The Flash Flood Potential Index (FFPI) for Pennsylvania.

Introduction

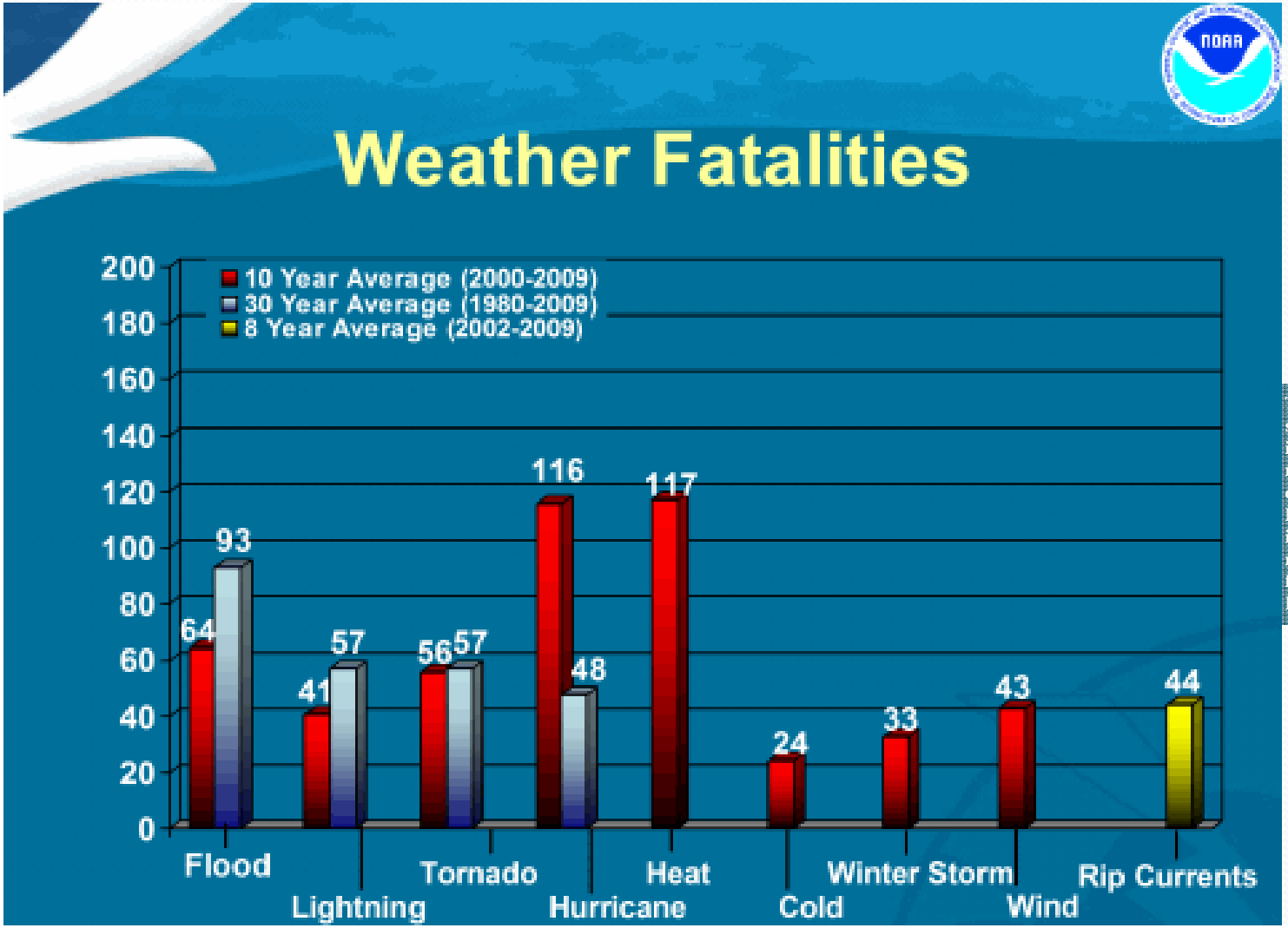
- The Flash Flood Potential Index (FFPI) incorporates physiographic characteristics of an individual drainage basin to determine its hydrologic response. In flash flood situations, the hydrologic response is influenced by many factors, including (1) soil type, (2) terrain slope, (3) vegetation and forest canopy, and (4) land use, especially urbanization.

- An FFPI is developed by obtaining maps of these characteristics as raster datasets over the domain of interest, then using GIS technology to resample, reclassify and combine the data. The result is a quasi-static numerical index of flash flood potential specific to a geographic area.

History and Impact of Flash Flooding

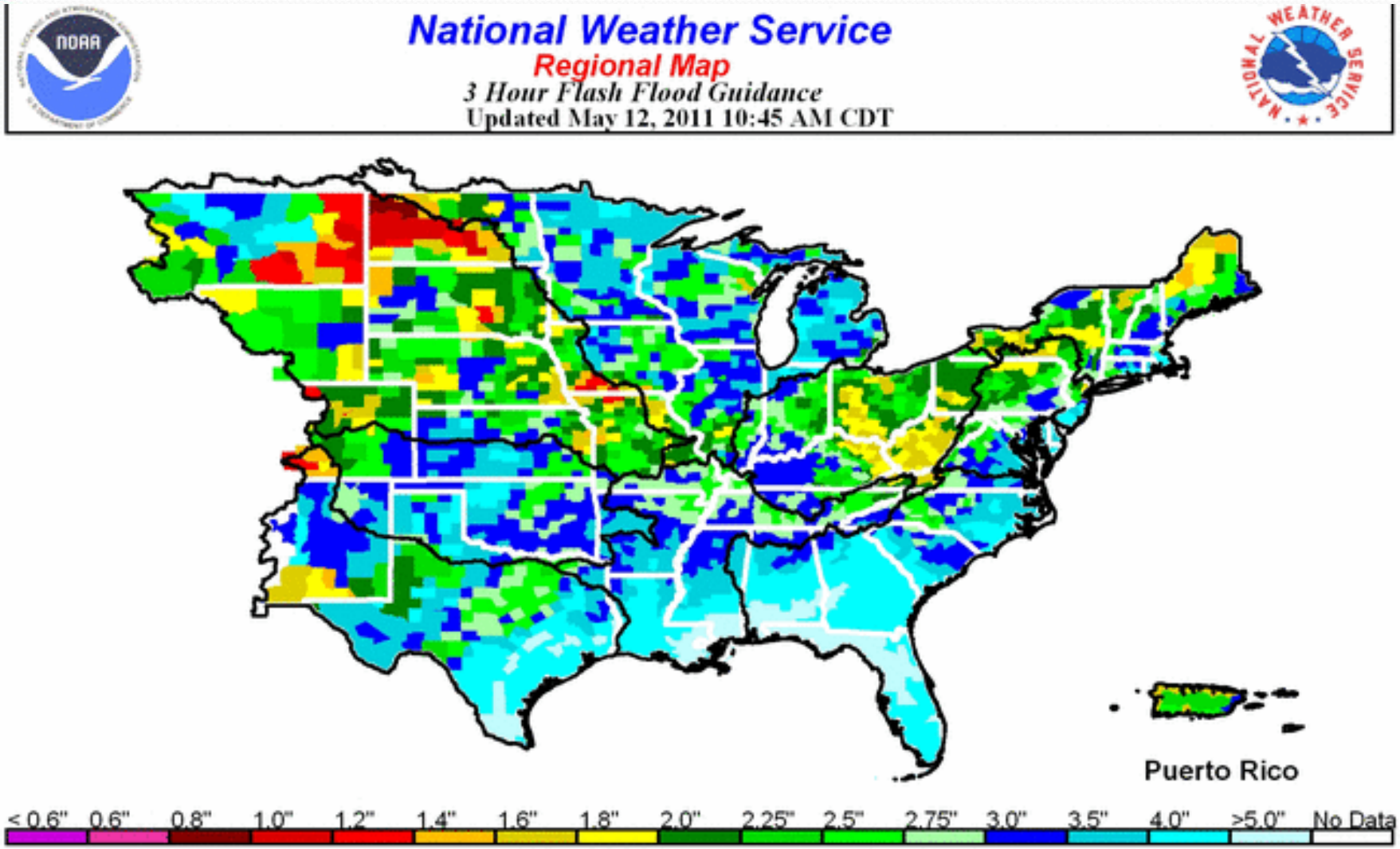
Why does the NWS care about Flash flooding?

