RUSLE 2021: Improvements and Issues with Modeling Upland Erosion

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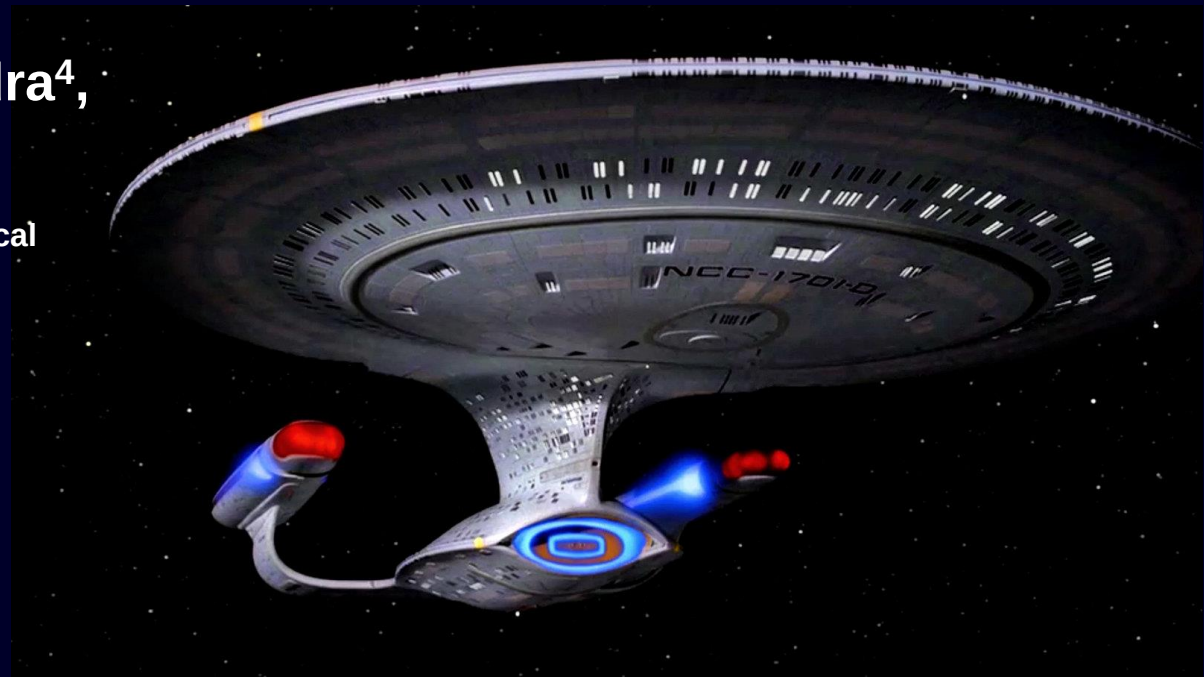


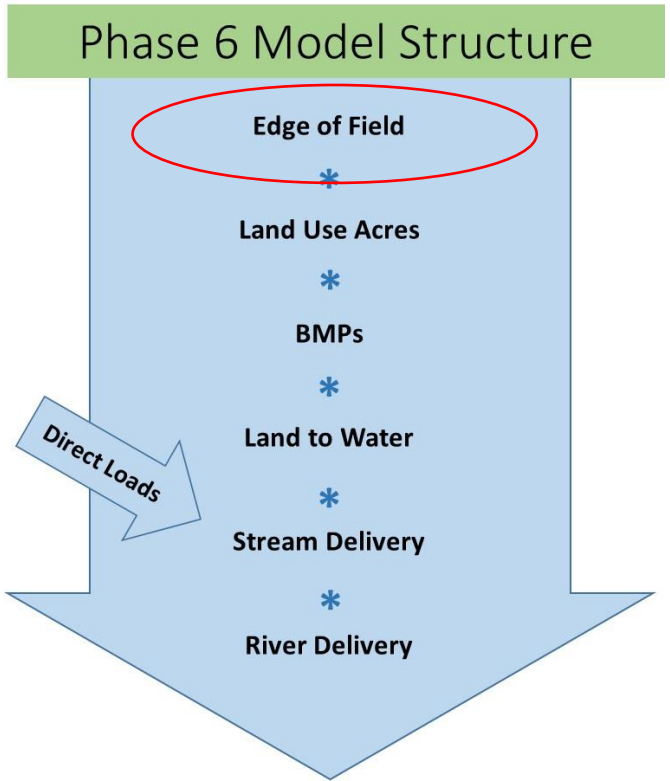
U.S. Department of the Interior
U.S. Geological Survey

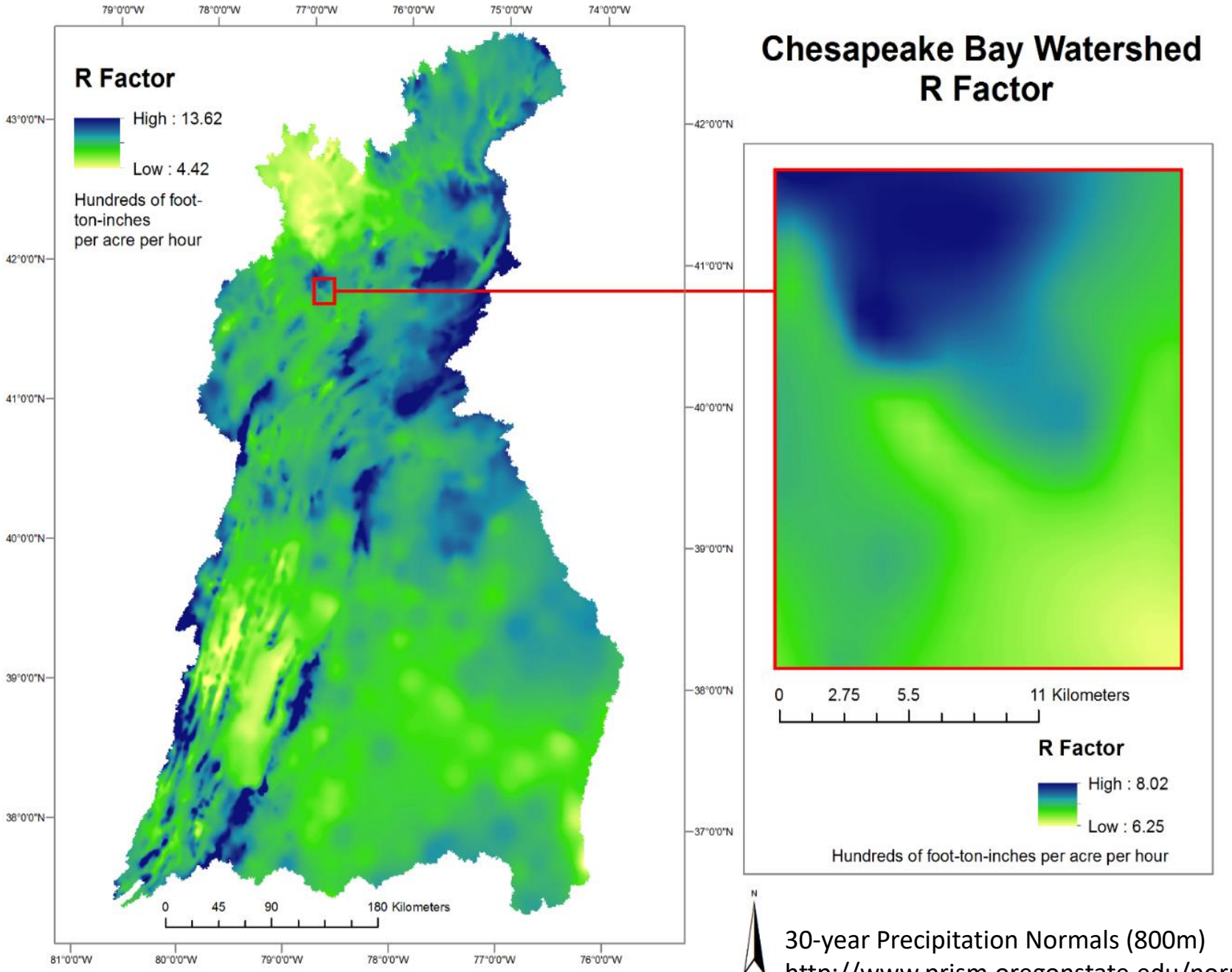
RUSLE => R * K * LS * C * P => Edge of Field Sediment Load

- R = Rainfall Erosivity
- K = Soil Erodibility
- LS = Slope Length and Steepness

