

# Determining an Appropriate Organic Matter Loading Rate for Created Forested Wetlands in the mid-Atlantic USA

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Since the mid 1990's, the most commonly employed method to "create" new wetlands is to take areas with soils like this, and enough of the upper soil to bring the wet zone (with redox features) close enough to the surface to be wet during the growing season.





## Documented Soil Problems in Virginia Contributing to Wetland Creation Failure.

(Stolt et al., 2000 & 2001; Fajardo, 2006)

1. Compaction due to heavy machinery
  - root limiting bulk densities
  - creation of a perching layer
2. Lack of Soil Organic Matter
  - water holding capacity
  - porosity/ bulk density
  - nutrients
  - microbial populations
  - redox feature formation



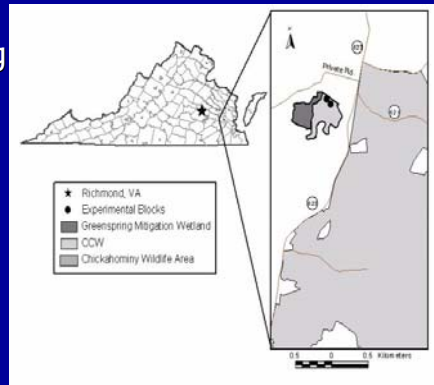
OM additions recommended by late 1990's and mandated in 2004 USCOE-DEQ guidance. Loading rates of 50 Mg/ha (ash free!) or higher were commonly recommended to achieve target SOM content of 5%.

## Research Objectives

1. Quantify the overall effects of organic matter amendments in relation to bulk density, water content, and redox potential;
2. To determine the effects of organic matter amendments on redox feature formation;
3. To measure the overall effects of organic matter amendment upon the growth, vigor, and survival of planted hardwood species in a created wetland;
4. To determine an appropriate loading rate of organic matter amendments for non-tidal forested created wetlands in the mid-Atlantic Coastal Plain.

## Charles City Mitigation Wetland

- Located in Charles City County, VA; Coastal Plain province
- VDOT mitigation wetland created in 1997
- 21 ha with 18 ha compensating for bottomland hardwood wetland disturbance

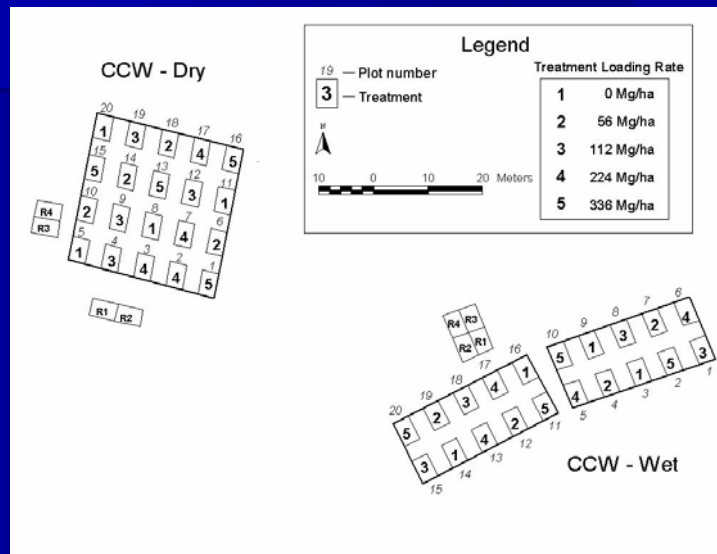


## Charles City Wetland "Creation"

- Created via excavation of upper 46 to 61 cm of solum
- Soil surface consists of an argillic, plastic Btg horizon
- Shrink-swell clay present
- Little topsoil replacement evident; renovated later
- Generally poor quality site



## CCW Experiments



## Methods: Installation of Experiments

- Vegetation on experiments mowed and soil ripped 15 cm with a root rake
- Organic matter (high quality wood fines compost) added to plots and incorporated into upper 12.5 cm soil in July 2002