If you look at the 10-year average, flooding is the 3rd leading cause in weather-related fatalities. In the 30-year average, it is the ***leading*** cause of weather-related fatalities.



The U.S. Natural Hazard Statistics provide statistical information on fatalities, injuries and damages caused by weather related hazards. These statistics are compiled by the Office of Services and the National Climatic Data Center from information contained in *Storm Data*, a report comprising data from NWS forecast offices in the 50 states, Puerto Rico, Guam and the Virgin Islands.

Existing NWS Flash Flood Guidance



FFG = Amount of rain necessary over a given duration to produce flash flooding. Based largely on preexisting soil moisture conditions.

Flash Flood Potential Index (FFPI)

- Developed by hydrologist Greg Smith, CBRFC (2003), as background information to be incorporated into production for better gridded Flash Flood Guidance
- Using a GIS, classified, compared and calculated to provide quantitative information about the flash flood potential inherent to a specific drainage basin.
- FFPI has been implemented at multiple NWS Eastern Region forecast offices.

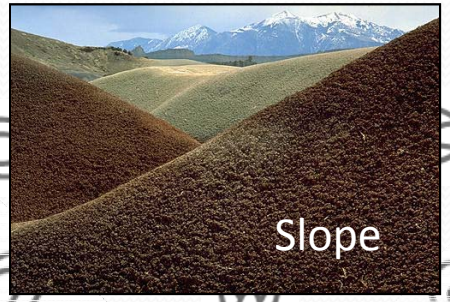
Flash Flood Potential Index (FFPI)

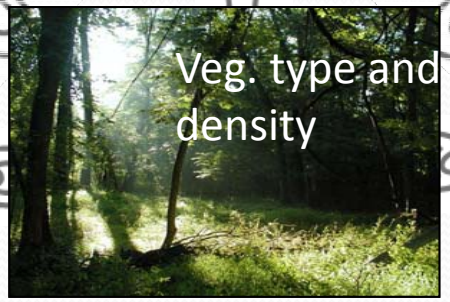
- Drainage basins are ranked (ordinal scale) with higher index values indicative of a greater hydrologic response to heavy rainfall or greater flash flood potential/threat.
- Utilize this information to:
- Identify flash flood prone areas (briefing tool)
- supplement FFMP (using the same basins as FFMP) –classify basins
- Use with areal or rule of thumb FFG to better qualify basins response
- Incorporate into alternative method for generating FFG

How does FFPI Improve Hydrologic Forecasts?

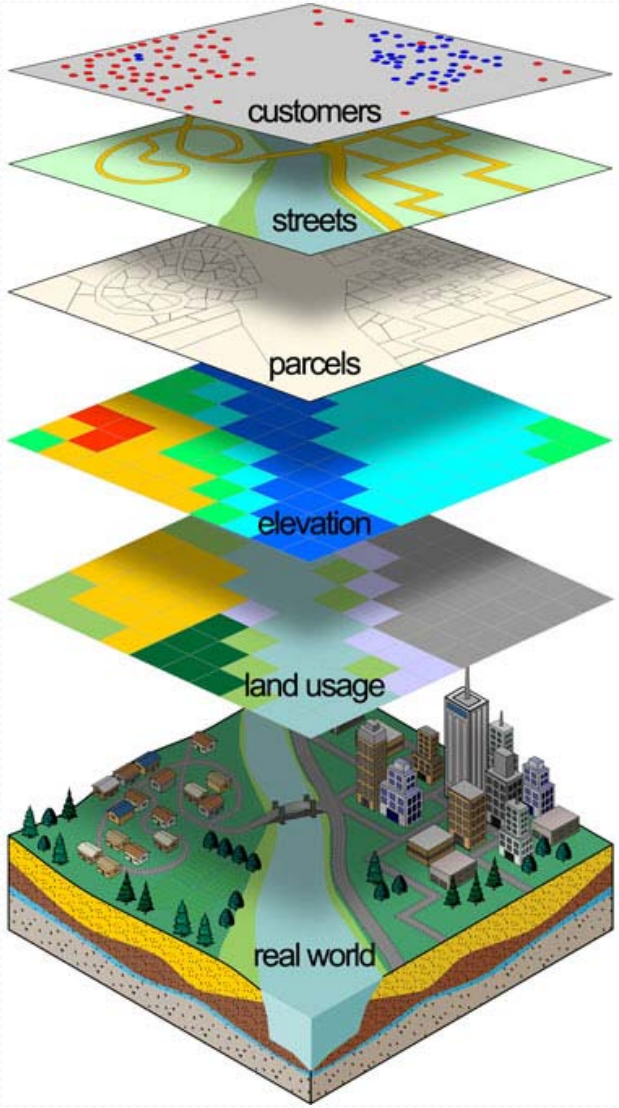
- Accounts for the impact of land use
  - Affects runoff volume and speed
- Factors in topography/slope
  - Impacts runoff speed
- Recognizes the influence of vegetation
  - Affects soil moisture and hydrologic flow
- Examines the soil-water relationship
  - Basis of many hydrologic models

