Using Soils Data to Map “Natural” Floodplains

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Also, a similar talk was co-presented with NRCS staff as a Natural Floodplain Function Alliance (NFFA) webinar on September 17, 2013

Agenda

- My questions in 2002
- Limitations of FEMA floodplains
- Mapping “geomorphic” floodplains in 2002
- Mapping “natural” floodplains in 2013
- Mapping other floodplain features
- Findings
- Recommendations
- Your questions?
My Questions in 2002

• Is there a way to visualize the natural expression of flooding across the landscape, ignoring the land cover disruptions caused by human interventions?

• If so, how do you delineate these “natural” floodplains?

• How would these “natural” floodplains compare and contrast to the floodplains mapped by FEMA?
Limitations of FEMA Floodplains

- There are several million square miles of FEMA A, V, and Shaded X Zones in the U.S.
- FEMA floodplains are focused in areas with population and insurable properties.
- FEMA Flood Insurance Study (FIS) reports have flood profiles showing 10-, 50-, 100-, and 500-year flood elevations; however, only the 100- and 500-year floodplains are mapped.
“Geomorphic” floodplains can be defined by soils subject to flooding.

Soils data were retrieved from State Soil Geographic Data Base (STATSGO) derived from 1:250,000 scale soils maps.

These data are coarse and for planning purposes only; i.e., for use above the county level.
Mapping “Geomorphic” Floodplains in 2002

- Geomorphic floodplains were delineated based on map units with 10% or more of the soils subject to rare, occasional, or frequent flooding.

Mapping “Natural” Floodplains in 2013
NRCS Soils Data

- STATSGO data are compiled from 1:250,000 scale soils maps and are appropriate for state-wide applications but are not precise enough for counties.

- SSURGO data are compiled from 1:12,000 to 1:63,360 scale soils maps and are appropriate for county-level analyses.

- SSURGO data were obtained from the Web Soil Survey.

http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm
NRCS Flooding Definitions

- National Soil Survey Handbook Section 618.30
  
  - Definition.—“Flooding” is the temporary covering of the soil surface by flowing water from any source, such as streams overflowing their banks, runoff from adjacent or surrounding slopes, inflow from high tides, or any combination of sources.

  - Shallow water standing or flowing that is not concentrated as local runoff during or shortly after rain or snowmelt is excluded from the definition of flooding.

  - Standing water (ponding) or water that forms a permanent covering is also excluded from the definition.
## NRCS Flooding Frequency Class

<table>
<thead>
<tr>
<th>Flooding Frequency Class</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>No reasonable possibility of flooding; one chance out of 500 of flooding in any year or less than 1 time in 500 years.</td>
</tr>
<tr>
<td>Very rare</td>
<td>Flooding is very unlikely but is possible under extremely unusual weather conditions; less than 1 percent chance of flooding in any year or less than 1 time in 100 years but more than 1 time in 500 years.</td>
</tr>
<tr>
<td>Rare</td>
<td>Flooding is unlikely but is possible under unusual weather conditions; 1 to 5 percent chance of flooding in any year or nearly 1 to 5 times in 100 years.</td>
</tr>
<tr>
<td>Occasional</td>
<td>Flooding is expected infrequently under usual weather conditions; 5 to 50 percent chance of flooding in any year or 5 to 50 times in 100 years.</td>
</tr>
<tr>
<td>Frequent</td>
<td>Flooding is likely to occur often under usual weather conditions; more than a 50 percent chance of flooding in any year (i.e., 50 times in 100 years), but less than a 50 percent chance of flooding in all months in any year.</td>
</tr>
<tr>
<td>Very frequent</td>
<td>Flooding is likely to occur very often under usual weather conditions; more than a 50 percent chance of flooding in all months of any year.</td>
</tr>
</tbody>
</table>
## NRCS Flooding Duration Class

<table>
<thead>
<tr>
<th>Flooding Duration Class</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extremely brief</td>
<td>0.1 to 4 hours</td>
</tr>
<tr>
<td>Very brief</td>
<td>4 hours to &lt; 2 days</td>
</tr>
<tr>
<td>Brief</td>
<td>2 days to &lt; 7 days</td>
</tr>
<tr>
<td>Long</td>
<td>7 days to &lt; 30 days</td>
</tr>
<tr>
<td>Very long</td>
<td>&gt; 30 days</td>
</tr>
</tbody>
</table>
Field Observed Clues to Flooded Soils

- Extent of flooded areas, flood debris in trees, damage to fences and bridges, and other signs of maximum water height are recorded.
- Aerial photographs showing former river channels, oxbows, point bars, alluvial fans, meander scrolls, sloughs, natural levees, backswamps, sand splays, and terraces.
- Vegetation that grows in flood areas may furnish clues to past flooding.
- Thin strata of material of contrasting color, texture, or both.
- An irregular decrease in organic matter content, not due to human-alteration by mixing or transportation of material, which is an indication of a buried genetic surface horizon.
- Soil layers that have abrupt boundaries to contrasting kinds of material, which indicate that the materials were laid down suddenly at different times and were from different sources or were deposited from stream flows of different velocities.
- Laboratory analyses of properly sampled layers are often helpful in verifying these observations. Organic carbon and particle-size analyses are particularly useful in verifying flood deposits.
- Microscopic observations may detect preferential horizontal orientation of plate-like particles; microlayering, which indicates water-laid deposits; or mineralogical differences between layers.
FEMA Flood Zone Data