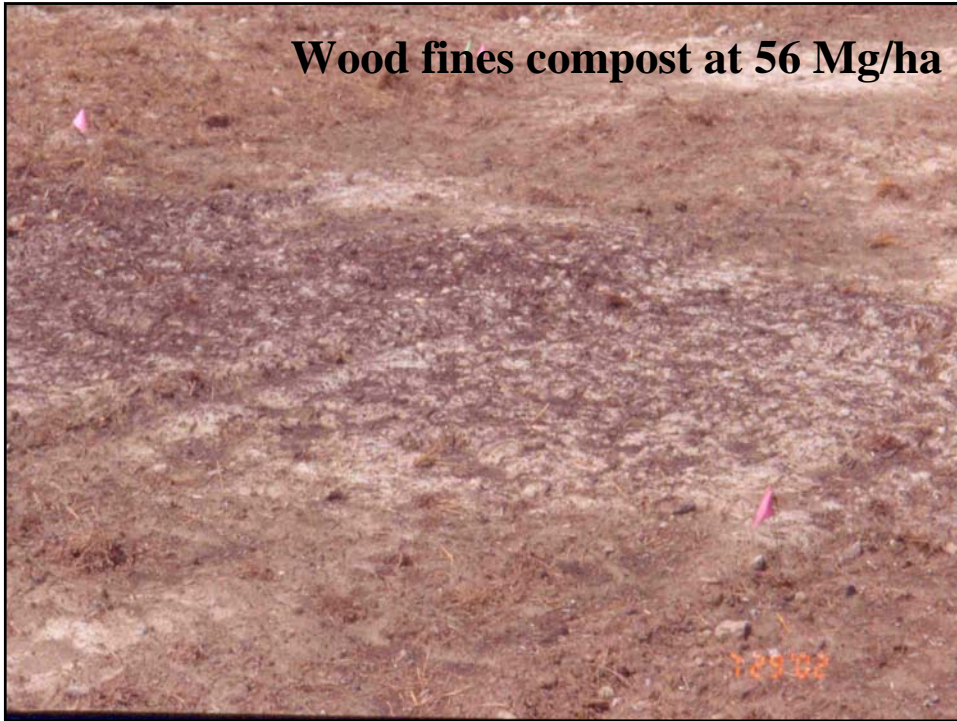


### **Dry Experimental Block at Charles City – Rt. 199 Site**

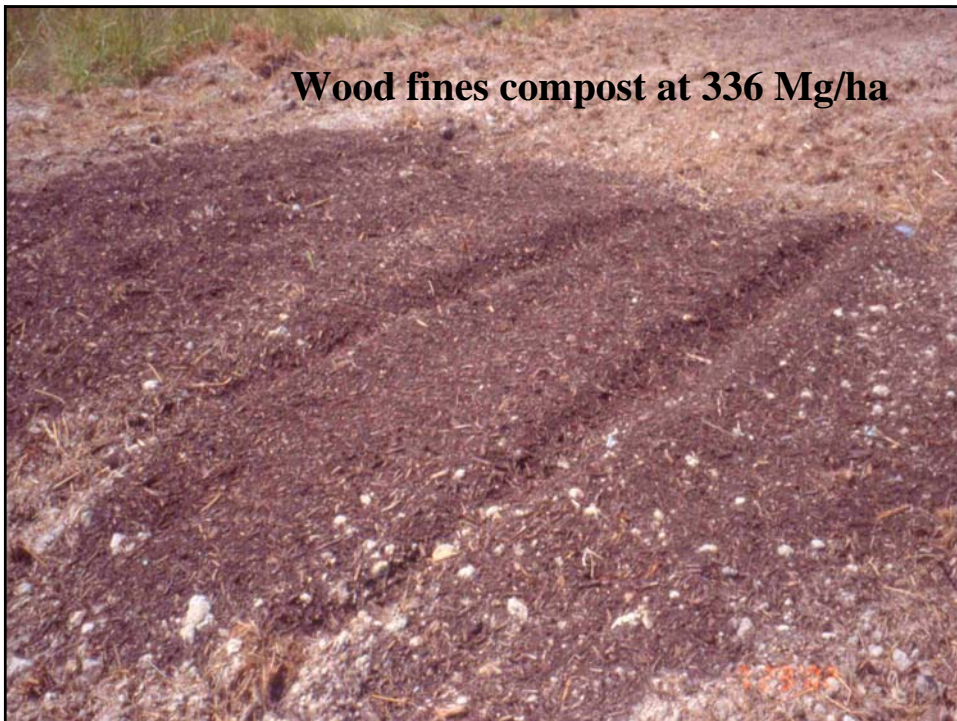




**Wood fines compost at 56 Mg/ha**



**Wood fines compost at 336 Mg/ha**



## Methods: Installation of Experiments

- Two bottomland hardwood tree species, *Betula nigra* and *Quercus palustris*, were planted in December of 2002
  - Each plot received five trees of each species
- Electric and chicken-wire fence constructed around both experiments to avoid herbivory



## Methods: Field Sampling

### 1. Bulk density

- Subsurface: Two cores collected from each plot at a depth of 25-30 cm with bulk density hammer
- Surface: Volumetric sample collected by excavating upper 12.5 cm of soil and filling hole with water



## Methods: Field Sampling

### 2. Moisture Content

- Data collected from each plot with a Trace System Model using Time Domain Reflectometry (TDR)

