Application of the equal-area spline function to legacy soil data

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Splines: background

- Use of splines in soil science is not new
- Original splines were freehand curves through data points (e.g. Jenny, 1942)
- Later, work began on quantitative techniques (e.g. Erh, 1972)

Background

• Various numerical approaches were developed during the 1960s and 70s
  e.g. exponential decay functions, polynomials
• Disadvantage is that any local variation in the soil profile affects the quality of fit everywhere
Background

• The solution: equal-area depth splines
• Consist of a series of local quadratic polynomials with “knots” or joins at horizon boundaries

Application

- Particularly useful for standardising soil property estimates taken at soil horizons into a set of standard depth increments.
- For example, the GlobalSoilMap.net product specifications indicate outputs of 0-5, 5-15, 15-30, 30-60, 60-100 and 100-200 cm.
Aims

• Apply the equal-area spline function to STATSGO2 map unit components
• Make weighted-means maps of total clay content at the GlobalSoilMap.net depth increments
Method

1. Extract soil property data from the Soil Data Mart for STATSGO2 map unit components
2. Run splines on map unit components, get estimates of total clay content at GlobalSoilMap.net depth increments
3. Deal with single-horizon components
4. Calculate weighted means per map unit per depth increment
5. Visualise results
Step 1: Extract soil property data

- Using “representative” values from Soil Data Mart database
- Convert clay (%) to clay (g kg\(^{-1}\)) by multiplying by 10
Step 2: Spline generation

Soil profile with property data

Property estimates at specific increments

Continuous spline (1 cm resolution)
Step 3: Single-horizon profiles

Can build spline:
- 235 g/kg
- 301 g/kg
- 452 g/kg
- 357 g/kg
- 322 g/kg

Cannot build spline:
- 271 g/kg

GSM increments:
- 0-5 cm
- 5-15 cm
- 15-30 cm
- 30-60 cm
Step 4: Weighted means

- Calculated weighted means as follows, for each depth increment:
  1. For each component in a mapunit, multiply property estimate by component’s proportion of composition of mapunit
  2. Sum the weighted property estimates to obtain weighted mean property estimate for mapunit

<table>
<thead>
<tr>
<th>Component</th>
<th>Property Estimate (g/kg)</th>
<th>Proportion (%</th>
<th>Weighted Mean (g/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>327</td>
<td>75</td>
<td>245.3</td>
</tr>
<tr>
<td>C2</td>
<td>252</td>
<td>12.5</td>
<td>31.5</td>
</tr>
<tr>
<td>C3</td>
<td>267</td>
<td>12.5</td>
<td>33.4</td>
</tr>
</tbody>
</table>

Total Weighted Mean: 310.2 g/kg
Results

STATSGO2 total clay:

- 98,369 components with total clay data (103,626 components total)
  - 97,798—more than one horizon of clay data (99.4%)
  - 571—only one horizon of clay data (0.6%)
30–60 cm
STATSG02
total clay (g kg$^{-1}$)
Comparison

- CONUS-SOIL (Miller and White, 1998)
  - based on original STATSGO (1994)
  - 1-km resolution
  - 11 standard layers
Summary

• **Benefits:**
  • Overall fit of spline not sensitive to individual values
  • Able to estimate soil property value for any depth increment
  • Estimates at standardised layers for modelling purposes

• **Disadvantages:**
  • Modelling of abrupt changes requires pseudo-horizons
  • Difficult to model sub-horizons
Future work

• Represent variability within mapunit as-is (Range? Weighted standard deviation?)
• Represent uncertainty/error (how?)
• Later versions:
  • Incorporate SSURGO data
• Even later:
  • Disaggregation of SSURGO mapunits