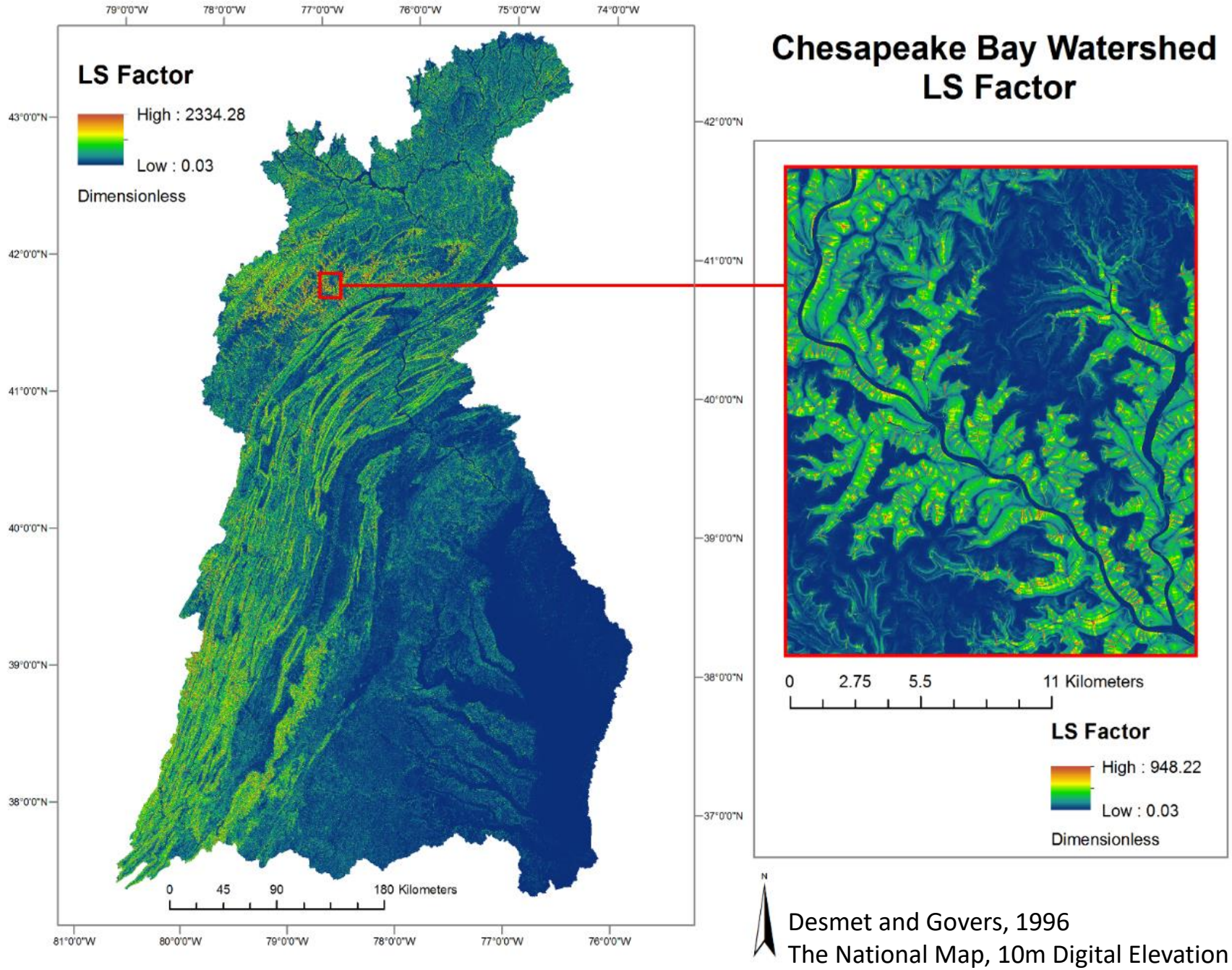
} Evaluated at 10-meter resolution

- C = Cover Management
  - By land use and Land-River segment
- P = Practices
  - = 1 since no action loads

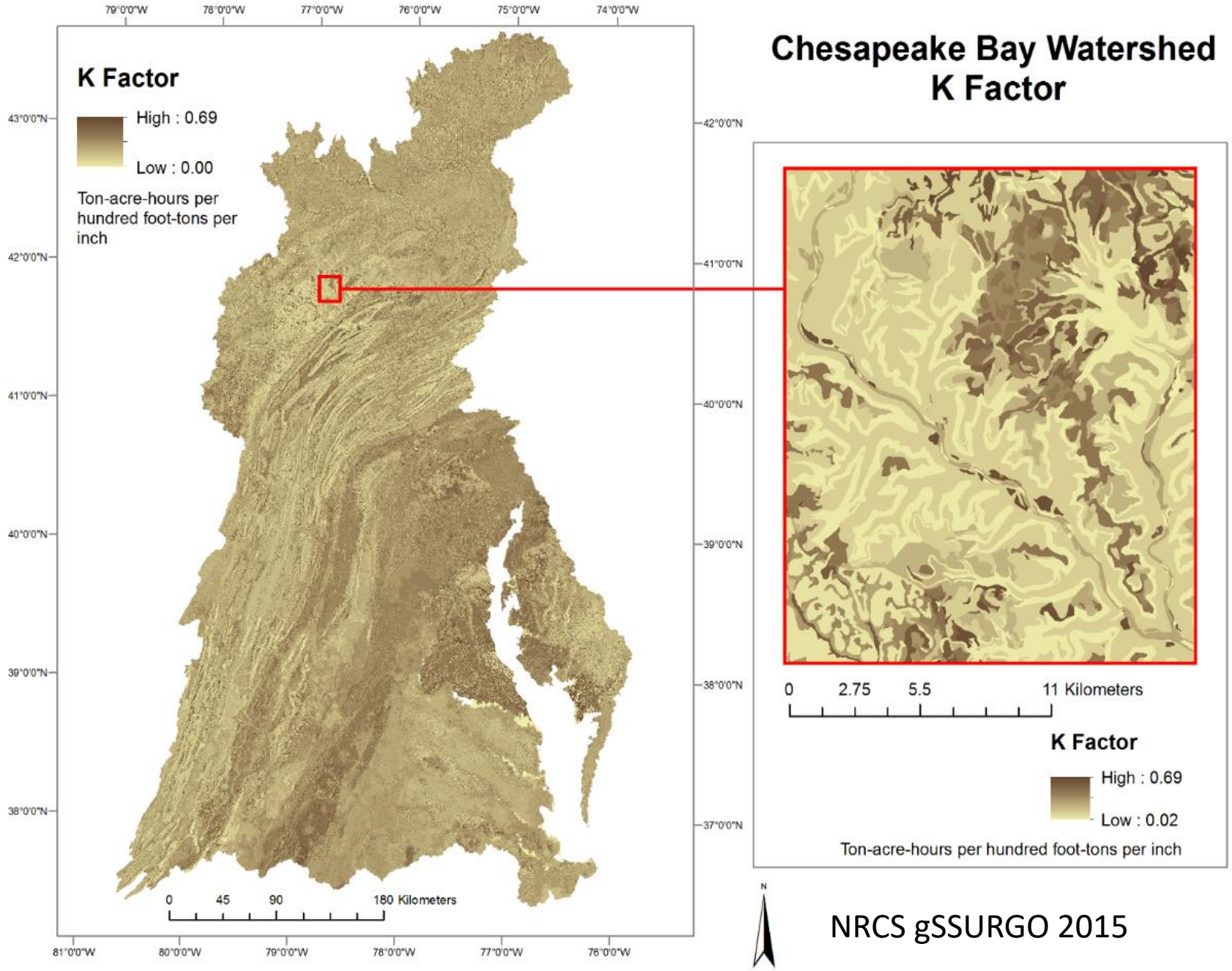




30-year Precipitation Normals (800m)
http://www.prism.oregonstate.edu/normals/



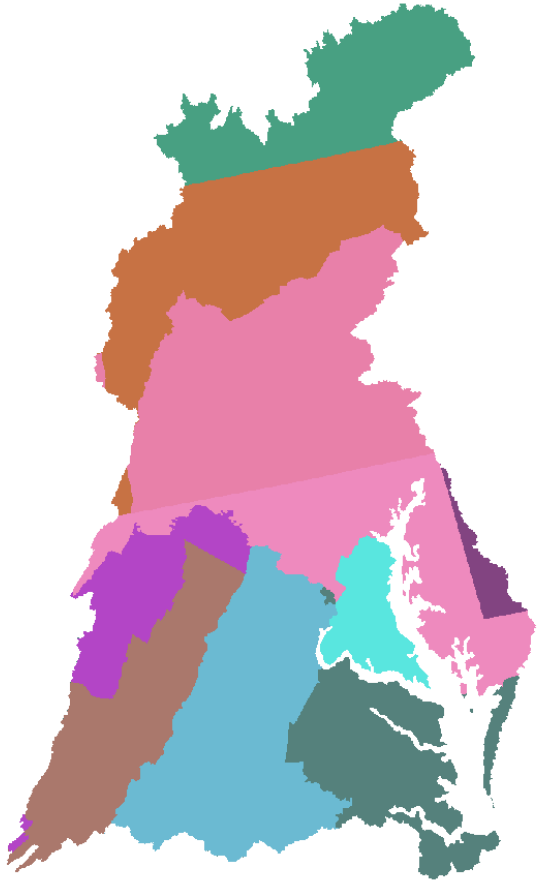
Desmet and Govers, 1996
The National Map, 10m Digital Elevation Model

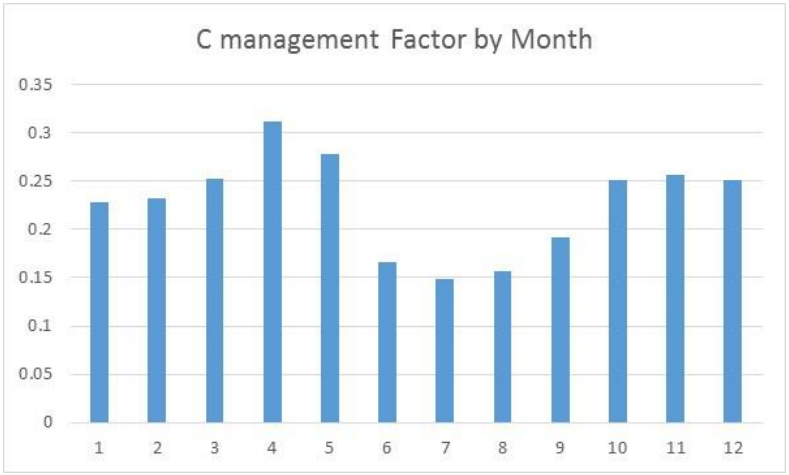


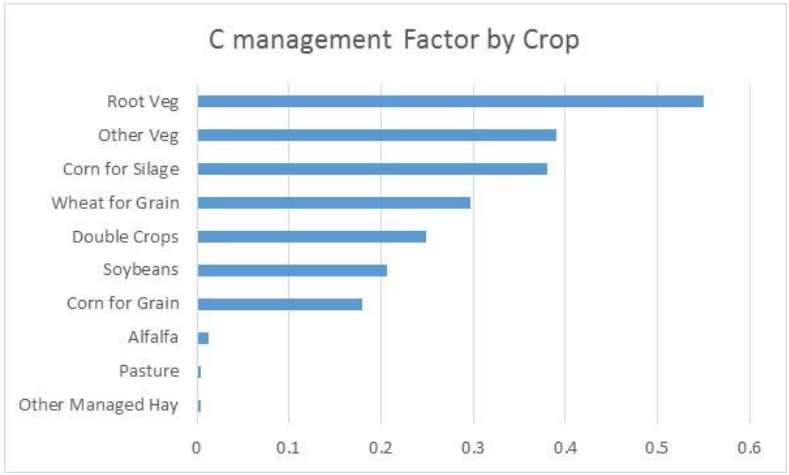
NRCS gSSURGO 2015

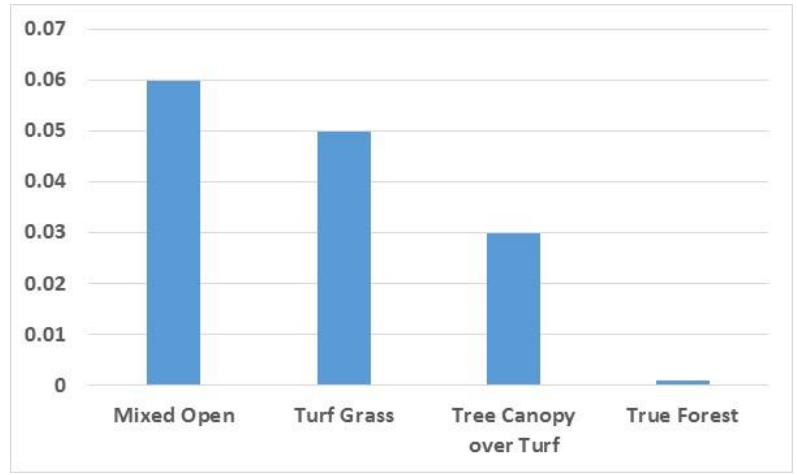
Chesapeake Bay Watershed C-factor

- The C management Factor represents the effect of vegetative cover on erosion rates.
- Agricultural values were challenged during a STAC review and were revised using RUSLE2
- Literature values were used for non-agricultural lands.