### 3. Soil Redox Potential

- Each plot measured using five Pt electrodes and a saturated calomel reference electrode inserted 12.5 cm below surface

## Methods: Field Sampling

### 4. Redox feature and pedogenic development

- "Mini-pits" from each plot evaluated for texture, matrix color, structure, root abundance, and redox features

### 5. Biomass

- All vegetation within a 0.5 m<sup>2</sup> collected, separated by species, dried, and weighed

### 6. Tree measurements

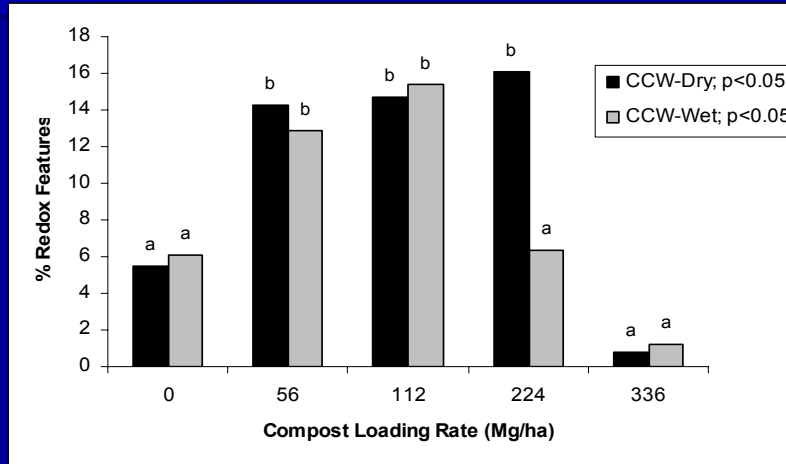
- Trees measured for total height, number, and length of branches





## Results: Pedogenesis – Oct. 2003

Figure 8. Average (n=4) % redox concentrations (active) in upper 15 cm of soil as affected by compost loading rate in CCW-Dry and CCW-Wet. Means contrasted via Tukey's HSD.