Variables that affect Flooding





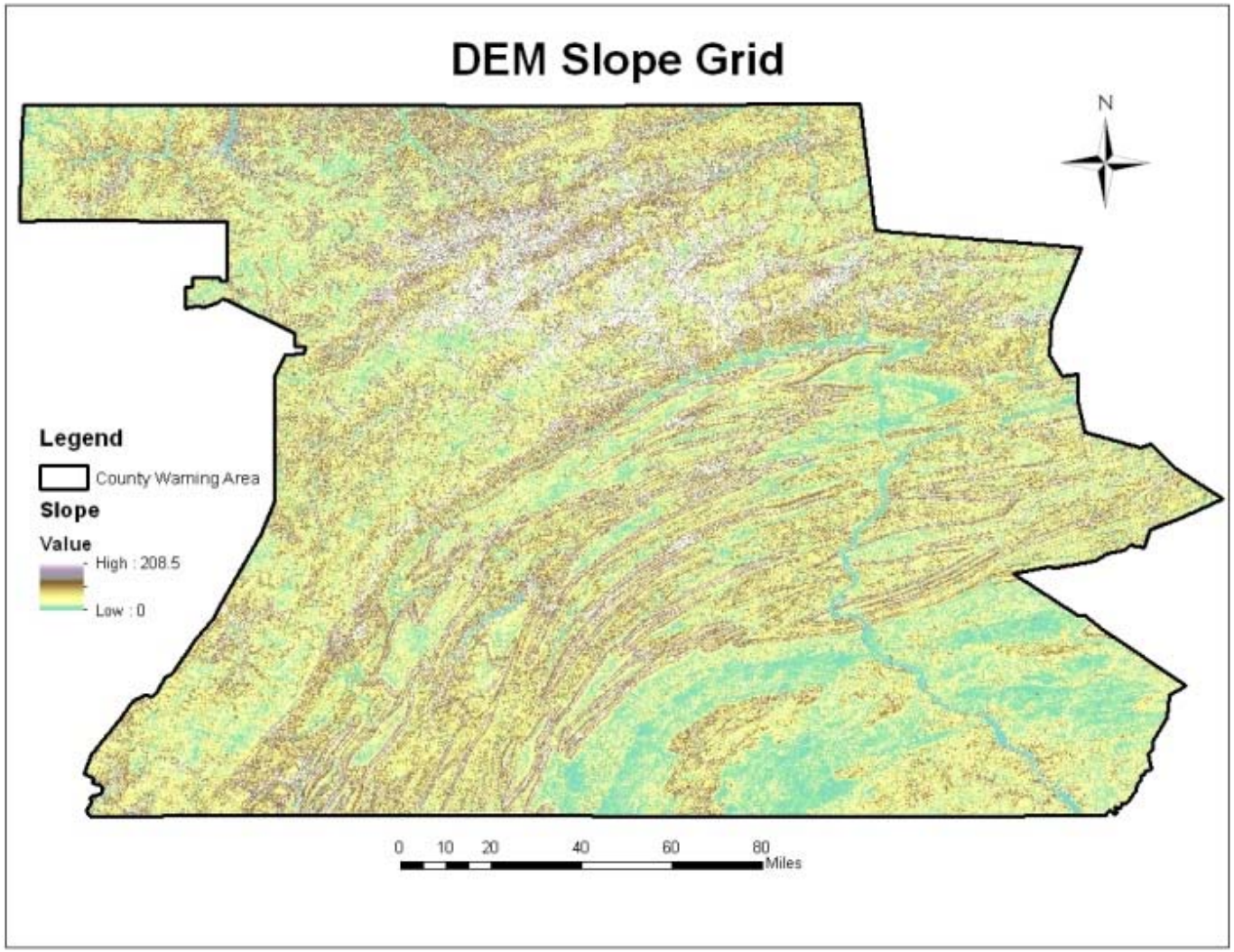
Input as Layers into a GIS



1. Slope
2. Land use / Land cover
3. Soil type / Soil texture
4. Vegetation density

= **FFPI**

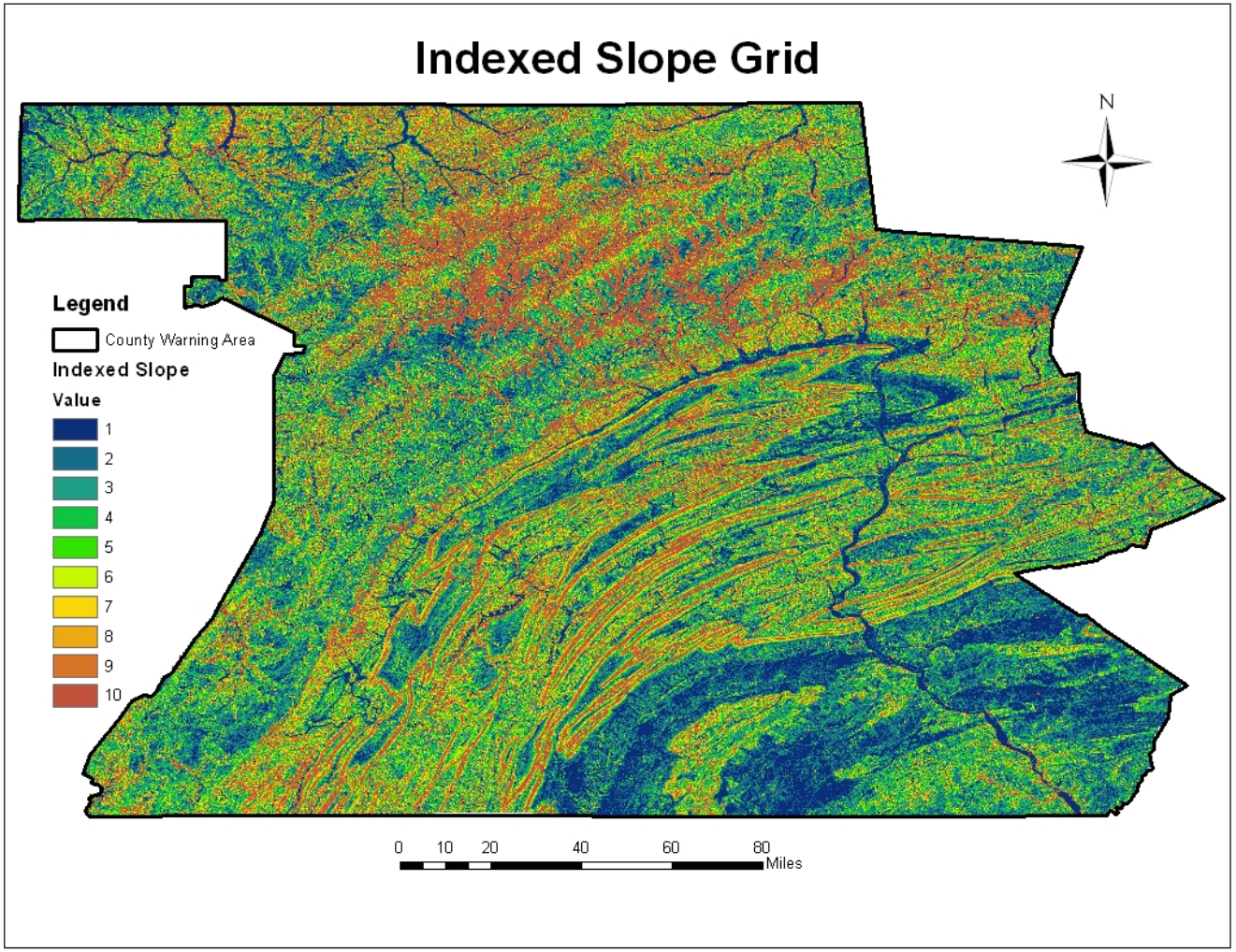
DEM Slope



Slope – Derived from the 30m Digital Elevation Model (DEM) from the USGS. Used ESRI ArcGIS to create Slope Raster, which was then reclassified.

The most important factor in flash-flooding, besides rainfall intensity, is topography.

CTP Indexed Slope



Class	FFPI Index
3%	1
6%	2
9%	3
12%	4
15%	5
18%	6
21%	7
24%	8
27%	9
30% and above	10

- 30-meter resolution DEM from USGS.
- Exponential scale where a slope of 30% or more was given an FFPI value of 10.
- A 100% slope = 45 angle.