Sediment Delivery to Small Streams

$$IC = log_{10}\left(\frac{D_{up}}{D_{dn}}\right)$$

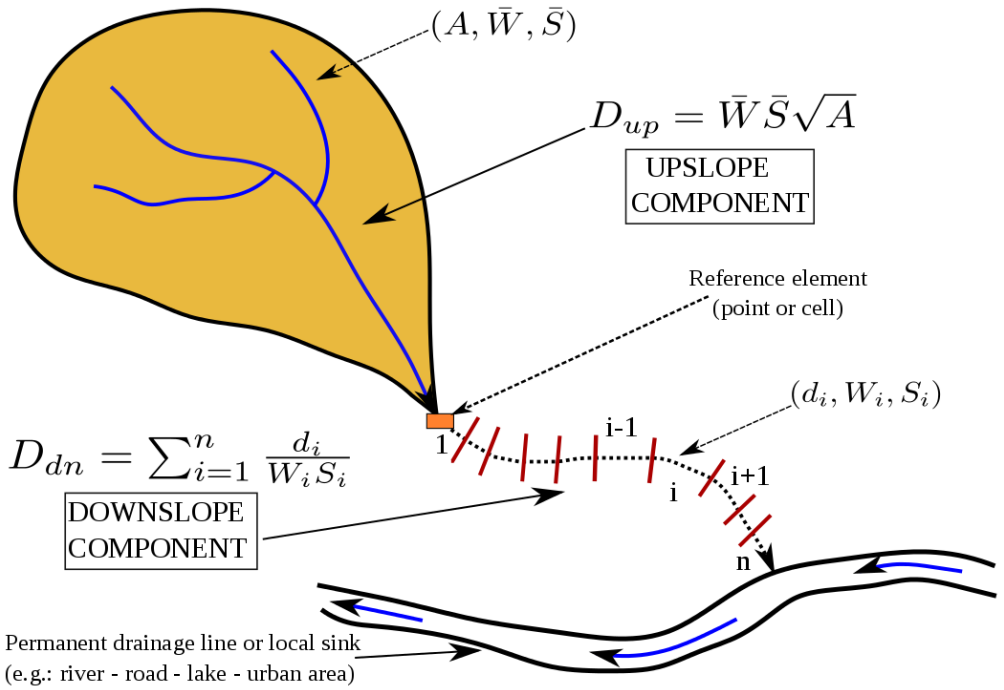
IC = Index of Connectivity

$$D_{dn} = \sum_i \frac{d_i}{W_i S_i}$$

Path length

Relative surface roughness

Slope gradient

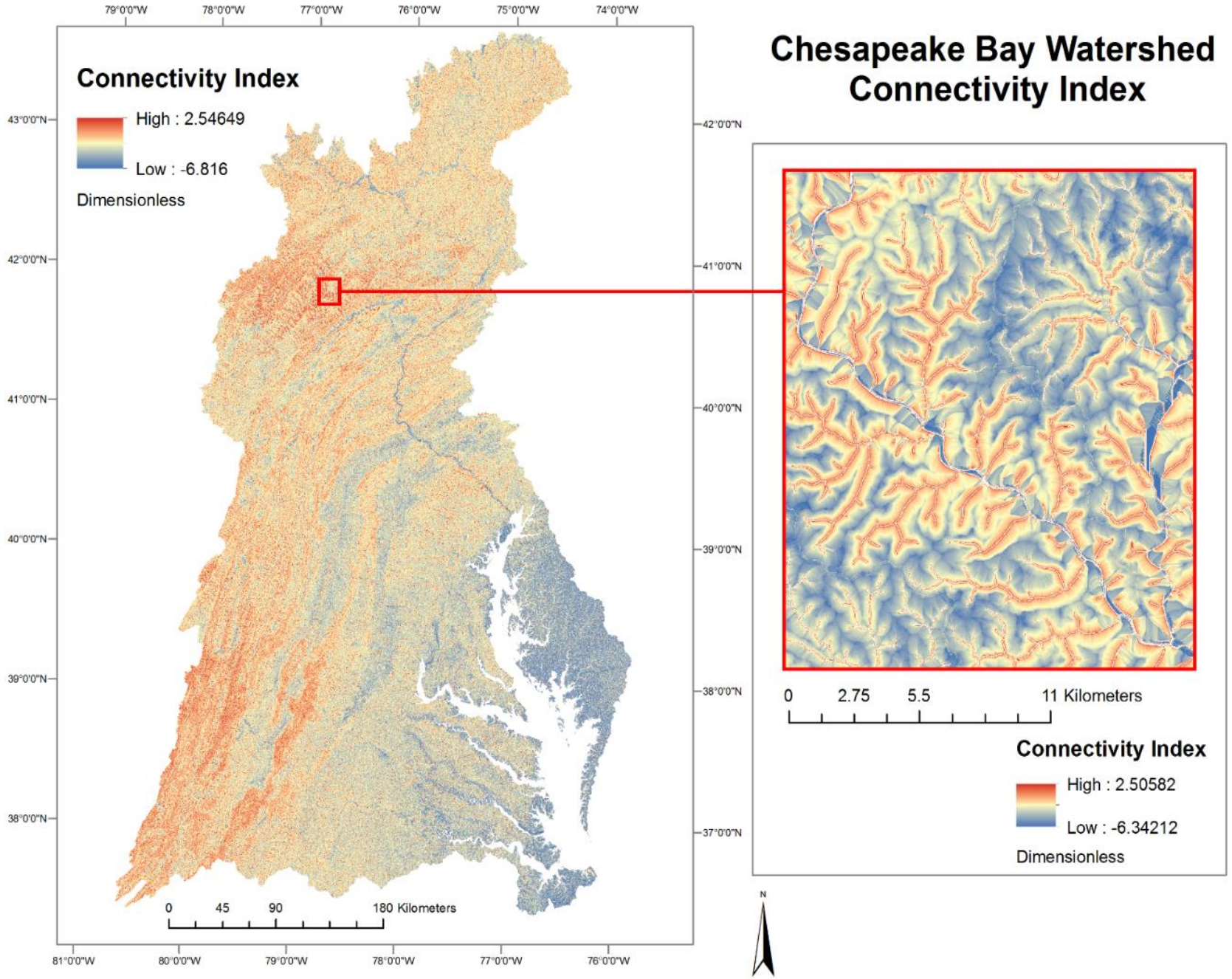


Guidelines on the Sediment Connectivity
ArcGis 10.1 and 10.2 Toolbox

Release: 1.1

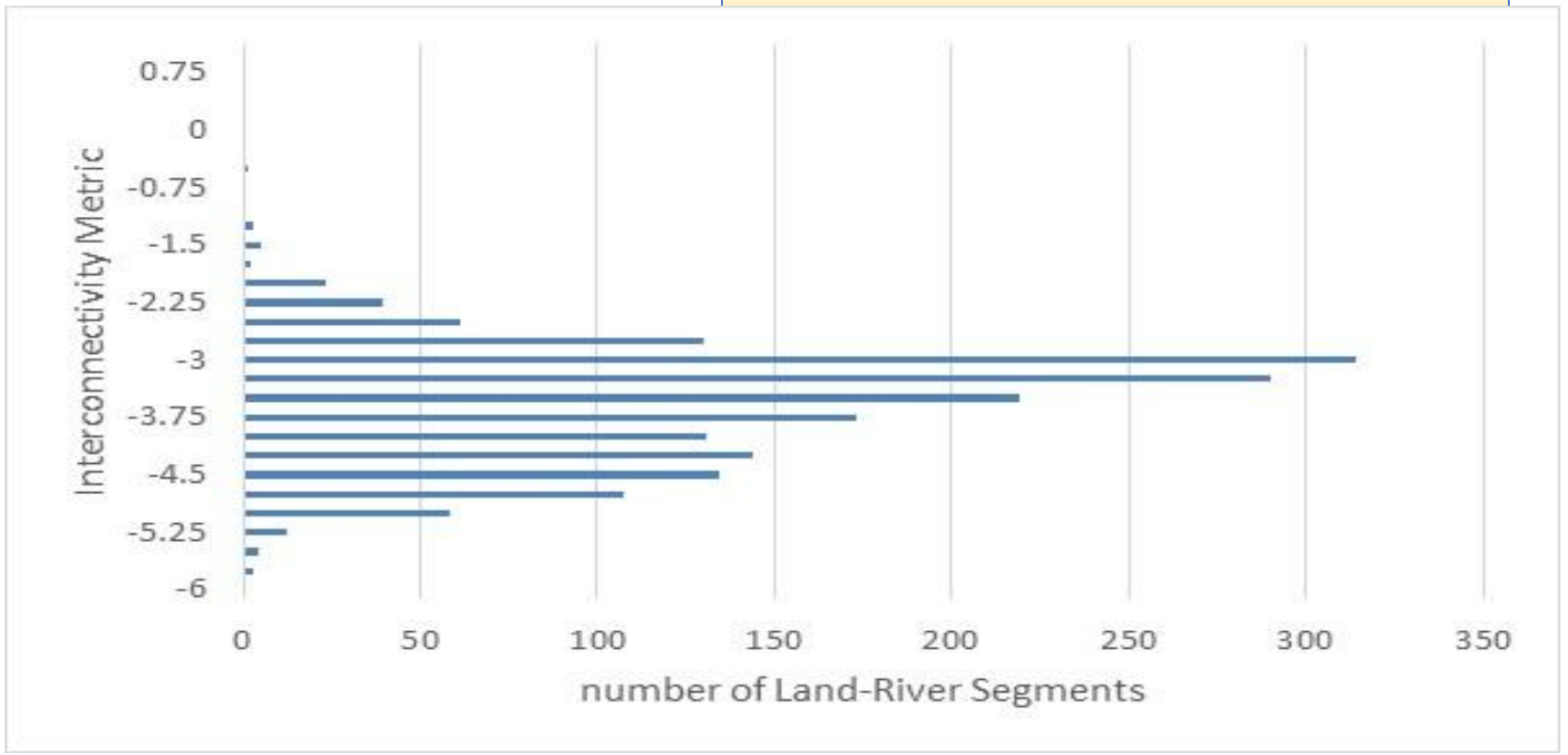
Marco Cavalli, Stefano Crema, Lorenzo Marchi
CNR-IRPI Padova (PP4)