## Results: Pedogenesis

0 Mg/ha rate



56 Mg/ha rate

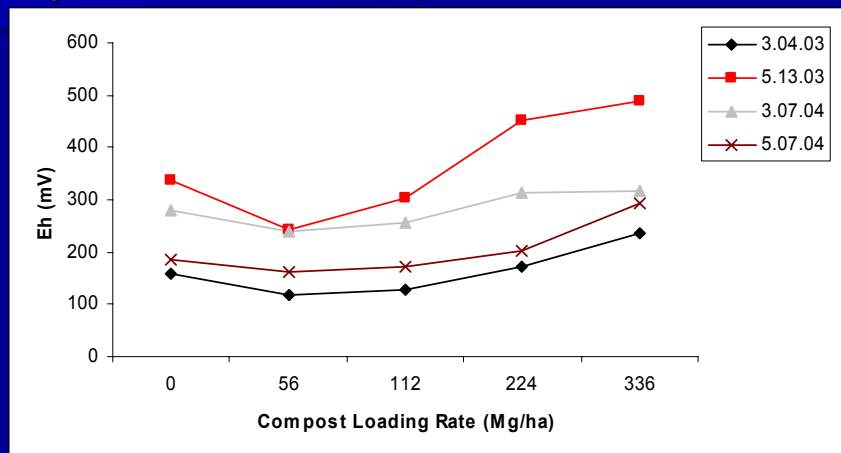


## Results: Pedogenesis



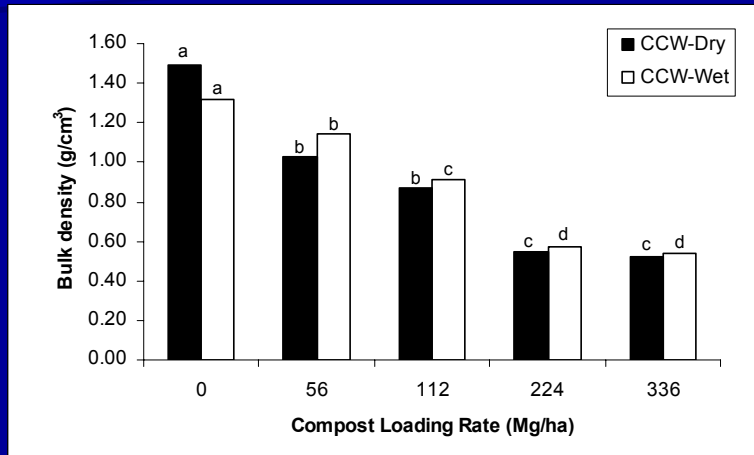
## Results: Redox Potential

Figure 7. Soil Redox Potential (Eh) for CCW-Wet.



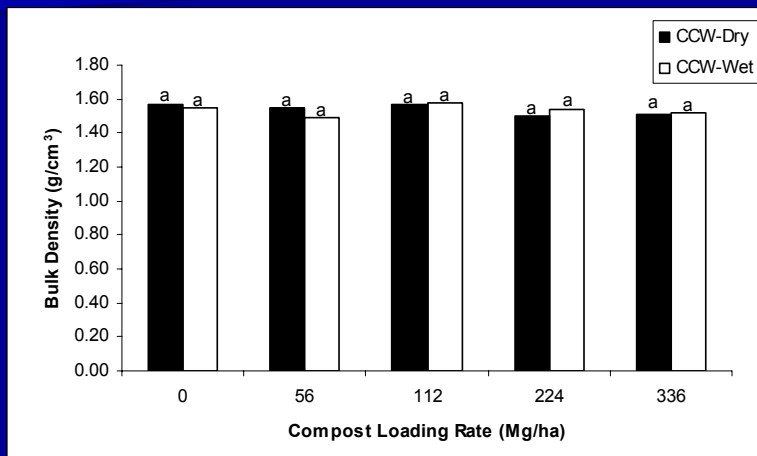
## Results: Bulk Density – Oct. 2003

Figure 1. Surface bulk density for CCW-Dry and CCW-Wet ( $p < 0.05$ ; for each experiment via Tukey's HSD)