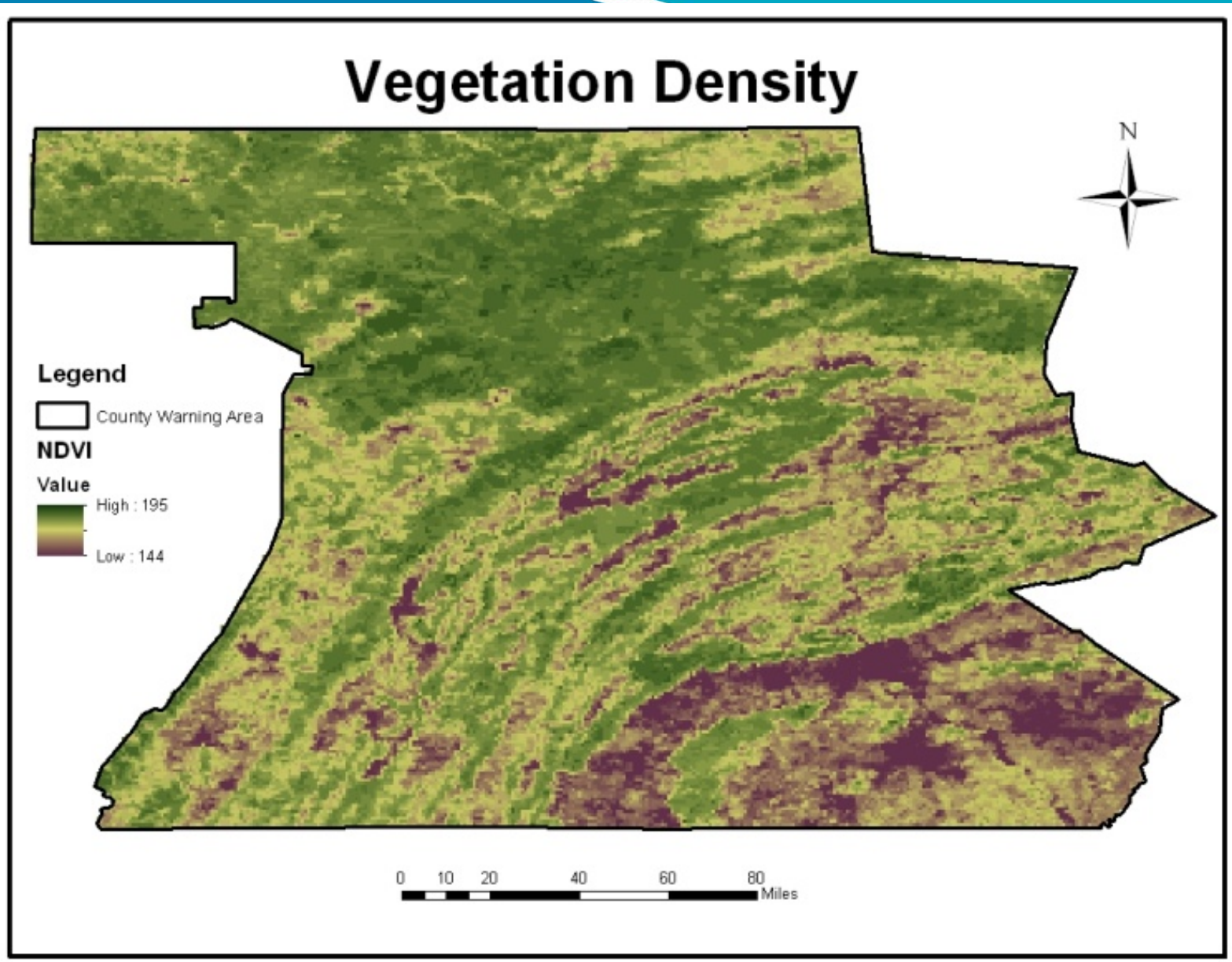
Vegetation - Runoff potential

Cornfield

Grassland

Forest

Bare

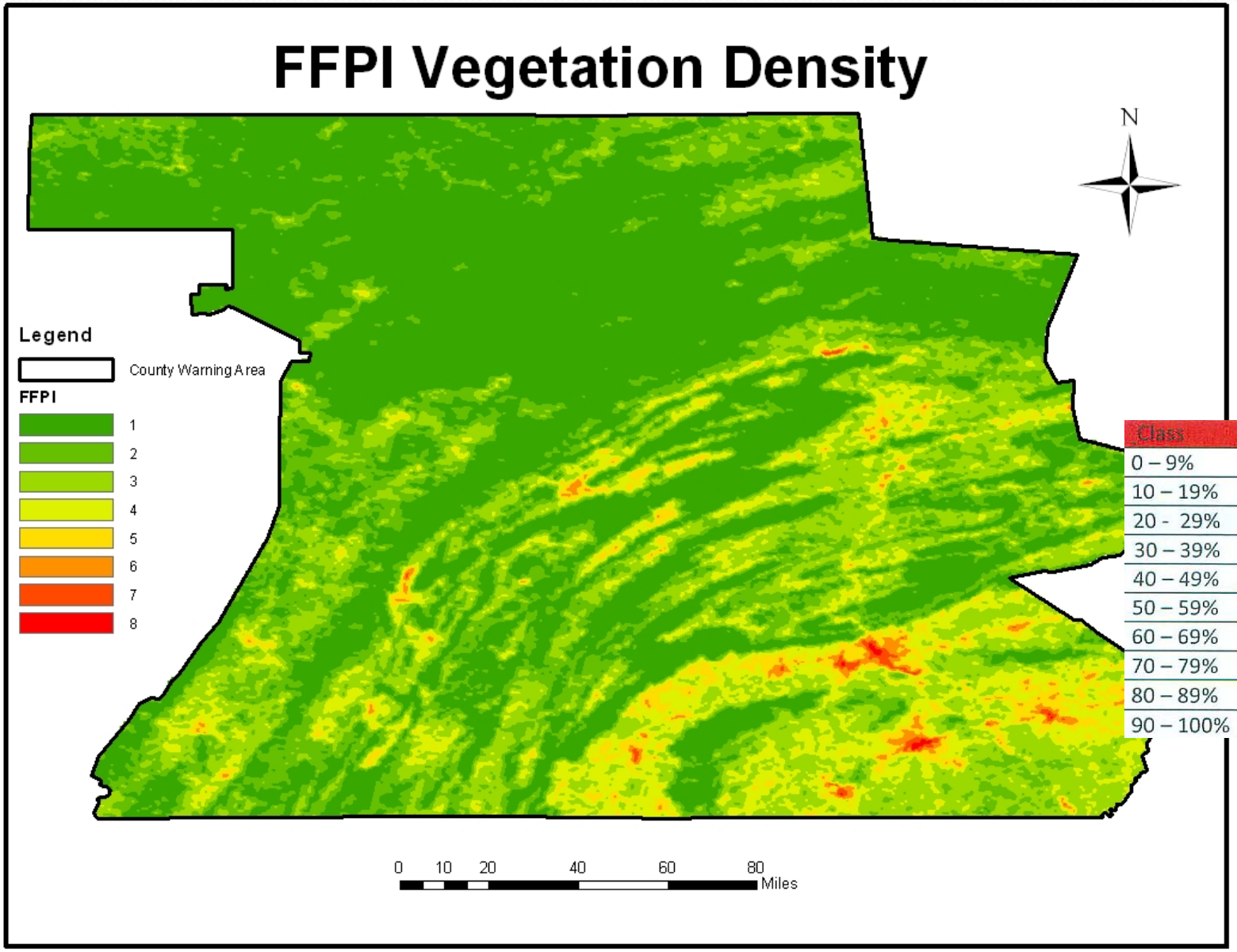


•Vegetation Density uses the Advanced Very High Resolution Radiometer (AVHRR) to provide four to six band multispectral data from the NOAA polar-orbiting satellite series.

