Introduction

- **Chesapeake Bay Pilot**
  - Restoration and protection a priority for stakeholders
  - High development pressure

- **Motivation**
  - Lack of information on ES and values applicable to local scale

- **Project Goal**
  - Provide ES information on streams and floodplains at scale useful to inform decision-making
Floodplain Ecosystem Services

Capacity of floodplain to **retain sediment, nutrients, and flood waters** provides critical ecosystem services to local and downstream communities.

Ecosystem Services of Interest

- **Nutrient/Sediment Retention**
- **Flood Attenuation**
- **Carbon Sequestration**

Photos courtesy of Chesapeake Bay Program
Project Approach

1. Floodplain lidar mapping
2. Use stream and floodplain physical characteristics to estimate ecologic functions
3. Develop metrics based on ecologic functions
4. Correlate ecologic functions with final ecosystem goods and services
5. Estimate value of local and downstream ecosystem services
6. Scale Up

Linking stream and floodplain physical characteristics with functions we can tie to biophysical production of services
Lidar Mapping
Sediment and Nutrient Retention
Linking Functions to Services

Ecosystem Function

Floodplains retain sediment and nutrients

Loads of sediment and nutrients are reduced

Improved water quality

Ecosystem Service

Opportunity to:
• view the environment
• to swim, wade, boat
• catch fish

Photos courtesy of Chesapeake Bay Program
Quantifying Sediment and Nutrient Retention

- Field estimates of sediment, nitrogen, & phosphorus
  - Bank erosion
  - Floodplain deposition
  - Net flux

- Stream reach predictions of flux of sediment, nitrogen, & phosphorus
Sediment and Nutrient Retention
Translating Services to Values

Link loads to water quality

Link water quality to final services

Valuing final services

Lower nutrient and sediment loads

Improved water quality

Opportunity to:
• view the environment
• to swim, wade, boat
• catch fish

Willingness to Pay for recreation

Proxy Replacement costs of wastewater treatment

Photos courtesy of Chesapeake Bay Program
Replacement Cost Method

- Estimating consumer surplus is currently intractable
- As a proxy, assessing replacement costs of nutrient and sediment retention services provided by floodplains

\[ V_e = \sum_i R_i \times P_i \]
Difficult Run Preliminary Results

Cost per pound of total nitrogen removed*

<table>
<thead>
<tr>
<th>Nitrogen concentration achieved</th>
<th>Cost per pound</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.0 mg/L to 7.5 mg/L</td>
<td>$5.75</td>
</tr>
<tr>
<td>7.5 mg/L to 5.0 mg/L</td>
<td>$18.78</td>
</tr>
<tr>
<td>5.0 mg/L to 3.9 mg/L</td>
<td>$115.06</td>
</tr>
</tbody>
</table>

*These data are preliminary and are subject to revision. They are being provided to meet the need for timely ‘best science’ information. The assessment is provided on the condition that neither the U.S. Geological Survey nor the United States Government may be held liable for any damages resulting from the authorized or unauthorized use of the assessment.
Flood Attenuation
Linking Functions to Services

Ecosystem Function

Floodplains store water during precipitation events

Stream peak flows are reduced

Adjacent community flooding reduced

Photos courtesy of Chesapeake Bay Program
Quantifying Flood Mitigation

Estimate inundation for baseline (w/ floodplain) and counterfactual scenarios (w/o floodplain) using GIS Flood Tool

\[ h = 8.2 \text{ ft} \]

\[ h = 22.2 \text{ ft} \]

Flood Attenuation
Translating Services to Values

Method Development: Translating flood attenuation to services and economic values

- Link water storage to flood attenuation
- Link flood attenuation to avoided damages

Photos courtesy of Chesapeake Bay Program
Estimating Flood Damages Avoided

Depth-Damage curves

- Developed by FEMA using insurance claims

Damage = 0.28 \times $838,380 = $234,736

Basemap imagery from ESRI and Digital Globe data

Figure from FEMA (2013). *Multi-hazard loss estimation methodology, Flood Model, Technical Manual.*
Carbon Sequestration
Linking Functions to Services

Ecosystem Function

Floodplains store carbon in soils and biomass

Lower carbon inputs to the atmosphere

Lower atmospheric carbon

Ecosystem Service

Reduced climate change

Photos courtesy of Chesapeake Bay Program
Determining Floodplain Carbon Flux

Using literature values to estimate carbon flux
Carbon Sequestration
Translating Services to Values

Select relevant floodplain areas

Extract Carbon flux from geospatial datasets

Social Cost of Carbon
$43.32 per ton of CO$_{2}$eq per year

Photos courtesy of Chesapeake Bay Foundation
Research Significance

- ES info provides decision-makers with critical data:
  - Nutrient and sediment retention capacity of floodplains
  - Flood mitigation capacity of floodplains
  - At local and watershed wide scales
  - Human impacts and values to understand tradeoffs

- Analysis may support targeting of conservation and/or restoration

- Research continues in Chesapeake Bay, new work underway in Delaware River Watershed
  - Grant from William Penn Foundation (FY17-19)
  - Refine USGS Toolkit
Questions??

Photo: Chesapeake Bay Foundation

Dianna Hogan
Krissy Hopkins
Fabiano Franco
Collin Lawrence
Emily Pindilli
Stephanie Gordan