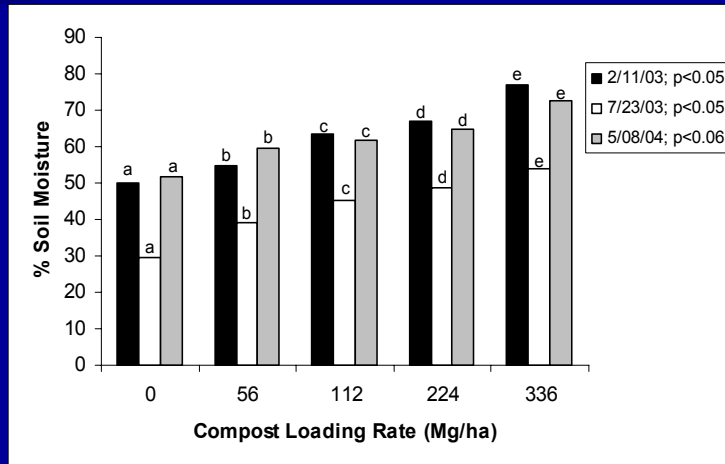
## Results: Bulk Density

Figure 2. Subsoil bulk density for CCW-Dry and CCW-Wet ( $p < 0.05$ ; for each experiment via Tukey's HSD)



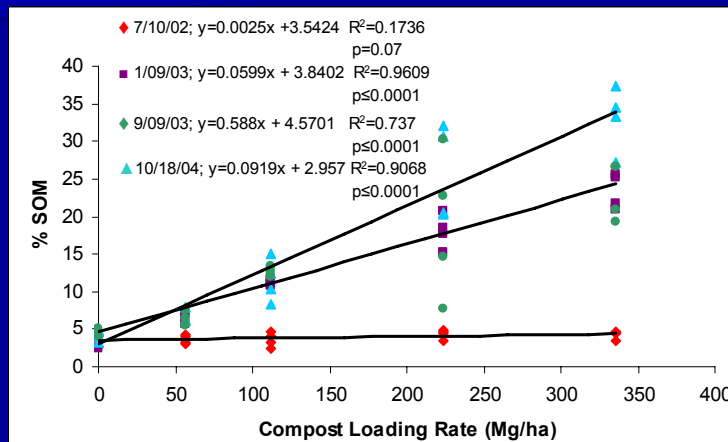
## Results: Moisture Content

Figure 4. Average (n=4) volumetric moisture as affected by compost loading rate in CCW-Wet. Treatment means by date followed by different letters are sig. different using Wilcoxon rank sums.



## Results: SOM

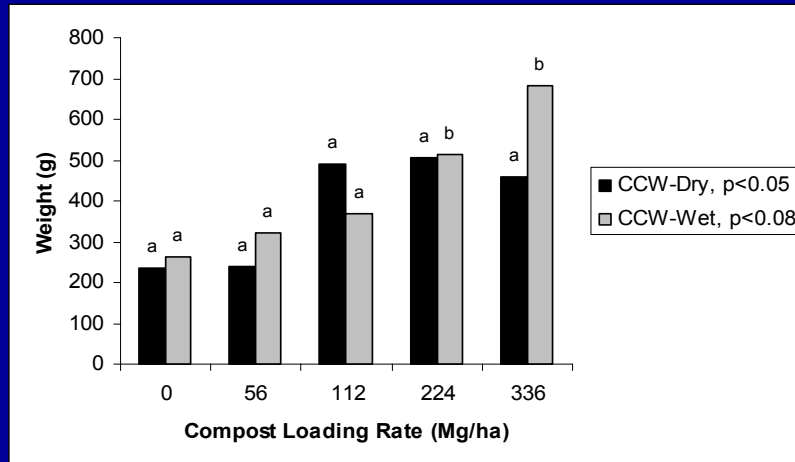
Figure 9. Regression analysis of % SOM as affected by compost loading rate in CCW-Dry for a 2-year sampling period.