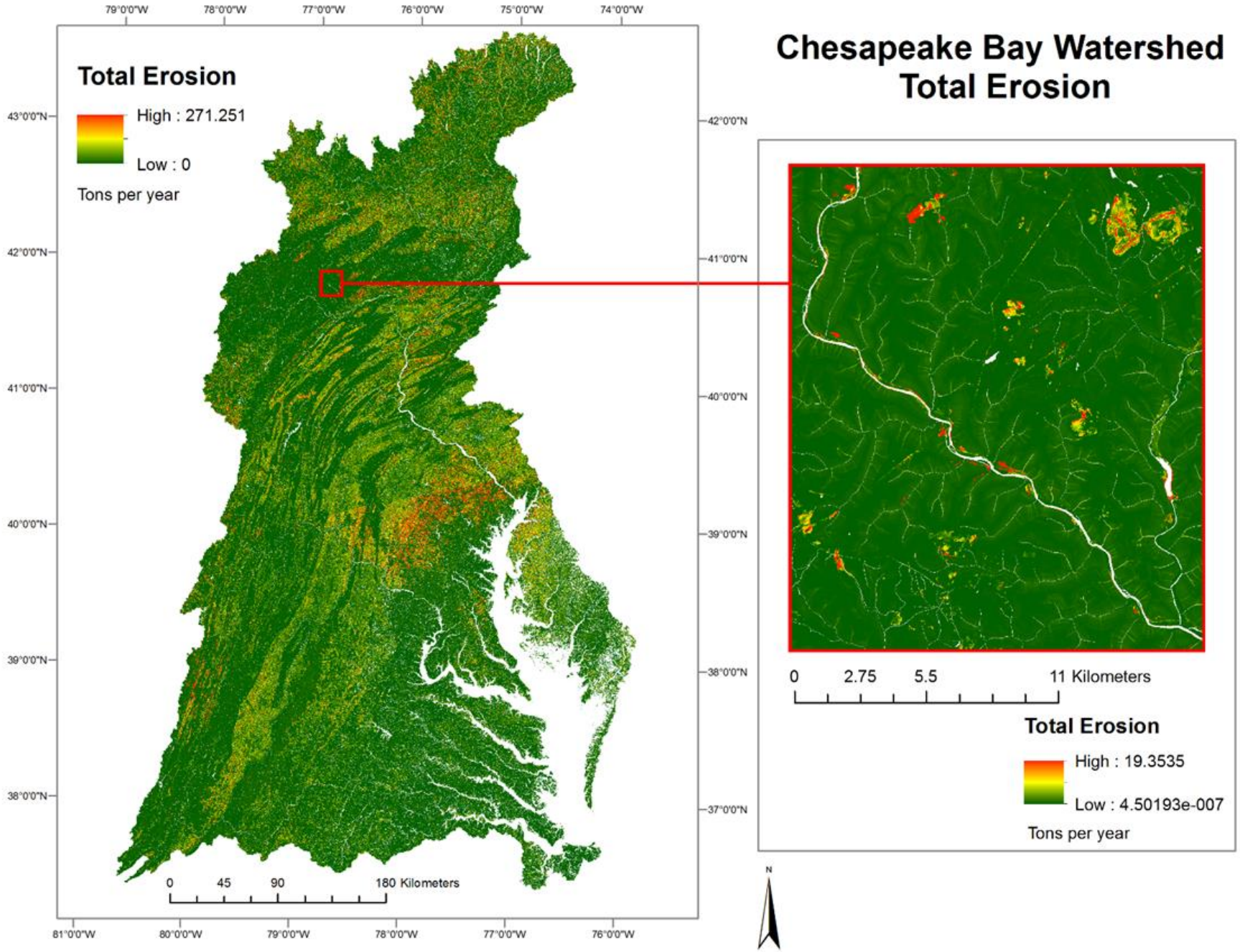
June 2014


Chesapeake Bay Watershed
Connectivity Index
Connectivity Index
High : 2.54649
Low : -6.816
Dimensionless
79°0'0"W
78°0'0"W
77°0'0"W
76°0'0"W
75°0'0"W
74°0'0"W
43°0'0"N
42°0'0"N
41°0'0"N
40°0'0"N
39°0'0"N
38°0'0"N
37°0'0"N
81°0'0"W
80°0'0"W
0
45
90
180 Kilometers
0
2.75
5.5
11 Kilometers
Connectivity Index
High : 2.50582
Low : -6.34212
Dimensionless
N

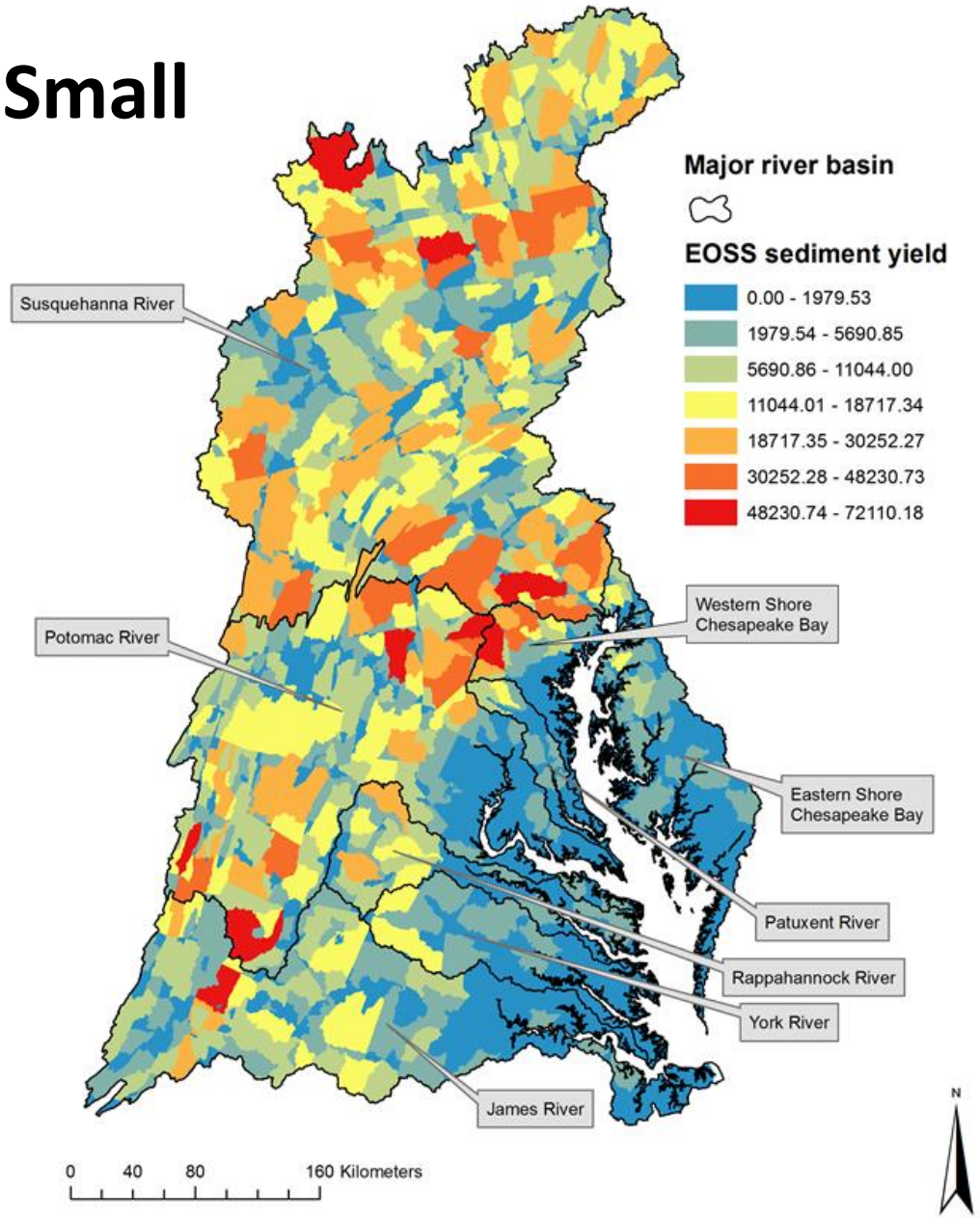
Sediment Delivery Ratio

- Need to convert to scale of 0 to 1 with an average of 0.48




Chesapeake Bay Watershed
Total Erosion
Total Erosion
High : 271.251
Low : 0
Tons per year
79°0'0"W
78°0'0"W
77°0'0"W
76°0'0"W
75°0'0"W
74°0'0"W
43°0'0"N
42°0'0"N
41°0'0"N
40°0'0"N
39°0'0"N
38°0'0"N
37°0'0"N
0
45
90
180 Kilometers
81°0'0"W
80°0'0"W
79°0'0"W
78°0'0"W
77°0'0"W
76°0'0"W
0
2.75
5.5
11 Kilometers
Total Erosion
High : 19.3535
Low : 4.50193e-007
Tons per year
N

