Today’s topics
- The USLE Equation

Announcements
- HW #11 due today
- Assignment: HW #12
- Read Chapter 9 in the text
- Lab on Thur (10/16) in 214 Scoates
Rill and Inter-rill Erosion Modeling

USLE

- Soil erosion by water
  - from a given slope
  - on a per unit area basis
  - not all soil erosion is lost from field
    - deposition in flatter / vegetated spots

- Sediment yield
  - volume of sediment that passes a given pt.

- USLE
  - predicts soil erosion not sediment yield
  - planning tool
    - impact of land use on soil erosion
Prediction of Soil Loss
The USLE Equation

- Originally developed for annual loss
  - modified => monthly / single storm loss
- \( A = R \ K \ L S \ C \ P \)
  - \( A = \) average soil loss per unit area
    - typical units = tons / ac / yr
  - \( R = \) rainfall / runoff erosivity index for a given geographic location \( \Rightarrow \) Fig. 9.6 text
  - \( K = \) soil erodibility factor \( \Rightarrow \) Fig. 9.8 text
  - \( LS = \) slope steepness and length factor
    - Fig. 9.10 text
Prediction of Soil Loss
The USLE Equation

- $A = R \times K \times L \times S \times C \times P$
  - $L = \text{slope length factor}$
    - soil loss relative to that from a slope length of 72.6 ft (22.1 m)
  - $S = \text{slope steepness factor}$
    - soil loss relative to that from a slope of 9%
  - $C = \text{cover and management factor}$
    - soil loss relative to that from a continuously fallow area
    - Tables 9.1 / 9.2 / 9.5 in the text
  - $P = \text{supporting conservation practice}$
    - Table 9.3 in the text
The USLE Equation R Factor

- Rainfall and runoff erosivity factor (R)
  - Varies with:
    - amount of runoff
    - individual storm precipitation patterns
  - characterizes:
    - the kinetic energy raindrop impact (E)
    - maximum 30-min storm intensity (I)
- an annual erosivity index for a location is determined by:
  - summing up E x I for all storms (n)
- the average annual rainfall and runoff erosivity index (R) = (sum of E x I) / n
Figure 6.3. Rainfall and runoff erosivity index, $R$ distribution in the United States (Wischmeier and Smith, 1978).
Soil Erodibility Factor (K)

- susceptibility of soil to erosion
- soil loss measured on a series of soils on a unit plot with “worst case” conditions
  - 72.6 ft long
  - 9% slope
  - continuously tilled and fallow
  - assumed constant all year
- Result of unit plot experiments
  - nomograph (Fig. 9.8) based on:
    - soil texture / structure / permeability
- Most erodible ➔ soils with high silt contents
- Least erodible ➔ soils with high organic matter / strong subsoil structure / high permeabilities
Figure 6.7. Fallow soil erosion plot located near Pullman, WA with a standard length of 72.6 ft and a slope steepness of about 9%.
Soil Erodibility Factor (K)

- Example 9.3 text
- Given:
  - Soil with:
    - 65% silt and very fine sand
    - 5% sand
    - 2.8 % organic matter (OM)
    - fine granular soil structure
    - slow to moderate permeability
- Required:
  - Determine the K factor
- Answer \( K = 0.31 \) (Fig. 9.8 text)
The soil-erodibility nomograph. Where the silt fraction does not exceed 70 percent, the equation is $100 \, K = 2.1 \, M^{0.14} \left(10^{-a}\right) + 3.25 \, (b - 2) + 2.5 \, (c - 3)$

where $M = (\text{percent } si + vfs) \left(100 - \text{percent } c\right)$, $a = \text{percent organic matter}$, $b = \text{structure code}$, and $c = \text{profile permeability class}$.

