Using RUSLE2 to Model Soil Erosion Potential for Shrub Willow

Danielle Kloster, Timothy Volk

SUNY College of Environmental Science and Forestry
Shrub Willow

- Potential applications in heating, electricity, and transportation fuels in the northeastern US
- Similar composition to other hardwoods facilitates mixing with forest residues
- Potential to sequester carbon in root systems (Pacaldo et al. 2012)
Soil Health and Erosion

- Soil health must be maintained over the production cycle, including:
  - Aggregate stability
  - Root health
  - Soil organic matter and carbon
  - Cation exchange capacity
  - pH
  - Water holding capacity

- All factors can be negatively impacted by water-driven soil erosion, the removal of topsoil by rainfall and runoff.
Willow Biomass - Crop Production Cycle

Site Prep Once
Plant Once
Rapid Re-growth
Harvest Woody Biomass
7 Crop Harvests

3 – 4 Years Growth
Coppice Once

Growth
Rapid Re-growth
Soil Erosion Impact of Perennial Energy Crop Production

- Tillage only occurs in the first year, surface disturbance every three years

- For perennial woody biomass crops, studies have shown improved:
  - Soil carbon (Blanco-Canqui 2010, Kahle et al. 2005, Tolbert et al. 2002); mixed results, either increase or no change
  - Aggregate stability (Blanco-Canqui 2010)
  - Water infiltration and soil porosity (Kahle et al. 2005)
Motivation

- Biomass Crop Assistance Program for willow in northern NY
- Natural Resource Conservation Service (NRCS) models soil erosion from potential sites
- Current willow vegetation file based on limited data
- Interest in thresholds for soil type and slope and the impact of cultivar on erosion
Widely used empirical soil erosion model

Predicts average annual soil loss from water erosion and calculates Soil Conditioning Index (SCI)

SCI is a measure of change in soil organic matter

Can be used to compare different managements (e.g. different cultivars, fall or spring site preparation)
RUSLE2

- \( A = R \times K \times L \times S \times C \times P \)
  - \( A \): average annual soil loss (Mg/ha or tons/ac)
  - \( R \): rainfall erosivity
  - \( K \): soil erodibility
  - \( L \& S \): field length and slope
  - \( C \): cover management (vegetation and management)
  - \( P \): support practices (cover crops, contour farming)
Cover Management Factor

- Vegetation file (over crop lifetime):
  - Canopy fall height
  - Root biomass in top 4 inches of soil
  - % Canopy cover
  - % Live ground cover
  - Yield

- Management file (over crop lifetime):
  - Site preparation and planting
  - Harvesting and regrowth
Developing a Vegetation File

- 2013 growing season – May through November
- Data collected using chronosequence approach
- Three cultivars: SV1, SX64, and Fish Creek
- Parameters for vegetation file: canopy fall height, live ground cover, canopy cover, and root biomass in the top 4 inches of soil
- Leaf area index data was also collected, but is not a part of the vegetation file.
Wolcott – 2 yr shoots, 6/12/13

SX64 – 2 yr shoots, 6/12/13

SV1 – 2 yr shoots, 6/12/13
Example: Middlebury, VT (3 yr shoots, 7 yr roots)
<table>
<thead>
<tr>
<th>Date</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/5/0</td>
<td>Sprayer, post-emergence</td>
</tr>
<tr>
<td>10/15/0</td>
<td>Plow</td>
</tr>
<tr>
<td>10/15/0</td>
<td>Disk</td>
</tr>
<tr>
<td>5/7/1</td>
<td>Sprayer, post-emergence</td>
</tr>
<tr>
<td>5/14/1</td>
<td>Disk</td>
</tr>
<tr>
<td>5/15/1</td>
<td>Plant</td>
</tr>
<tr>
<td>5/17/1</td>
<td>Sprayer, pre-emergence</td>
</tr>
</tbody>
</table>
Results

- Low average values over the entire rotation (23 years)
  - Using a 6% slope, 150 feet long hillside
  - Silt loam soil type
  - Standard fall site preparation
  - T-value: **6.7** Mg/ha/yr (3 t/ac/yr)
  - Fish Creek: **1.75** Mg/ha/yr
  - SX64: **1.70** Mg/ha/yr
  - SV1: **1.53** Mg/ha/yr
  - SCI: ~1 for all cultivars
Fish Creek had consistently the highest erosion (3% higher than SX64 under default conditions).

- Yield ➔ aboveground biomass ➔ dead ground cover
Results – Erosion by Year

- Highest erosion in the first year (fall site prep through the following fall)
## Results – Spring Site Preparation

<table>
<thead>
<tr>
<th>Date</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/5/0</td>
<td>Sprayer, post-emergence</td>
</tr>
<tr>
<td>5/7/1</td>
<td>Sprayer, post-emergence</td>
</tr>
<tr>
<td>5/14/1</td>
<td>Plow, moldboard</td>
</tr>
<tr>
<td>5/14/1</td>
<td>Disk, offset, heavy</td>
</tr>
<tr>
<td>5/15/1</td>
<td>Planter, transplanter</td>
</tr>
<tr>
<td>5/17/1</td>
<td>Sprayer, pre-emergence</td>
</tr>
</tbody>
</table>
Results – Effect of Soil Type

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Fish Creek</th>
<th>SX64</th>
<th>SV1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay</td>
<td>0.36</td>
<td>0.35</td>
<td>0.32</td>
</tr>
<tr>
<td>Clay loam</td>
<td>0.90</td>
<td>0.87</td>
<td>0.79</td>
</tr>
<tr>
<td>Loam</td>
<td>1.56</td>
<td>1.51</td>
<td>1.37</td>
</tr>
<tr>
<td>Silt</td>
<td>2.38</td>
<td>2.32</td>
<td>2.08</td>
</tr>
<tr>
<td>Silt Loam</td>
<td>1.75</td>
<td>1.70</td>
<td>1.53</td>
</tr>
<tr>
<td>Silty Clay</td>
<td>0.63</td>
<td>0.61</td>
<td>0.56</td>
</tr>
<tr>
<td>Silty Clay Loam</td>
<td>1.11</td>
<td>1.08</td>
<td>0.98</td>
</tr>
</tbody>
</table>

- No sandy types included – too well drained for willow
Results – Effect of Slope

![Graph showing soil loss vs. slope percentage for Fish Creek, SX64, and SV1. The graph indicates a linear relationship between soil loss and slope percentage, with Fish Creek showing the highest soil loss at higher slopes.]
Further Research

- Adaptation of RUSLE2 to perennial woody crops
- Data collection on growth characteristics for different sites over a wider geographic area
- Empirical measurements of erosion to compare to the model
References


Thank you! Questions?

For more information, please contact dpkloste@syr.edu.