Sediment Yield to Small Streams

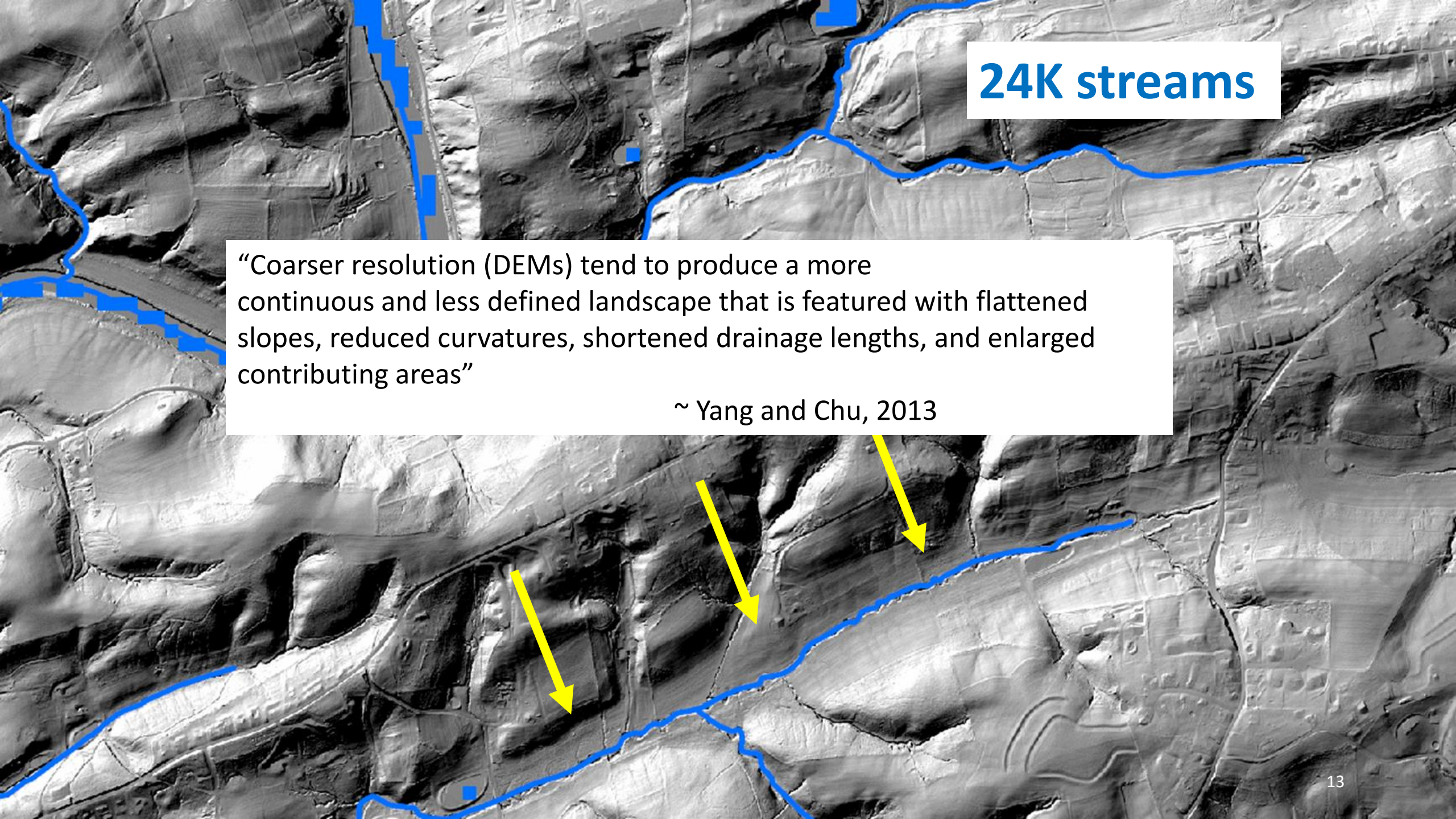


Significance of Topography and Hydrography Scale in Erosion Modeling

Hyper-Res 2K ⟵ ⟶ **NHD+ 100K**

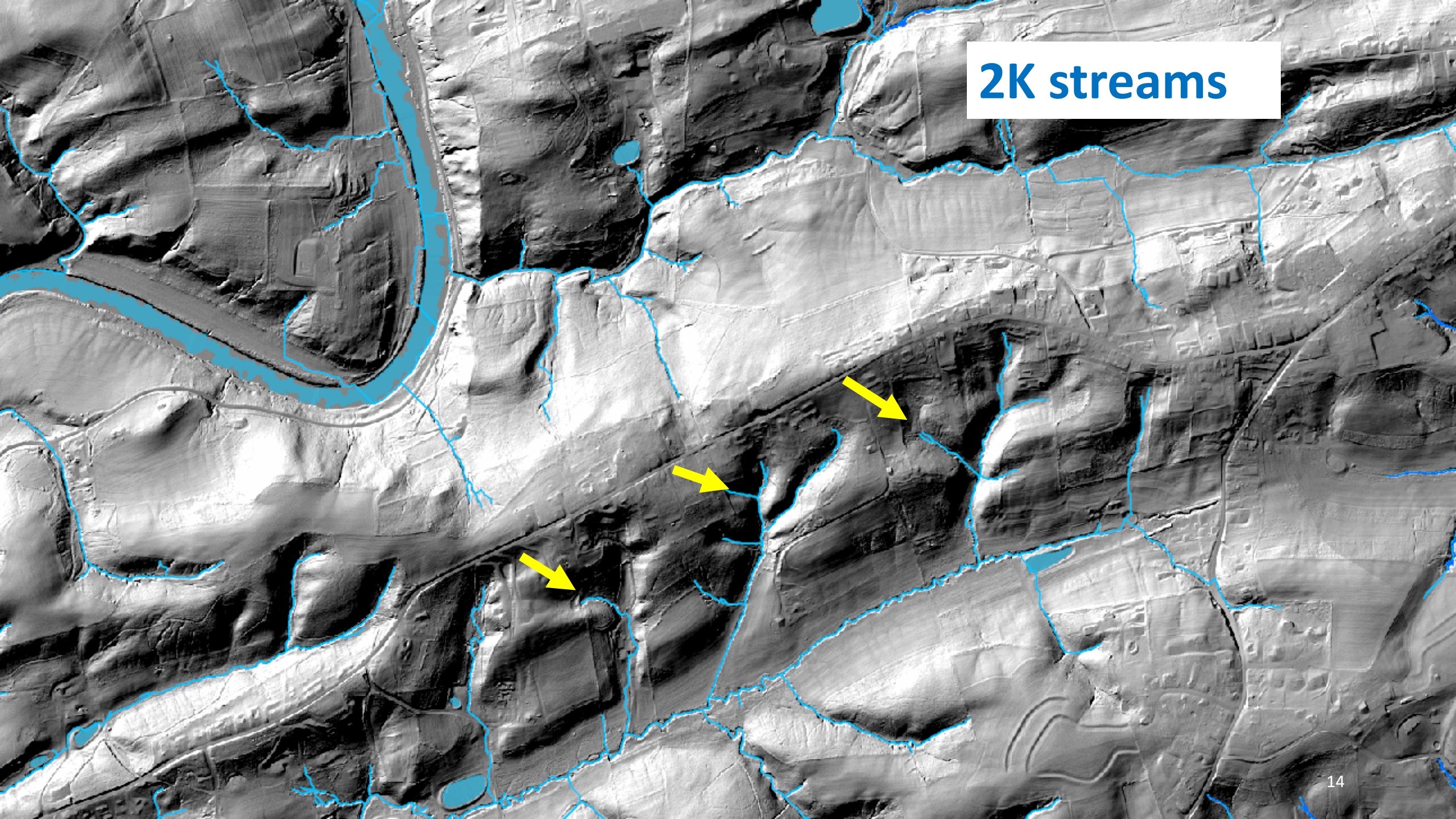
- More and longer zero and first-order streams
- Higher stream density = longer but faster and more erosive hillslope pathways
- Increased density associated with ditches, gullies, and other ephemeral or intermittent flow features

- Dominated by perennial streams
- Lower stream density = shorter but slower and less erosive hillslope pathways
- Headwater and zero-order streams poorly represented.



"Coarser resolution (DEMs) tend to produce a more continuous and less defined landscape that is featured with flattened slopes, reduced curvatures, shortened drainage lengths, and enlarged contributing areas"

~ Yang and Chu, 2013


2K streams

Chesapeake Bay Program Land Use Classification (60+ classes)

1. Water (8)
- 1.1 Lentic
  - 1.1.1 Estuary
  - 1.1.2 Lakes & Ponds
- 1.2 Lotic
  - 1.2.1 Streams
    - 1.2.1.1 Sunlit
    - 1.2.1.2 Shaded
    - 1.2.1.3 Culverted/ Buried
  - 1.2.2.Ditches
    - 1.2.2.1 Sunlit
    - 1.2.2.2 Shaded
    - 1.2.2.3 Culverted/ Buried

2. Developed (12)
- 2.1 Impervious
  - 2.1.1 Roads
  - 2.1.2 Structures
  - 2.1.3 Other Impervious (Parking lots, driveways)
- 2.2 Pervious
  - 2.2.1 Turf Grass
  - 2.2.2 Bare Construction
  - 2.2.3 Suspended Succession (rights-of-way)
    - 2.1.7.1 Barren
    - 2.1.7.2 Herbaceous
    - 2.1.7.3 Scrub-shrub
- 2.3 Urban Tree Canopy (TC)
  - 2.3.1 TC over Roads
  - 2.3.2 TC over Structures
  - 2.3.3 TC over Other Impervious
  - 2.3.4 TC over Turf Grass