- Flood zones are geographic areas that FEMA has defined according to varying types of flood hazards.
- These zones are depicted on a community's Flood Insurance Rate Map (FIRM) or Flood Hazard Boundary Map. Each zone reflects the severity or type of flooding in the area.
- This study focused on A Zones (100-year) and Shaded X Zones (500-year).
FEMA Flood Zone Data

- FEMA DFIRM (Digital Flood Insurance Rate Map) data were obtained from the Map Service Center (MSC) at https://msc.fema.gov.
- DFIRMs provide a digital version of the FEMA flood insurance rate map that is designed for use with digital mapping and analysis software.
- FEMA DFIRM data can be downloaded by U.S. county.
Soil Flooding Frequency and Duration Example
FEMA Flood Hazard
Source: HSIP GOLD 2012
Rainfall occurs mostly in the winter months for Xeric or Mediterranean Soil Moisture Regime.
January

Annual Flooding Frequency Class

- Very frequent
- Frequent
- Occasional
- Rare
- Very rare
February

Annual Flooding Frequency Class

- Very frequent
- Frequent
- Occasional
- Rare
- Very rare
March

Annual Flooding Frequency Class

- Very frequent
- Frequent
- Occasional
- Rare
- Very rare
April

Annual Flooding Frequency Class

- Very frequent
- Frequent
- Occasional
- Rare
- Very rare
June

Annual Flooding Frequency Class

- Very frequent
- Frequent
- Occasional
- Rare
- Very rare
July Annual Flooding Frequency Class

- Very frequent
- Frequent
- Occasional
- Rare
- Very rare
August

Annual Flooding Frequency Class

- Very frequent
- Frequent
- Occasional
- Rare
- Very rare
November

Annual Flooding Frequency Class

- Very frequent
- Frequent
- Occasional
- Rare
- Very rare
Annual Flooding Frequency Class

- Very frequent
- Frequent
- Occasional
- Rare
- Very rare
Annual Flooding Duration

FEMA Flood Hazard
Source: HSIP GOLD 2012

Flood Hazard Areas 1
January

Annual Flooding Duration Class

- Very long
- Long
- Brief
- Very brief
- Extremely brief

Legend:

Sources: ECI, DigiGlobe, GeoEye, IREST, USGS, AEI, SolMap, Agrodd, IOM, ISW, Salgado, and the GIS User Communities.
April

Annual Flooding Duration Class

- Very long
- Long
- Brief
- Very brief
- Extremely brief
August

Annual Flooding Duration Class

- Very long
- Long
- Brief
- Very brief
- Extremely brief
November

Annual Flooding Duration Class

- Very long
- Long
- Brief
- Very brief
- Extremely brief
Mapping Other Floodplain Features

- **Height Above River (HAR)** - ArcGIS tool initially developed in 2010 by University of Nevada Reno (UNR) for riparian/ecological investigations to view heights above a floodplain terrain surface relative to a changing river surface (Dilts, 2010).

  ![Comparison of a flood height map (left) and high resolution aerial photograph for Mason Valley in the Walker River Basin.](http://arcscripts.esri.com/details.asp?dbid=16792%20)

  **Figure 8:** Comparison of a flood height map (left) and high resolution aerial photograph for Mason Valley in the Walker River Basin.

- **Flood Inundation Potential (FIP)** – Similar to HAR, but modified to view relative heights and depths from a hypothetical flood profile.

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HAR and FIP Applied in the Central Valley

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Height Above River (HAR)

Flood Inundation Potential (FIP)

AECOM in DWR (2012)
50% ACE Flood Inundation Potential (FIP)

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AECOM in DWR (2012)
Greco et al. (2008) investigated relative elevations to analyze depth to groundwater, as a planning technique for riparian restoration efforts. Relative elevations were compared to well logs and achieved a reasonable correlation.
Findings

• NRCS soils data and FEMA floodplain data are readily available over the Internet for GIS applications.

• NRCS flood frequency classes generally coincide with FEMA data; i.e., 1% ACE (Annual Chance Event), 2% ACE, 5% ACE, 10% ACE, 50% ACE.

• In Sacramento County there are about 370 mi² of FEMA floodplains and 286 mi² of “natural” floodplains, with about 252 mi² of land area where both types of floodplains overlap.

• Other GIS techniques, such as HAR and FIP utilize topography and flood profiles and can indicate “natural” floodplain characteristics of depth and extent and morphology for designated flood events by projecting floodplains landward of flood control features such as levees. Note, however that this does not replace floodplain modeling because projected flood levels do not account for the actual movement of floodwaters.
Recommendations

- Use soils data in investigations of flooding, especially for floodplain restoration projects.
- Apply soils data from the reach scale to the watershed scale and to larger spatial scales.
- Utilize soils data to map “natural” floodplains and augment floodplains defined by FEMA, which are derived for insurance purposes.
- Associate the spatial relationships of flood prone soils and their flood frequency class to observed water surfaces or hypothetical floodplains using GIS tools such as HAR and FIP.
- Utilize HAR and FIP output to provide a topographic and geomorphic context for viewing flood prone soils.
Selected References


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• Dr. Steven Greco, University of California, Davis CA
Your Questions?

“Super-Natural” Floodplains by Rob Gonsalves

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