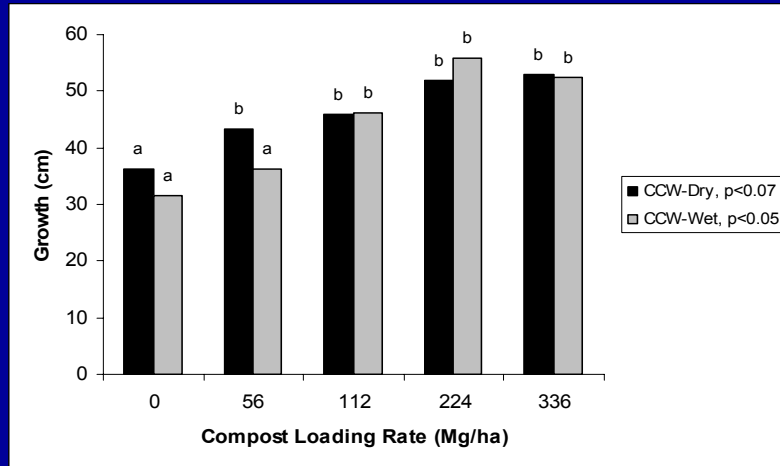
## Results: Biomass in August 2003

Figure 11. Average (n=4) plant biomass weight as affected by compost loading rate for CCW-Dry and CCW-Wet. Means contrasted via Tukeys HSD.



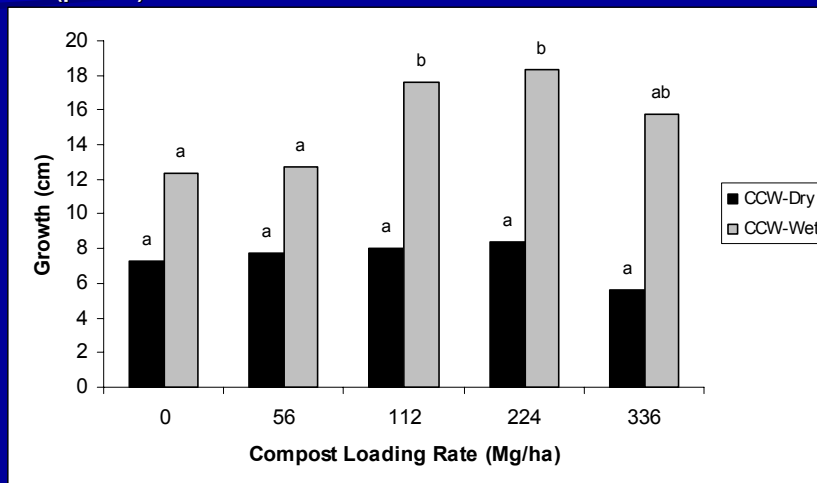
## Results: Tree growth – Dec. 2004

Figure 12. Average (n=4) *Betula nigra* (river birch) height growth as affected by compost loading rate. Means contrasted by Wilcoxon rank sums.



## Results: Tree growth – Dec. 2004

Figure 13. Average (n=4) *Quercus palustris* (pin oak) height growth as affected by compost loading rate. Means contrasted by Wilcoxon rank sums ( $p \leq 0.05$ ).



## Conclusions

- Our findings indicate 112 Mg/ha yardwaste compost appeared optimal in the short-term for inducing hydric soil conditions and plant response in a Coastal Plain forested mitigation wetland
- When organic loading rates exceed 112 Mg/ha, adequate incorporation of the organic matter amendment is challenging and leads to higher surface elevations and higher redox levels in the growing season.

*Soil bulk density, organic matter content  
and overall soil reconstruction procedures  
are now specifically required by:*

**COE/DEQ, Norfolk District Corps and Virginia  
Department of Environmental Quality  
Recommendations for Wetland Compensatory  
Mitigation Including Site Design, Permit Conditions,  
Performance and Monitoring Criteria - July, 2004**

[www.nao.usace.army.mil/Regulatory/Annotated\\_Corps-DEQ\\_Mit\\_7-04.pdf](http://www.nao.usace.army.mil/Regulatory/Annotated_Corps-DEQ_Mit_7-04.pdf)

## **Acknowledgments**

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