Figure 6.5. Nomograph to determine soil erodibility $K$ factor (Wischmeier and Smith, 1978).
Topographic Factor (LS)

- Adjusts erosion rates for:
  - greater erosion on longer / steeper slopes
  - less erosion on shorter / flatter slopes
  - when compared to the USLE standard of:
    - 9% slope
    - 72.6 length
- Slope length measured from:
  - top of ridge to the outlet channel
  - top of ridge to where deposition begins
Figure 6.6. Graph to determine slope length and steepness factor, $LS$. 
Cropping Management Factor

- $C = \text{integration of several factors}$
  - vegetation cover
  - crop sequence
  - productivity level
  - length of growing season
  - land management (tillage practices)
  - residue management
  - soil surface
  - expected time distribution of erosive events
  - interception drip $\Rightarrow$ splash erosion
  - binding of plant roots
Cropping Management Factor

- For agricultural systems C factors based on:
  - crop rotations
  - tillage sequences
  - Conventional tillage leaves the surface bare
    - therefore susceptible to erosion
  - Conservation tillage leaves residue on surface
    - protects the soil from rainfall impact
    - reduces sheet and rill erosion

- For forest, rangeland and other non-agricultural lands C factors based on:
  - density of vegetation
  - vegetative residue on the soil surface

- For disturbed bare soil \( C = > 1.0 \)
Table 6.1. Cover management C factors for permanent pasture, rangeland, and idle land\(^1\) (Cooperative Extension Service and The Ohio State University, 1979).

<table>
<thead>
<tr>
<th>Vegetal Canopy</th>
<th>Canopy Cover(^3)</th>
<th>Type(^4)</th>
<th>0</th>
<th>20</th>
<th>40</th>
<th>60</th>
<th>80</th>
<th>95–100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Column No:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No appreciable</td>
<td></td>
<td></td>
<td>G</td>
<td>0.45</td>
<td>0.20</td>
<td>0.10</td>
<td>0.042</td>
<td>0.013</td>
</tr>
<tr>
<td>canopy</td>
<td>G</td>
<td></td>
<td>W</td>
<td>0.45</td>
<td>0.24</td>
<td>0.15</td>
<td>0.090</td>
<td>0.043</td>
</tr>
<tr>
<td>Canopy of tall</td>
<td></td>
<td></td>
<td>G</td>
<td>0.36</td>
<td>0.17</td>
<td>0.09</td>
<td>0.038</td>
<td>0.012</td>
</tr>
<tr>
<td>weeds or short</td>
<td></td>
<td></td>
<td>W</td>
<td>0.36</td>
<td>0.20</td>
<td>0.13</td>
<td>0.082</td>
<td>0.041</td>
</tr>
<tr>
<td>brush</td>
<td></td>
<td></td>
<td>G</td>
<td>0.26</td>
<td>0.13</td>
<td>0.07</td>
<td>0.035</td>
<td>0.012</td>
</tr>
<tr>
<td>(1.5 ft fall ht.)(^2)</td>
<td></td>
<td></td>
<td>W</td>
<td>0.26</td>
<td>0.16</td>
<td>0.11</td>
<td>0.075</td>
<td>0.039</td>
</tr>
<tr>
<td>Appreciable brush</td>
<td></td>
<td></td>
<td>G</td>
<td>0.17</td>
<td>0.10</td>
<td>0.06</td>
<td>0.031</td>
<td>0.011</td>
</tr>
<tr>
<td>or bushes</td>
<td></td>
<td></td>
<td>W</td>
<td>0.17</td>
<td>0.12</td>
<td>0.09</td>
<td>0.067</td>
<td>0.038</td>
</tr>
<tr>
<td>(6 ft fall ht.)(^2)</td>
<td></td>
<td></td>
<td>G</td>
<td>0.34</td>
<td>0.16</td>
<td>0.085</td>
<td>0.038</td>
<td>0.012</td>
</tr>
<tr>
<td>50</td>
<td></td>
<td></td>
<td>W</td>
<td>0.34</td>
<td>0.19</td>
<td>0.13</td>
<td>0.081</td>
<td>0.041</td>
</tr>
<tr>
<td>Trees but no</td>
<td></td>
<td></td>
<td>G</td>
<td>0.28</td>
<td>0.14</td>
<td>0.08</td>
<td>0.036</td>
<td>0.012</td>
</tr>
<tr>
<td>appreciable low</td>
<td></td>
<td></td>
<td>W</td>
<td>0.28</td>
<td>0.17</td>
<td>0.12</td>
<td>0.077</td>
<td>0.041</td>
</tr>
<tr>
<td>brush</td>
<td></td>
<td></td>
<td>G</td>
<td>0.39</td>
<td>0.18</td>
<td>0.09</td>
<td>0.040</td>
<td>0.013</td>
</tr>
<tr>
<td>(12 ft. fall ht.)(^2)</td>
<td></td>
<td></td>
<td>W</td>
<td>0.39</td>
<td>0.21</td>
<td>0.14</td>
<td>0.085</td>
<td>0.042</td>
</tr>
<tr>
<td>50</td>
<td></td>
<td></td>
<td>G</td>
<td>0.36</td>
<td>0.17</td>
<td>0.09</td>
<td>0.039</td>
<td>0.012</td>
</tr>
<tr>
<td>75</td>
<td></td>
<td></td>
<td>W</td>
<td>0.36</td>
<td>0.20</td>
<td>0.13</td>
<td>0.083</td>
<td>0.041</td>
</tr>
</tbody>
</table>

