Organic Matter Dynamics in Reclaimed Mine Soils

A. F. Wick, P.D. Stahl, W.L. Daniels
Mining Disturbances

• Appalachian:
  – 390,217,000 short tons coal produced (33% of total production in US for 2008)

• Western:
  – 633,597,000 short tons coal produced (54% of total production in US for 2008)
Southwest Virginia Mine, view from 30,000’-post mining: forest
Northeast Wyoming Mine, view from 30,000’
-post mining: wildlife areas, grazing
Differences in Reclamation

• **East**
  – Amendments/handling crushed rock
  – High precipitation (~120 cm)
  – Tree establishment desirable
  – 5 yr bond release

• **West**
  – Topsoil salvaged (stockpile or direct haul)
  – Low precipitation (<55 cm)
  – Shrub and grass establishment
  – 10 yr bond release
Though mining and reclamation practices are very different in each region, there is still the potential to accumulate and store C in reclaimed soils.

What are the accumulation rates?
Carbon Accumulation Rates

- Shrestha and Lal, 2006
  - 0.31 – 3.1 Mg ha\(^{-1}\) yr\(^{-1}\) (0-30 cm) in grasslands (OH)
  - 0.58 – 4.0 Mg ha\(^{-1}\) yr\(^{-1}\) (0-30 cm) in forest
- Benfeldt et al., 2001
  - 0.43 Mg ha\(^{-1}\) yr\(^{-1}\) (0-10 cm) in grasslands (VA)
- Schafer et al., 1980
  - 1.33 Mg ha\(^{-1}\) yr\(^{-1}\) (0-200 cm) in soils <10 yr old (MT)
  - 0.45 Mg ha\(^{-1}\) yr\(^{-1}\) (0-200 cm) in soils >10 yr old
- Anderson et al., 2008
  - 1.17 Mg ha\(^{-1}\) yr\(^{-1}\) (0-30 cm) in grass/shrub mix (WY)
Pre-mining

Time Since Disturbance

Soil Carbon

Climate
Soil Structure
Soil Function
Plant Community
Relative Amount of C at t0

Land Use 1
Land Use 2
Land Use 3
East: <2 yr

East: Native
Loss of C with Disturbance-East

This loss is for the 0-5 cm depth:

- 0.31 Mg ha\(^{-1}\) yr\(^{-1}\): 170 yrs
- 3.1 Mg ha\(^{-1}\) yr\(^{-1}\): 17 yrs

(Wick and Daniels, 2009, BLRS proceedings)
West: 1 yr

West: native
Loss of C with Disturbance-West

This loss is for the 0-5 cm depth

0.31 Mg ha\(^{-1}\) yr\(^{-1}\): 147 yrs

3.1 Mg ha\(^{-1}\) yr\(^{-1}\): 15 yrs

1.17 Mg ha\(^{-1}\) yr\(^{-1}\): 39 yrs

(Wick et al., 2009, Soil Use Mgt 25: 311-319)
Physical Separation of Active OM

<1 year reclamation

Native Site
Location of OM

- **Active**
  - Living or newly added biomass
  - <10-20% of total OM
  - 10’s of years
- **Slow**
  - Physically protected (aggregates)
  - Important source for nitrogen
  - 100’s of years
- **Passive**
  - Very stable, chemically altered and bound (humus)
  - 60-90% of total OM
  - 1000’s of years
Eastern Soil Carbon Accumulation Rates

Whole soil: 0.30 Mg ha\(^{-1}\) yr\(^{-1}\)

- Active: 0.11
- Slow: 0.10
- Passive: 0.09

194 yrs to reach “native” in 0-5 cm

Coarse Textured, 27 yr reclaimed site

Plant Inputs

- Active 3.16 Mg ha\(^{-1}\)
- Slow 2.99 Mg ha\(^{-1}\)
- Passive 2.82 Mg ha\(^{-1}\)
Eastern Carbon Concentrations

Bars represent one standard error from the mean
Asterisks indicate significantly higher values among soil ages (P<0.05)
Western Soil Carbon Accumulation Rates

Whole soil: 0.17 Mg ha$^{-1}$ yr$^{-1}$
  – Active: 0.03
  – Protected: 0.14

462 yrs to reach “native” in 0-5 cm

Coarse Textured Soil, 16 yr reclaimed site

Plant Inputs

Active
3.58 Mg ha$^{-1}$

Protected (slow+passive)
2.23 Mg ha$^{-1}$
Western C Concentrations-Coarse

Site Age (yrs)

<1 5 10 16 undisturbed

g C kg\(^{-1}\) sand free soil

active
slow+passive

Site Age (yrs)

<1 5 10 16 undisturbed
Western Soil Carbon Accumulation Rates

Whole soil: 0.71 Mg ha$^{-1}$ yr$^{-1}$
  – Active: 0.55
  – Protected: 0.16

86 yrs to reach “native” in 0-5 cm

Fine Textured Soil, 26 yr reclaimed site
Western C Concentrations-Fine

![Western C Concentrations-Fine](image)
Conclusions

• **EAST**: active pool contained 35% total C

• **WEST**: active pool contained 60-70% total C
Conclusions

- **EAST:** Physical protection by aggregates and chemical binding of C to soil particles
- **WEST:** Climatic conditions and soil texture
Questions
Abbey Wick (abbey.wick@ndsu.edu)

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