation, PA Nutrient Trading Program and industry sources

- Reclamation/revegetation costs of 30-acre demonstration projects in Clearfield County

- Draft business case analysis for June 2010

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Duquesne University Sustainability MBA Research Effort – Jan. 2009 to May 2010

Phased Approach:

1. Comparison of conventional versus manure & paper mill sludge reclamation techniques
2. Can nutrient trading fund the transportation of manure to reclamation sites
3. Paper mill sludge disposal and supply economics
4. Nutrient trading market research
5. Revenue sources: biomass sales and environmental credit (e.g. carbon offsets) sales
6. Biomass market research in coal region

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Phase I – Revegetation Cost Comparison

- Review of PA DEP Bureau of Mining recent bond charts for post-mining reclamation of surface mines.
- Clearfield County demonstration project costs
- Cost data for raw manure, composted manure from industry sources
- Isolate comparative revegetation costs; application of lime, commercial fertilizer and grass seed versus application of raw poultry manure, paper mill sludge and switchgrass seed.
- Draft report under review

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Comparative Revegetation Cost Details

- Revegetation Est. Costs – Clearfield County Project:
- Conventional - $400/acre
- Manure & Paper Mill Sludge - $1,000/acre

- Assumptions:
- Conventional – lime, commercial fertilizer (4.25 tons/acre) one application of combined mixture followed by seeding
- Manure delivered at no cost (35 tons/acre)
- Paper mill sludge delivered and applied at no cost. Costs paid by paper mill (110 tons/acre)
- 4–Step Process: Paper mill sludge and manure applied separately using calibrated spreaders then chisel plowed prior to seeding (costs can be reduced by limiting steps and applications of materials and allowing mixing of materials prior to application)

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General Permit for Application of Paper Mill Sludge

- 2/4/04 – DEP (Bureau of Land Recycling and Waste Management) issued a 10-year General Permit for Processing/Beneficial Use of Residual Waste for wastewater treatment sludge generated by paper mills.
- Need to obtain approval from the DEP for land application of paper mill sludge as a soil amendment for mine reclamation purposes.
- On operating mine lands the Bureau of Mining oversees the application of the paper mill sludge.
- The active mining permit is modified to reflect that paper mill sludge and manure is being used as part of the reclamation plan.
- 3-6 months to obtain approvals from the Bureau.

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Phase II – Nutrient Trading & Manure on Mined Lands

Deliverables:

- Evaluation of transaction costs (manure transportation costs, payment to farmer, broker and aggregator) versus market credit price to incentivize trading activity

- Market research about expected demand and pricing for nutrient reduction credits in 2010 and beyond

- Paper mill sludge production and the economics of conventional paper mill sludge disposal

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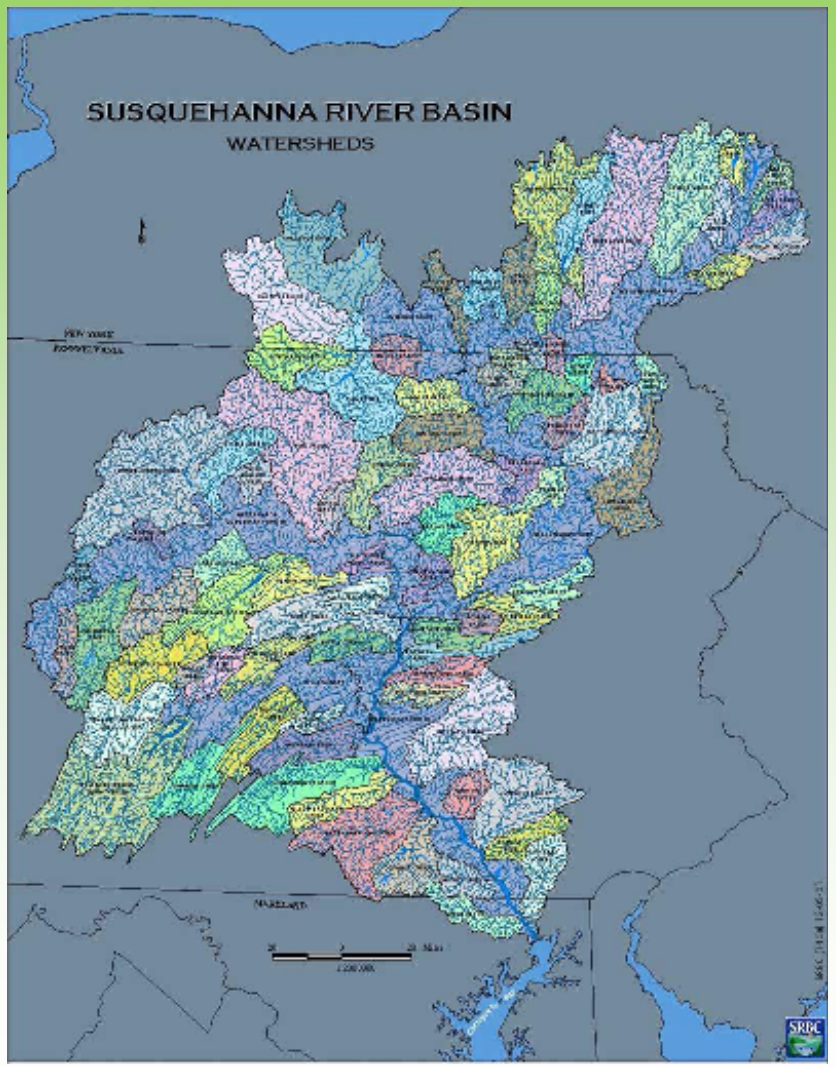
Susquehanna River Basin



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Cheseapeake Bay Watershed

FIGURE 1

Chesapeake Bay Watershed

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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

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Manure Production vs. Mine Reclamation

- Manure export from qualified farms eligible for credit generation
- 321,154 tons of poultry manure produced in PA in 2006* (broilers, hens and turkeys)
- One ton of poultry manure contains approximately 60-80 lbs. of N and 50-70 lbs. of P
- 900 acres of AML reclaimed in 2008 by DEP BA (31,500 tons)
- 2008 Stage 1 reclaimed on operating mines – 5,967 acres
- 2008 Stage 2 - 3,152 acres

* Dr. Paul Patterson, Professor of Poultry Science, Penn State University – PDA 2008 poultry data

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Nutrient Trading Program Potential

- Credit Generation from Manure Export
  - Nitrogen – 9 Million lbs. annually *
  - Phosphorus – 1 Million lbs. per year*

- Trading Limit Restriction - Nitrogen (DEP)
  - 5.76 Million lbs. per year * (115,200 tons of poultry manure)

*Chesapeake Bay Tributary Strategy Compliance Study. Issue brief. Legislative Budget and Finance Committee. Metcalf and Eddy. November 2008.

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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”?

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Questions

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