•Used to calculate a "***greenness***" value. Used an average Vegetation Density raster to determine FFPI.

• The "***greenness***" data is produced bi-weekly throughout the year.

Indexed Vegetation Density



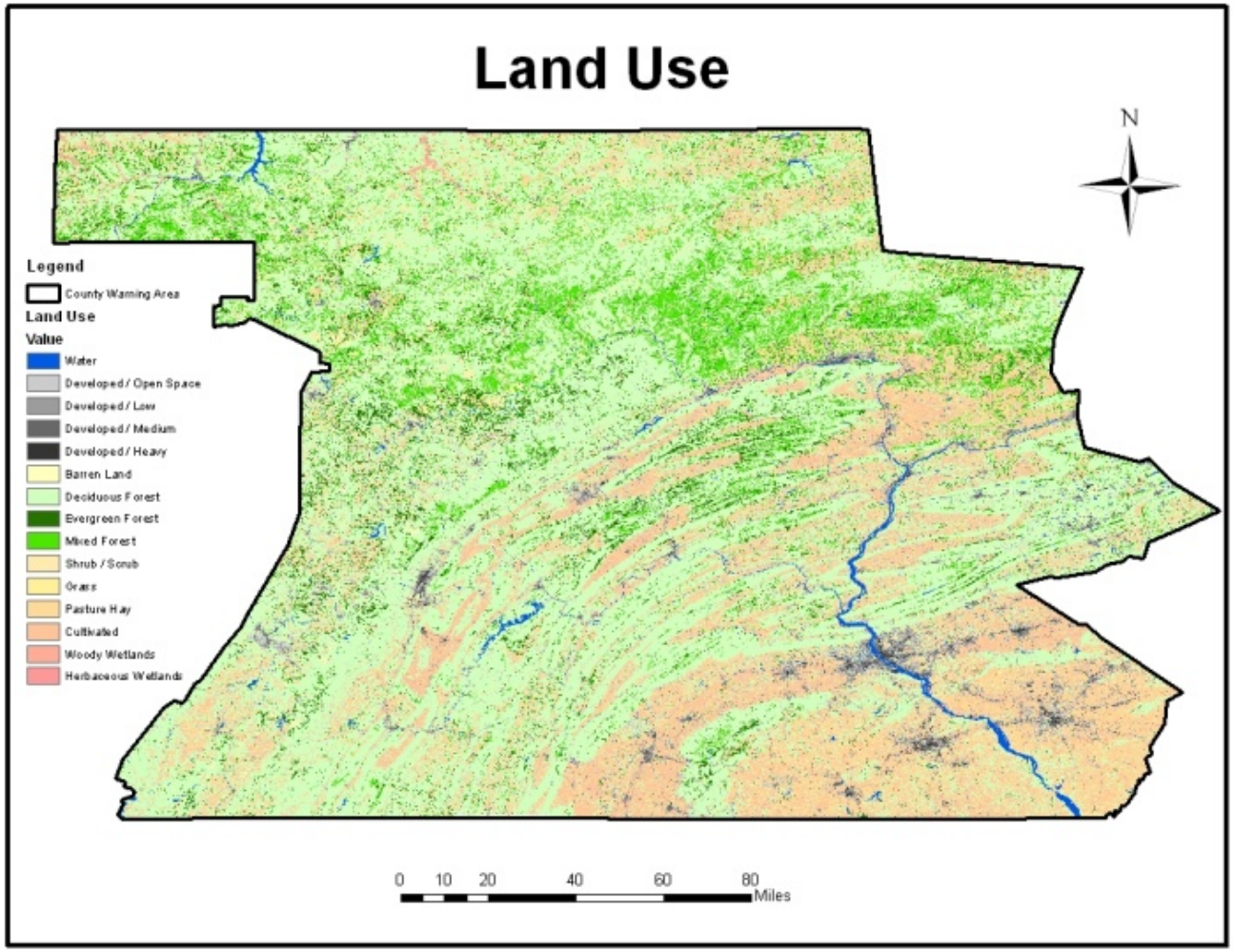
Class	FFPI Index
0 – 9%	10
10 – 19%	9
20 - 29%	8
30 – 39%	7
40 – 49%	6
50 – 59%	5
60 – 69%	4
70 – 79%	3
80 – 89%	2
90 – 100%	1

3. Urbanization

- Decrease roughness
- Decrease infiltration
- Increase stream density
- Increase slope