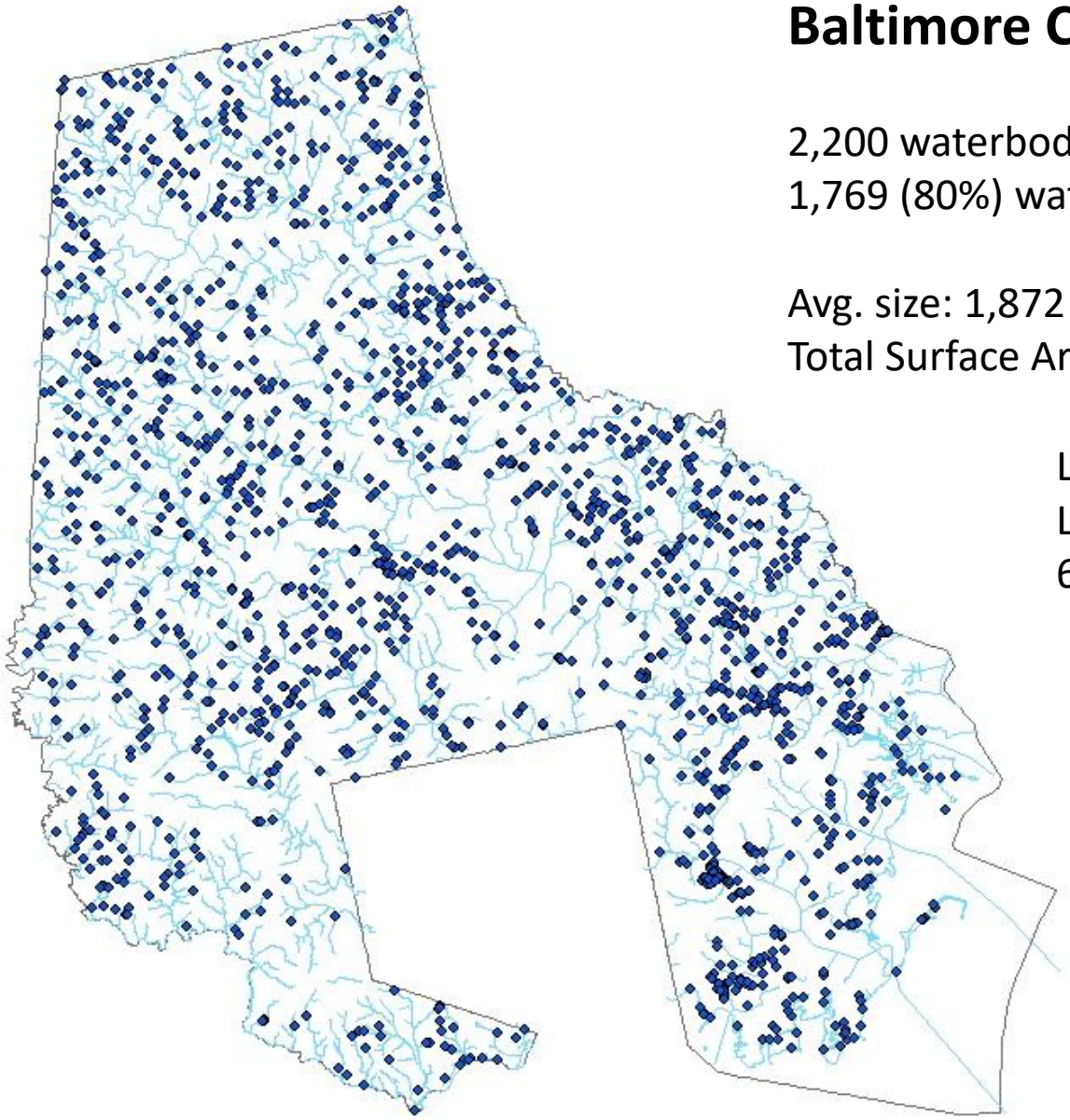
3. Forest (5)
- 3.1 Contiguous (> 1 acre)
- 3.2 Fragmented (< 1 acre)
- 3.3 Natural Succession (e.g., Fallow)
  - 3.3.1 Barren
  - 3.3.2 Herbaceous
  - 3.3.3 Scrub-shrub

4. Production (14)
- 4.1 Agriculture*
  - 4.1.1 Cropland
    - 4.1.1.1 Barren
    - 4.1.1.2 Herbaceous
  - 4.1.2 Pasture
    - 4.1.2.1 Barren
    - 4.1.2.2 Herbaceous
  - 4.1.3 Orchard/vineyard
    - 4.1.3.1 Barren
    - 4.1.3.2 Herbaceous
    - 4.1.3.3 Scrub-shrub
- 4.2 Timber Harvest
  - 4.2.1 Barren
  - 4.2.2 Herbaceous
  - 4.2.3 Scrub-shrub
- 4.3 Solar fields
- 4.4 Extractive
  - 4.4.1 Barren
  - 4.4.2 Herbaceous
  - 4.4.3 Scrub-shrub

5. Wetlands and Water Margins (25)
- 5.1 Tidal
  - 5.1.1 Open water
  - 5.1.2 Barren
  - 5.1.3 Herbaceous
  - 5.1.4 Scrub-shrub
  - 5.1.5 Contiguous Forest
  - 5.1.6 Fragmented Forest
- 5.2 Non-tidal
  - 5.2.1 Riverine (groundwater)
    - 5.2.1.1 Open water
    - 5.2.1.2 Barren
    - 5.2.1.3 Herbaceous
    - 5.2.1.4 Scrub-shrub
    - 5.2.1.5 Contiguous Forest
    - 5.2.1.6 Fragmented Forest
  - 5.2.2 Riverine (surface water)
    - 5.2.2.1 Open water
    - 5.2.2.2 Barren
    - 5.2.2.3 etc…
  - 5.2.3 Other
    - 5.2.3.1 Open water
    - 5.2.3.2 Barren
    - 5.2.3.3 etc…
- 5.3 Bare shore

USGS

Significance of Thematic Scale in Erosion Modeling



Baltimore County

2,200 waterbodies*
1,769 (80%) waterbodies less than 1 ha.

Avg. size: 1,872 m^2 (~0.5 acres)
Total Surface Area: 331 has. (818 acres)

Loch Raven and
Liberty Reservoir Area:
6,300 acres

Nationally, small ponds compose ~20% of the total surface water area.