1. All values shown assume: (1) random distribution of mulch or vegetation, and (2) mulch of appreciable depth where it exists.
2. Average fall height of waterdrops from canopy to soil surface.
3. Percent of total-area surface that would be hidden from view by canopy in a vertical projection.
4. G: Cover at surface is grass, grasslike plants, decaying compacted duff, or litter at least 2 in. deep. W: Cover at surface is mostly broadleaf herbaceous plants (as weeds) with little lateral-root network near the surface, and/or undecayed residue.
Erosion Control Practice

- $P =$ effect of erosion control practices
  - practices besides vegetation management
  - practices characterized by $P$ are:
    - strip cropping
    - contouring
    - terraces
  - $P$ varies greatly with slope gradient
  - for many applications no erosion control practices are used $\Rightarrow 1.0$
  - no experimental data for forests and rangelands
Table 6.3. Conservation Practice Factor $P$ for the USLE (Wischmeier and Smith, 1978; and Bengston and Sabbagh, 1990).

<table>
<thead>
<tr>
<th>Farming up and down slope</th>
<th>$P = 1.0$</th>
</tr>
</thead>
<tbody>
<tr>
<td>All crops</td>
<td>$P = 1.0$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Contour Farming</th>
<th>$P$ factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land Slope Percent</td>
<td>Maximum Slope Length$^a$</td>
</tr>
<tr>
<td></td>
<td>(feet)</td>
</tr>
<tr>
<td>1 to 2</td>
<td>400</td>
</tr>
<tr>
<td>3 to 5</td>
<td>300</td>
</tr>
<tr>
<td>6 to 8</td>
<td>200</td>
</tr>
<tr>
<td>9 to 12</td>
<td>120</td>
</tr>
<tr>
<td>13 to 16</td>
<td>80</td>
</tr>
<tr>
<td>17 to 20</td>
<td>60</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Strip Cropping</th>
<th>$P$ factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>With grass and row crop</td>
<td>Contour $P \times 0.5$</td>
</tr>
<tr>
<td>With small grain and row crop</td>
<td>Contour $P \times 0.67$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Terraces</th>
<th>$P$ factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss from crop</td>
<td>Same as Contouring $P$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Loss from Terrace</th>
<th>$P$ factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>With graded channel outlet</td>
<td>Contour $P \times 0.2$</td>
</tr>
<tr>
<td>With underground outlet</td>
<td>Contour $P \times 0.1$</td>
</tr>
</tbody>
</table>

| Subsurface Drainage        | $P = 0.6$ |

$^a$ Maximum slope length for strip cropping can be twice contouring.
Class Wrap-up

- Assignment: HW #12
- Lab on Thur (10/16) in 214 Scoates

- Test #1
  - Average = 77%
  - 1) 100%
  - 3) A
  - 22) B
  - 6) C
  - 7) D
  - 3) F