Channelization

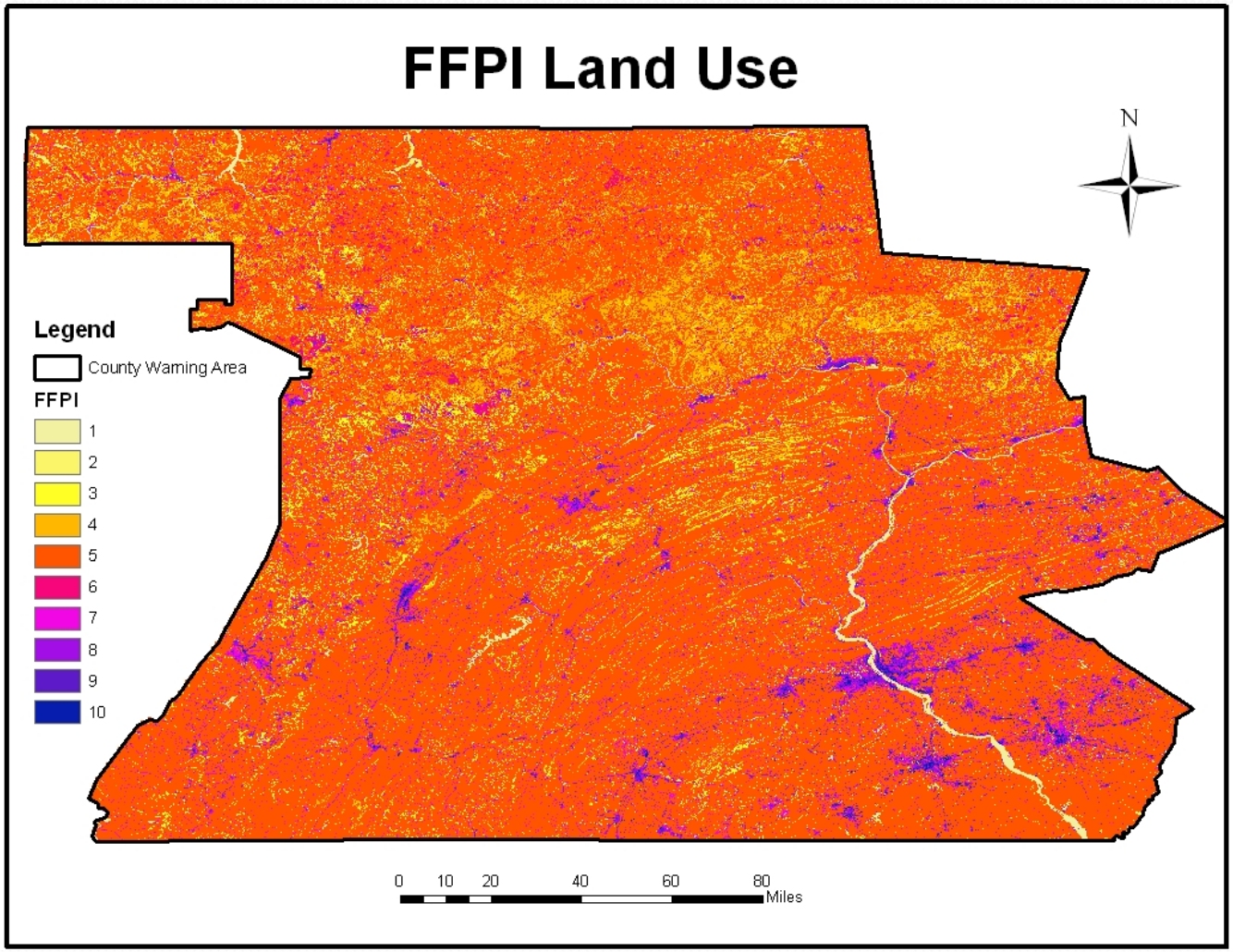
Land Use/Land Cover



Land Use/Land Cover – Multi-resolution Land Characteristics Consortium (MRLC) derived from Landsat imagery.

Of these data sets, Land Use has the second biggest influence on runoff.

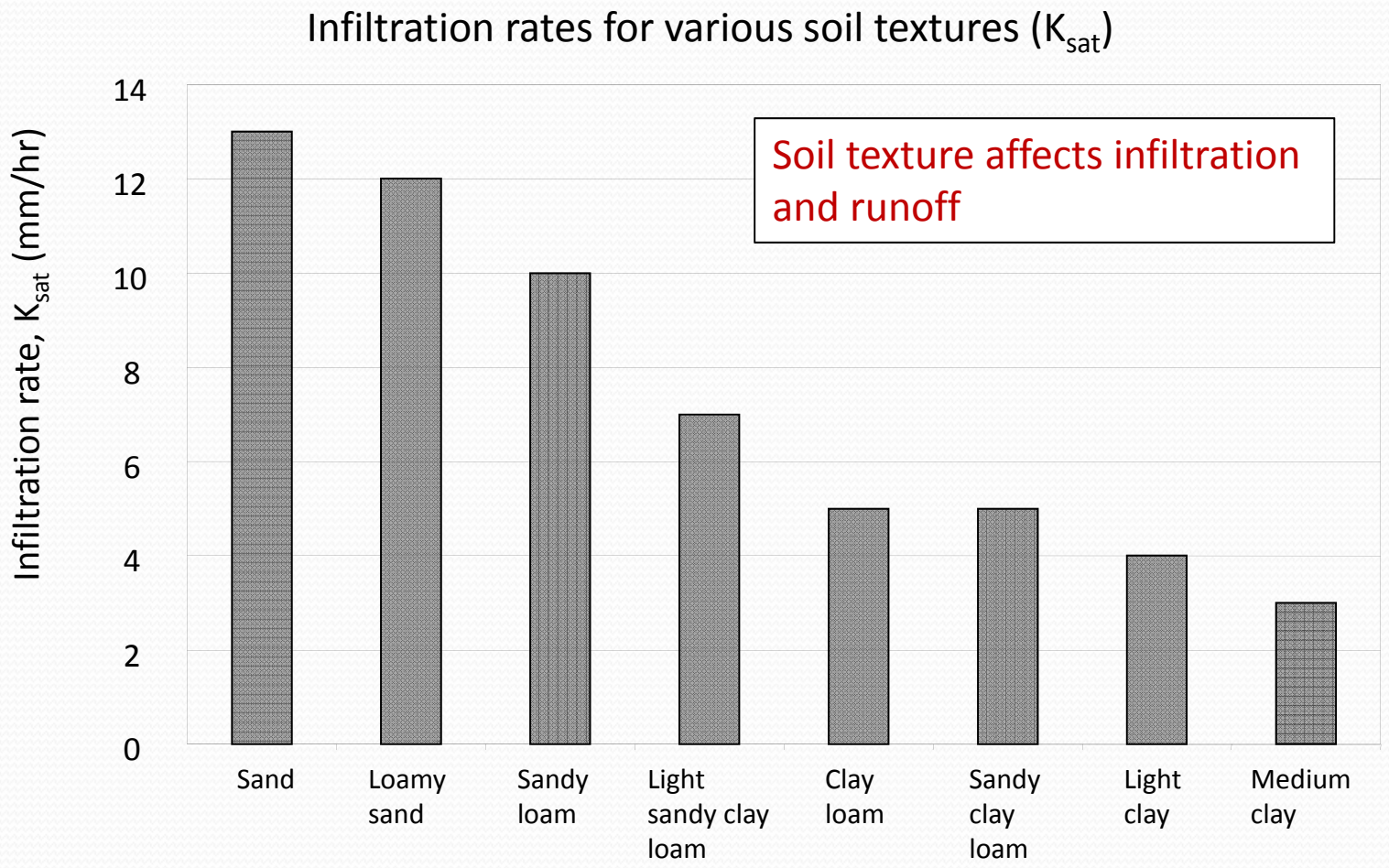
Indexed Land Use



Class	FFPI Index
11 – Water	1
21 – Developed/Open space	7
22 - Developed/Low	8
23 - Developed/Medium	9
24 – Developed/Heavy	10
31 - Barren Land	8
41 - Deciduous Forest	5
42 - Evergreen Forest	3
43 - Mixed Forest	4
52 - Shrub/Scrub	6
71 - Grass	6
81 - Pasture Hay	5
82 - Cultivated	5
90 - Woody Wetlands	2
95 - Herbaceous Wetlands	2