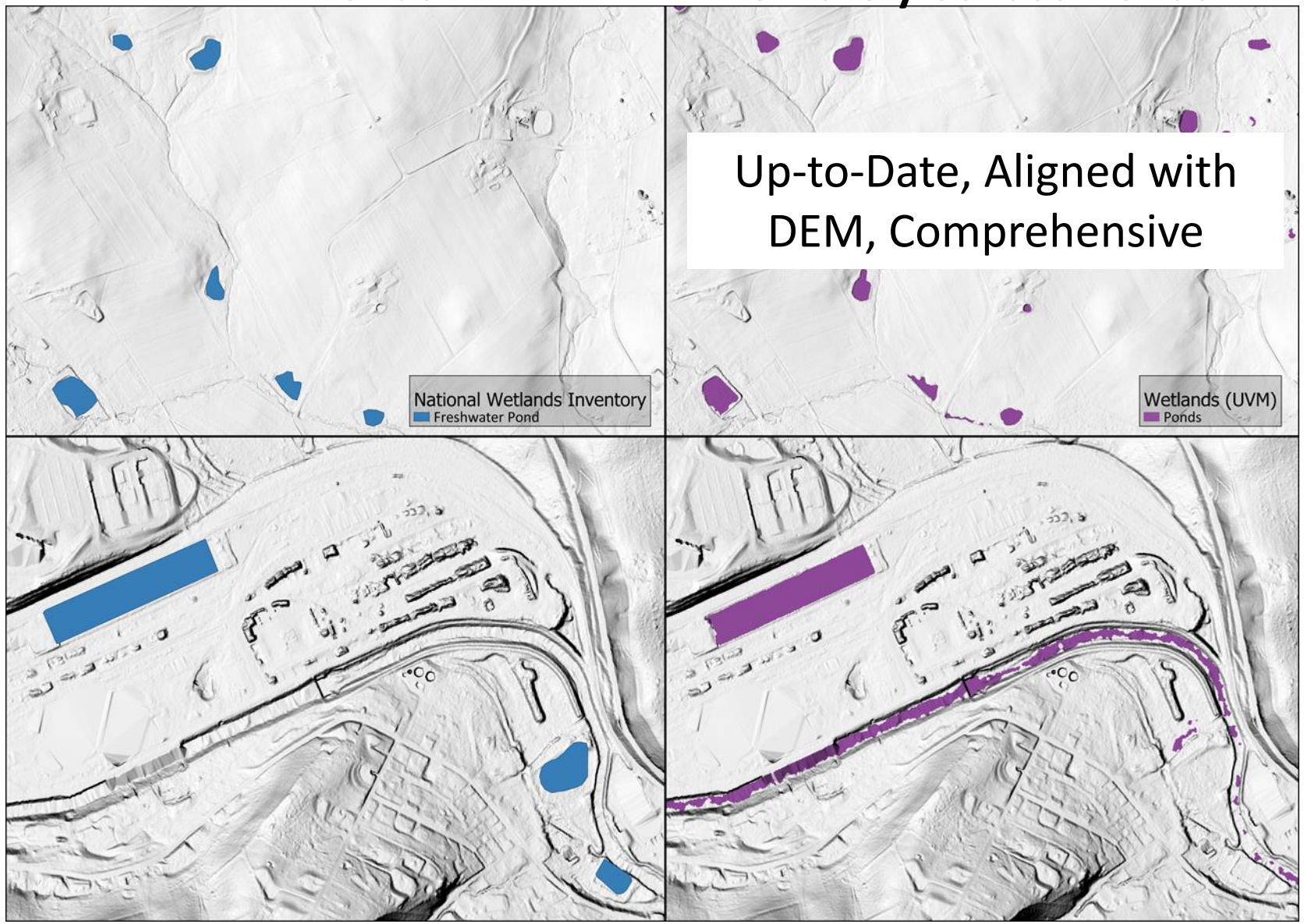
~ Smith et al., 2002

* NHD-H waterbodies and NWI lakes and ponds

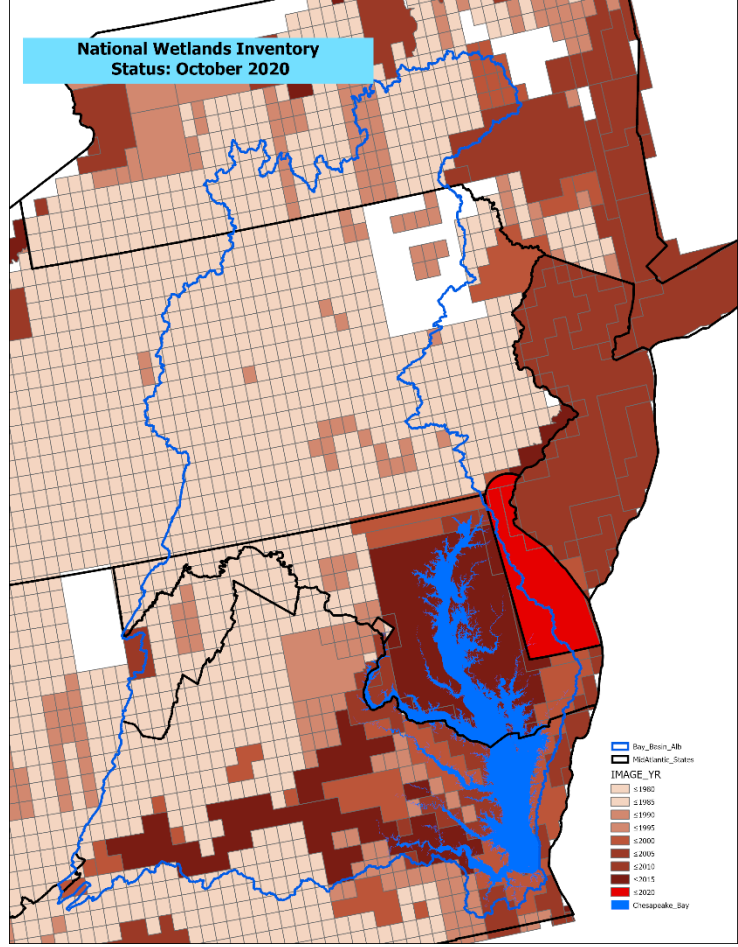
Accounting for retention in ponds…

NWI Ponds

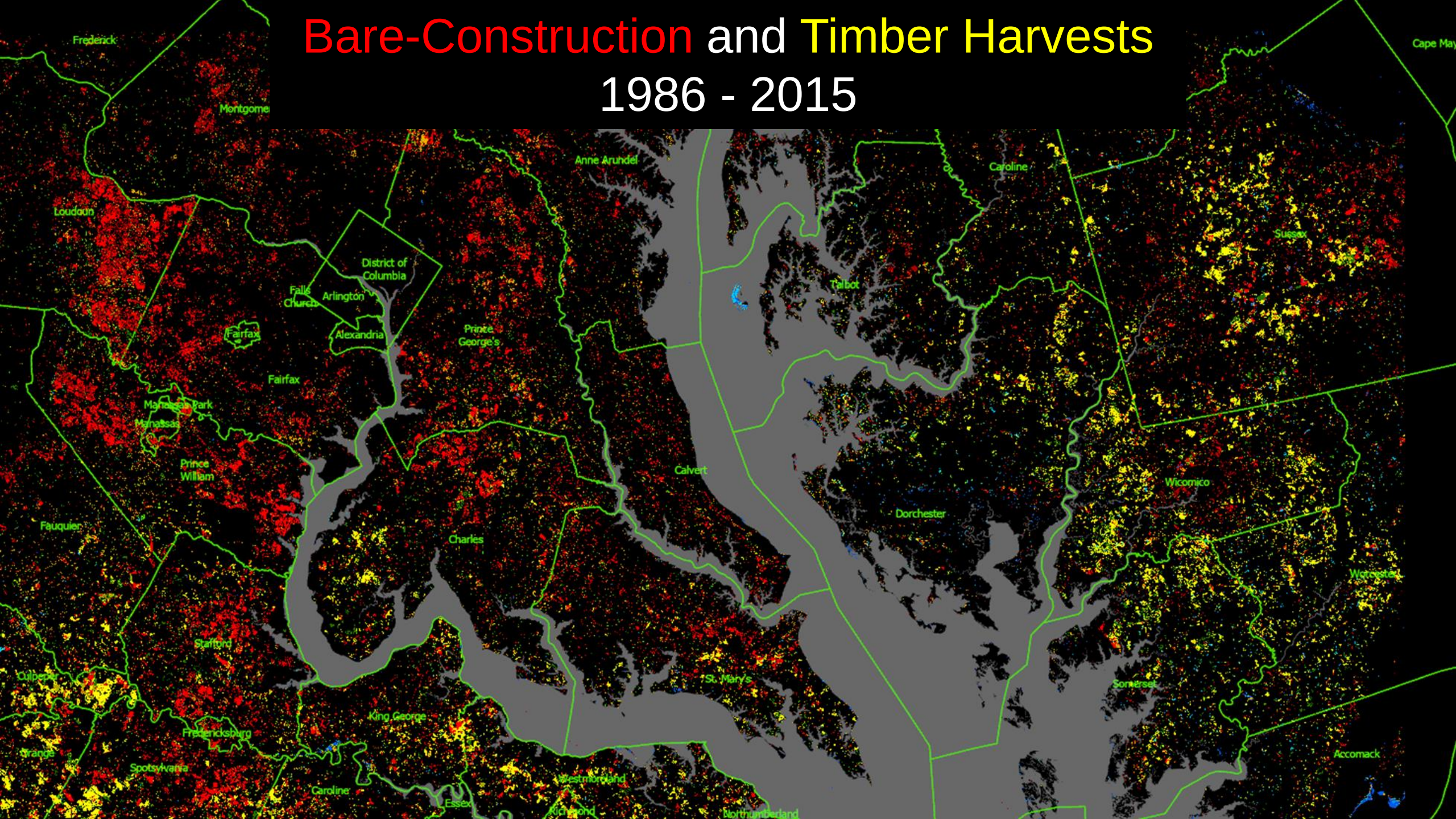
Remotely-sensed Ponds



Up-to-Date, Aligned with DEM, Comprehensive

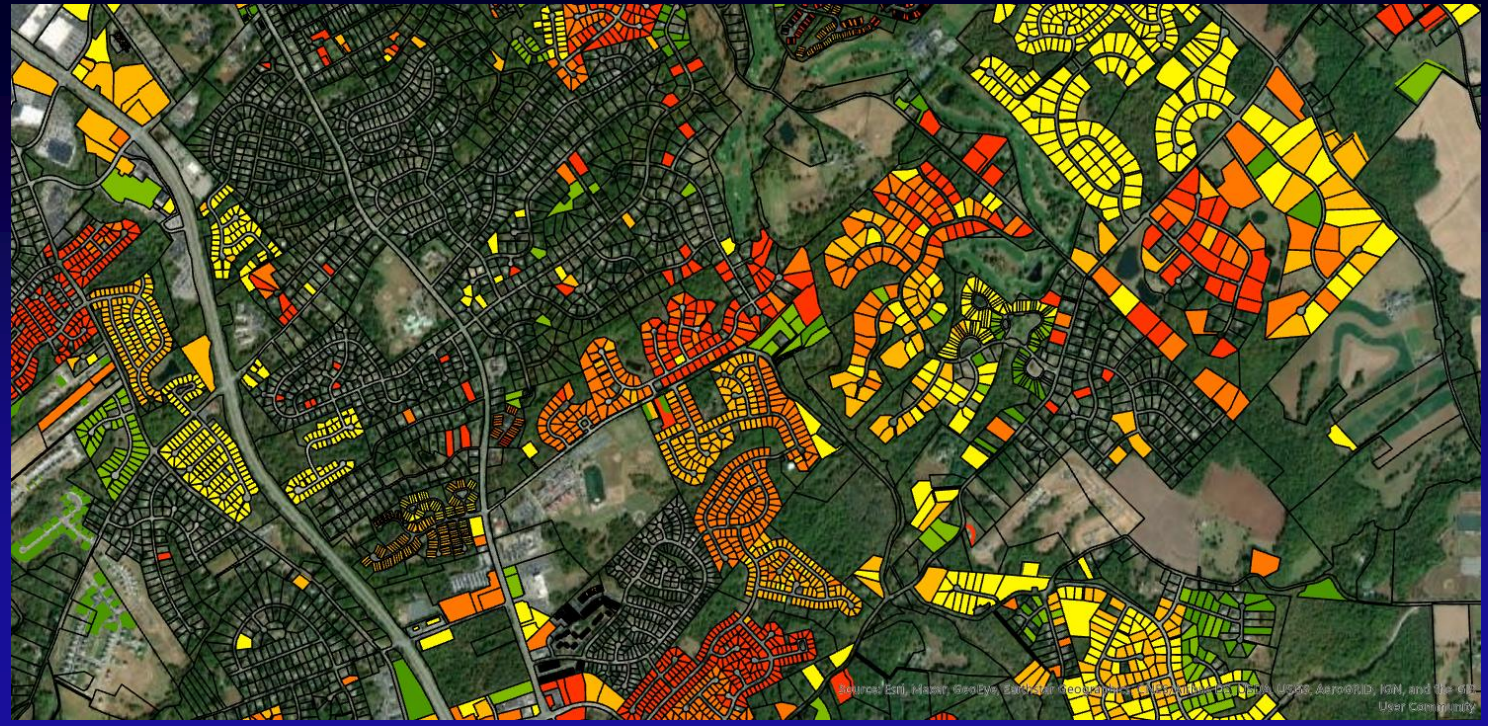


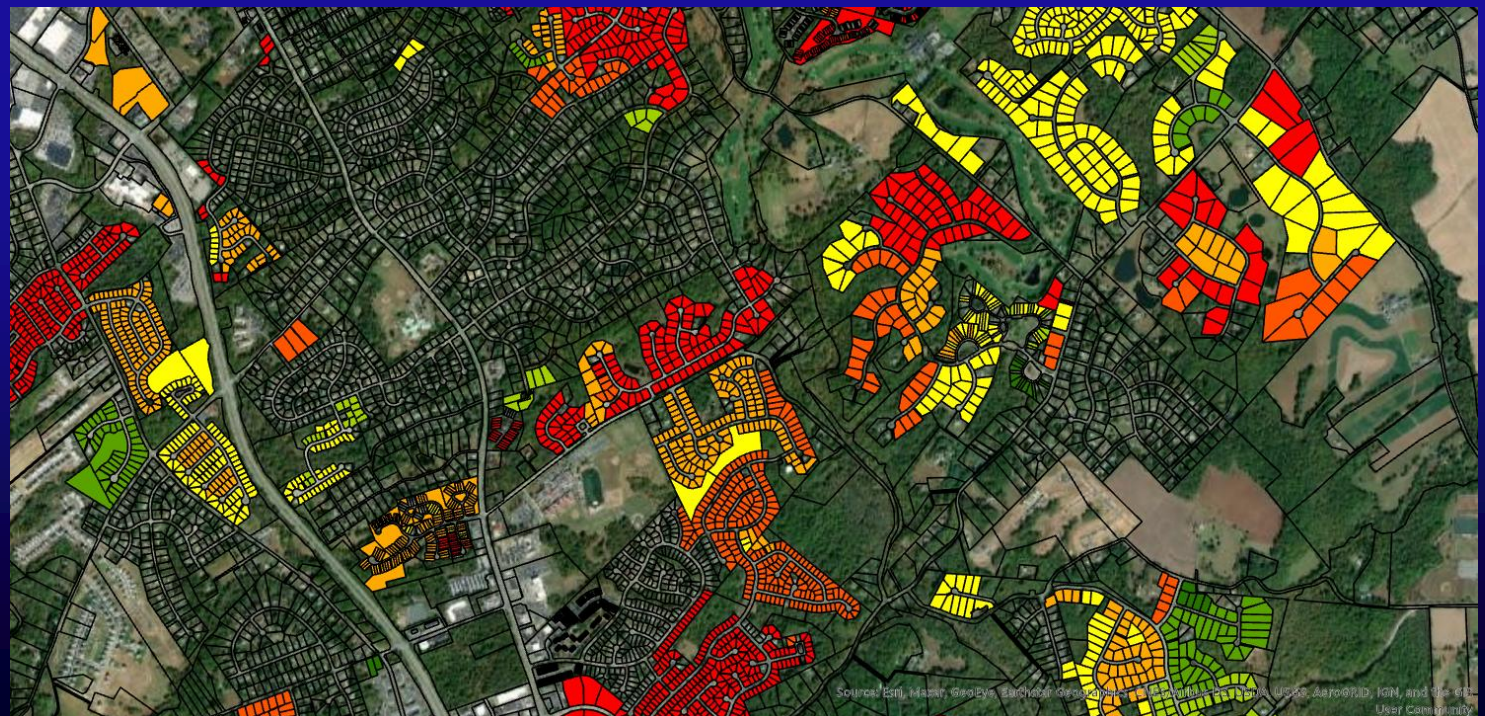
Bare-Construction and Timber Harvests
1986 - 2015