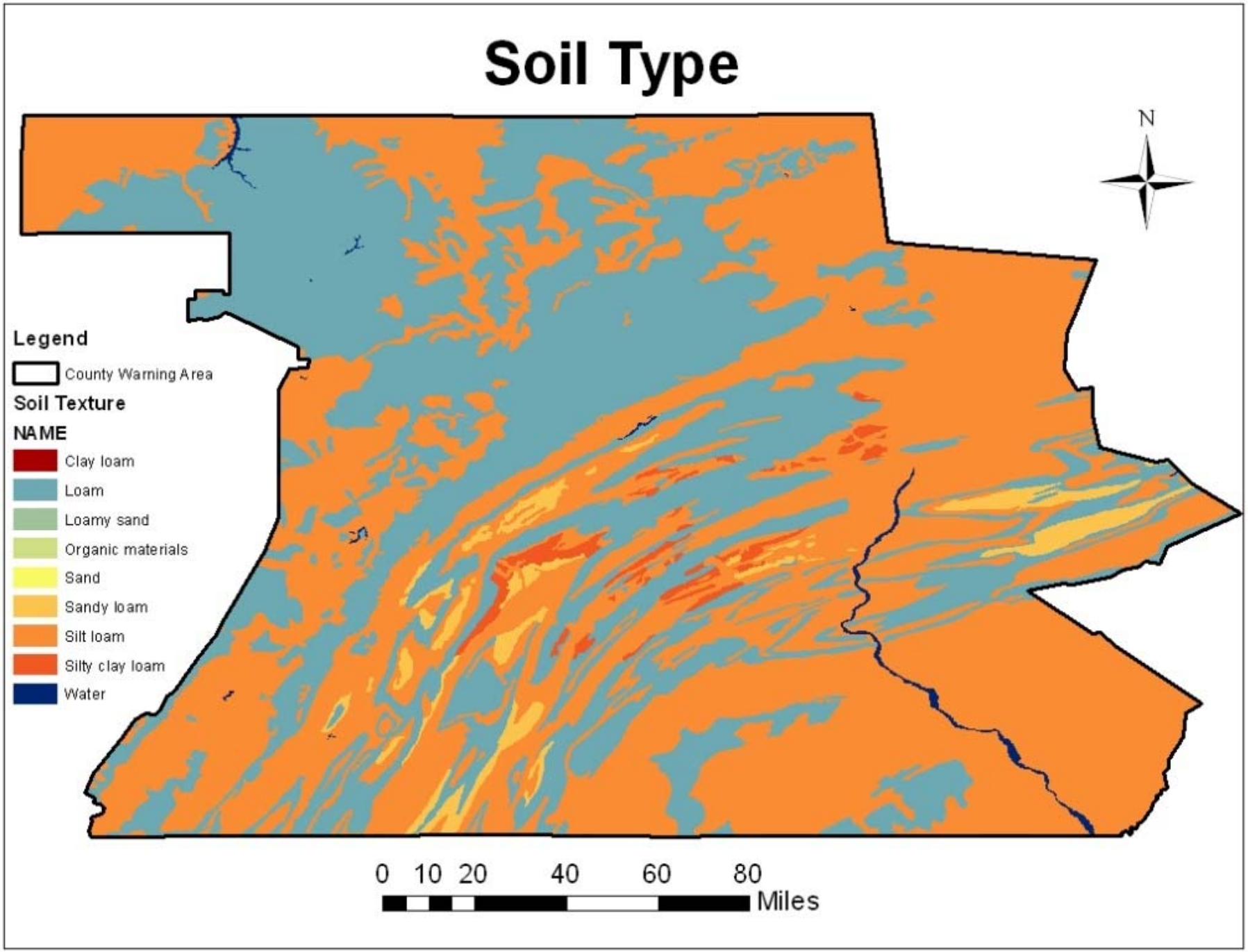
- Fifteen classes were indexed:
  - Water was given a 1 on the FFPI
  - Wetlands a 2
  - Cultivated and Pasture land a 5
  - Dense Urban Development a 10

4. Soils - Infiltration Rates

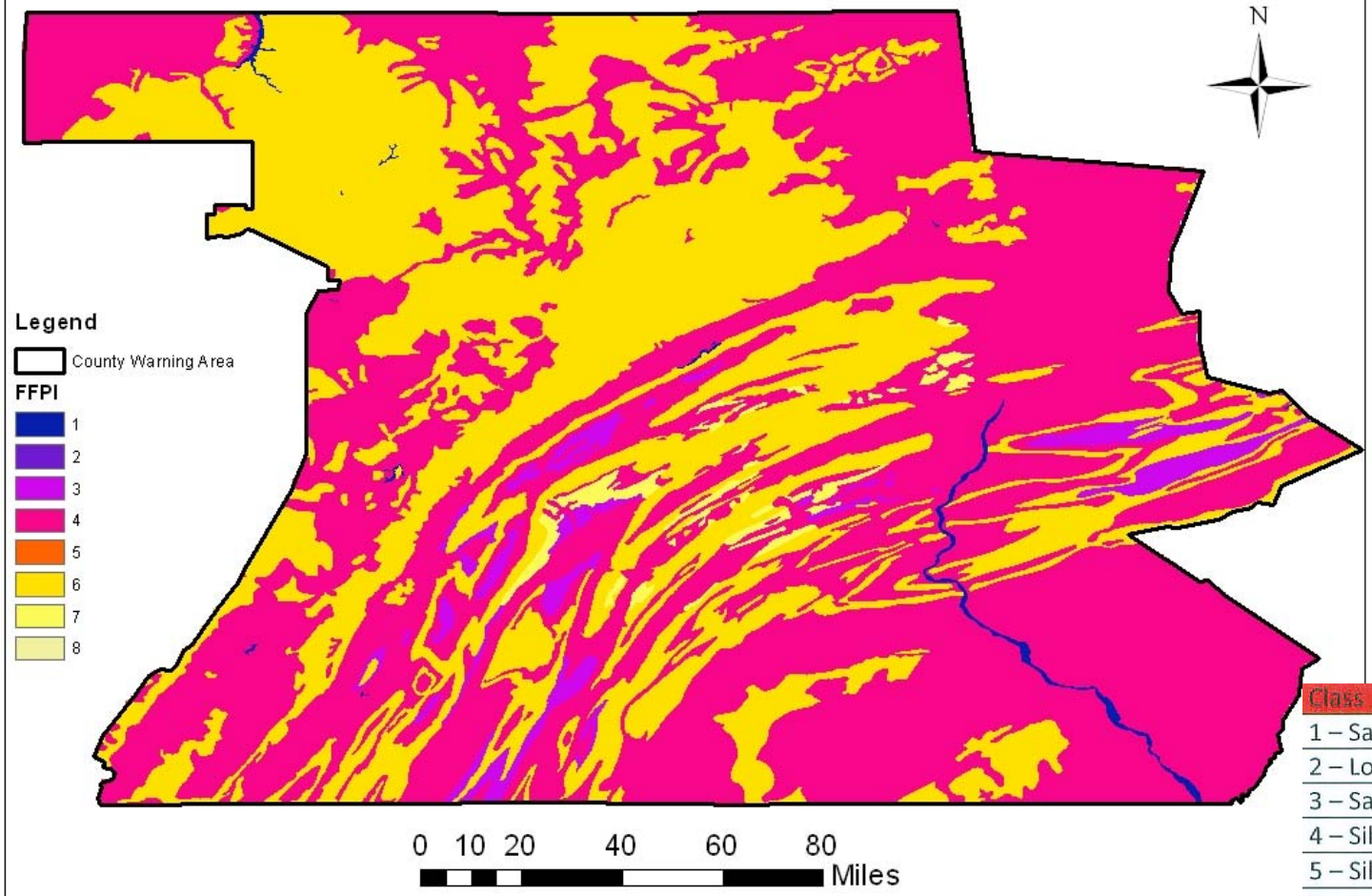


Source: Brady, N. 1974. The Nature and Properties of Soils, 8th ed., MacMillan Pub. Co.