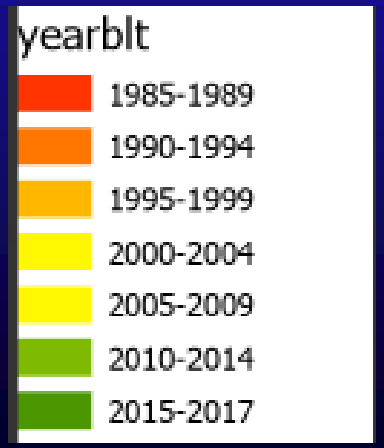
Bare-Construction: Annual Urban Development

Year-Built Attributes from Tax Records





Year-Built Attributes from USGS' LCMAP

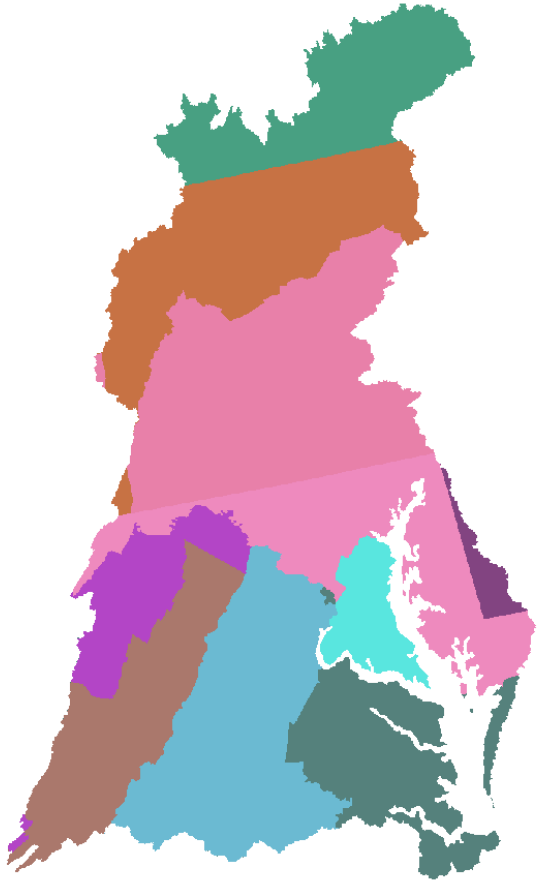


Map all Animal Feeding Operations and develop unique C-factors for them?

These areas have unique spectral properties and features.

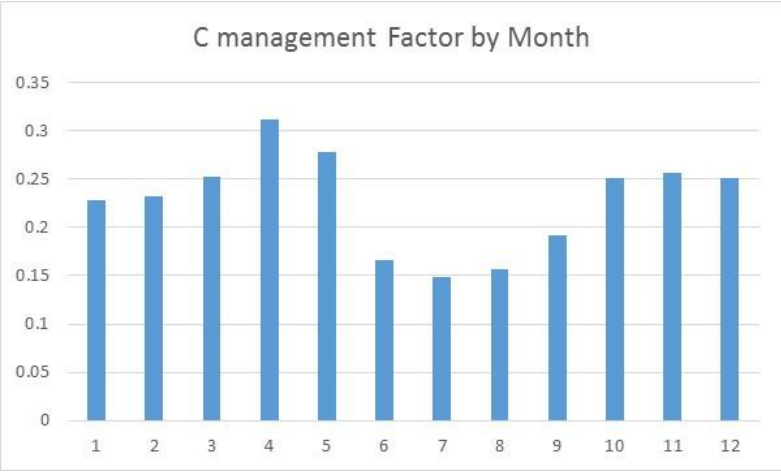
Develop parcel-scale training data and employ Artificial Intelligence to map AFO’s

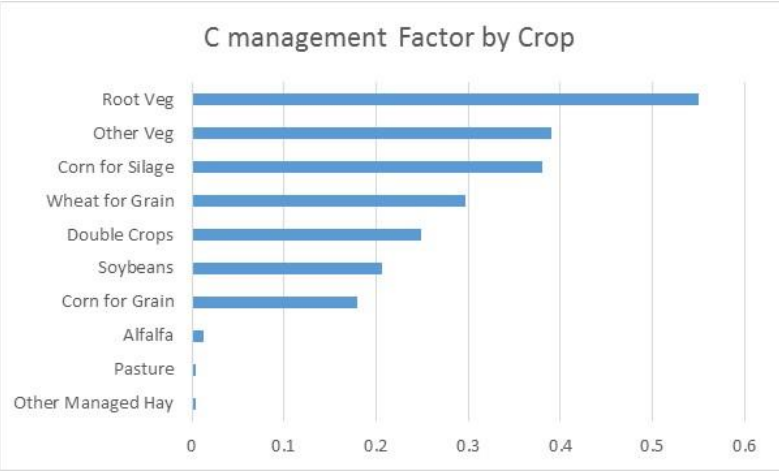
Chesapeake Bay Watershed C-factor

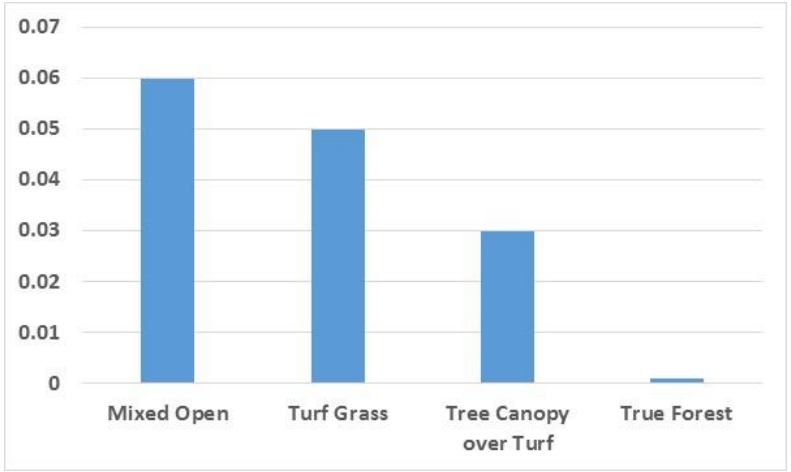


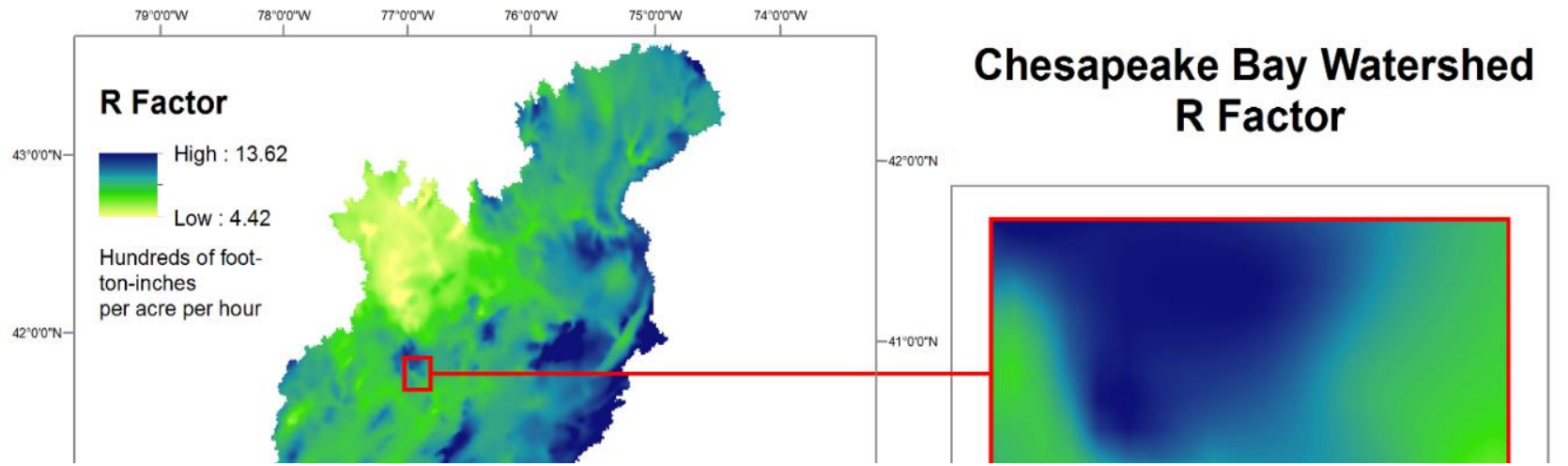
- The C management Factor represents the effect of vegetative cover on erosion rates.
- Agricultural values were challenged during a STAC review and were revised using RUSLE2
- Literature values were used for non-agricultural lands.

Refine regional spatial resolution?





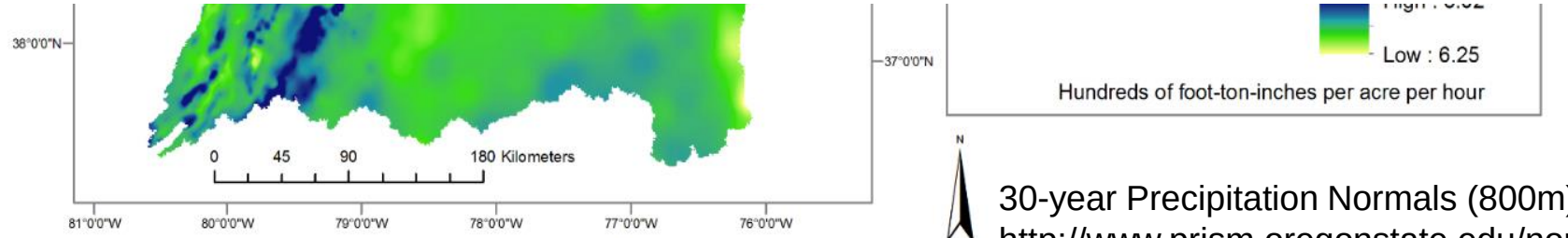




Downscale to 100 or 30-meter?

Use NLDAS point data, topography, other precipitation sources?

Refine R-factor formula, $R = 1.24p^{1.36}$, to better reflect precipitation intensity?



30-year Precipitation Normals (800m)
http://www.prism.oregonstate.edu/normals/

USGS


USGS
science for a changing world