Soil Type


N
Legend
County Warning Area
Soil Texture
NAME
Clay loam
Loam
Loamy sand
Organic materials
Sand
Sandy loam
Silt loam
Silty clay loam
Water
0 10 20 40 60 80
Miles

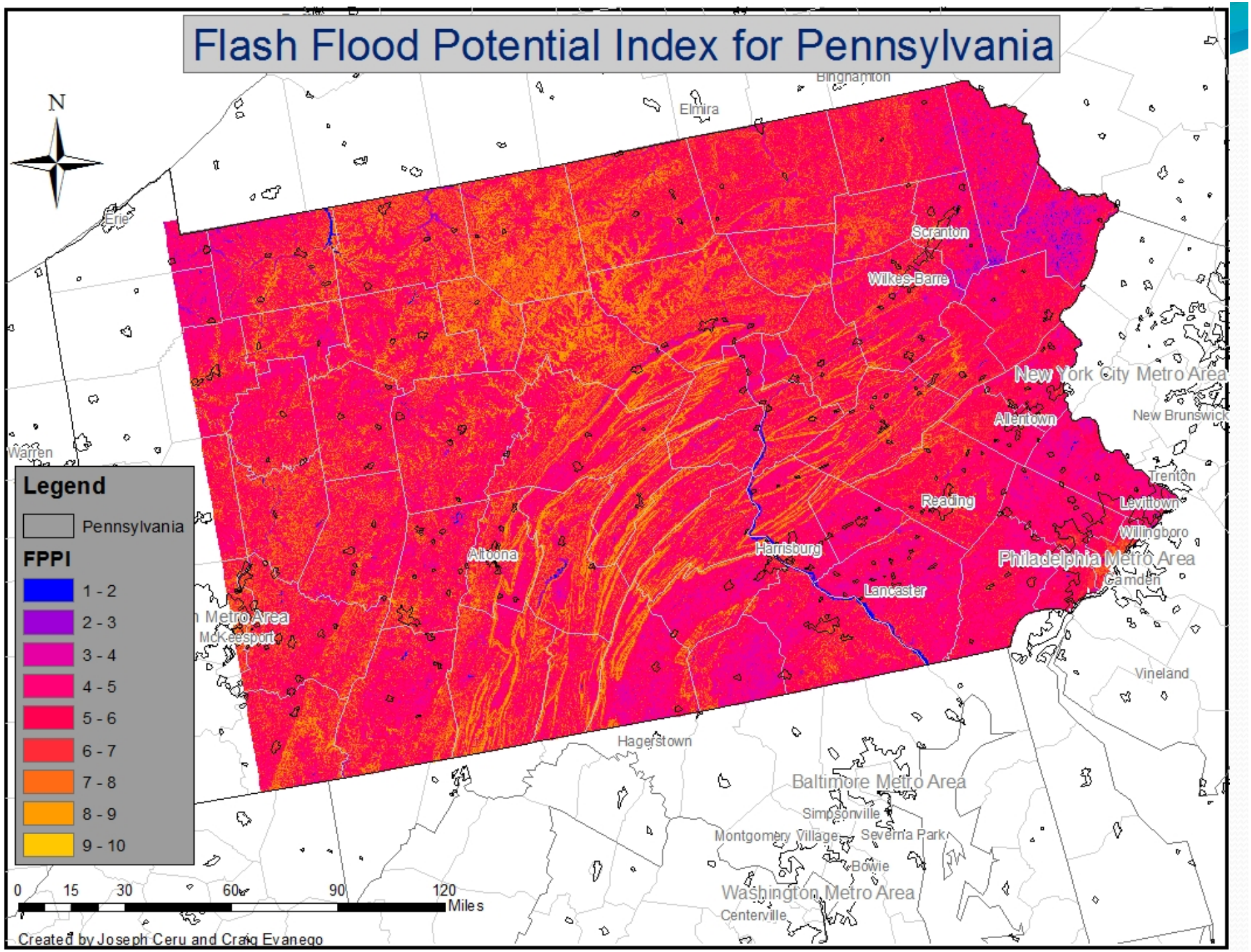
FFPI Soils



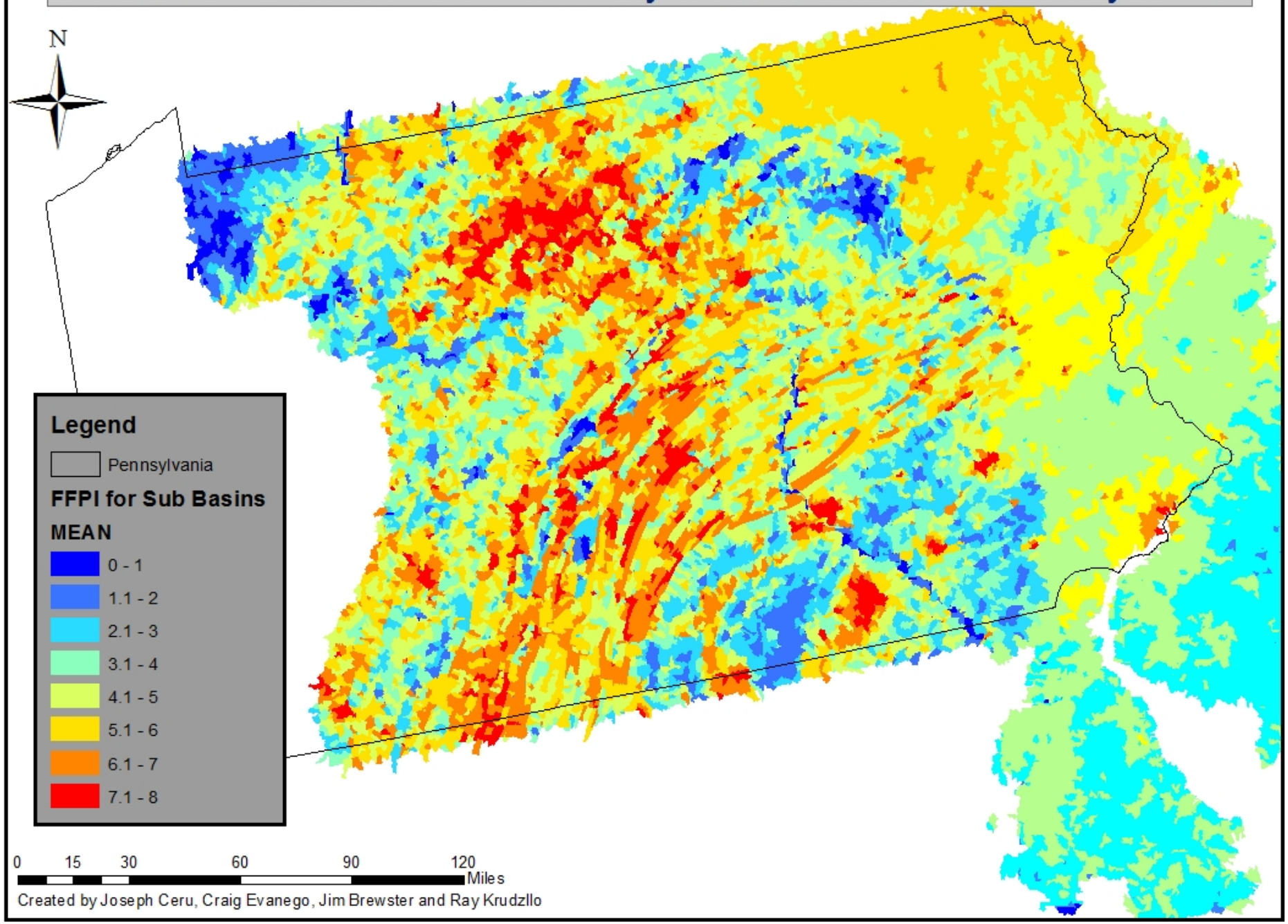
Class	FFPI Index
1 – Sand	2
2 – Loamy Sand	4
3 – Sandy Loam	3
4 – Silty Loam	4
5 – Silt	5 (4)
6 – Loam	6
7 – Sandy Clay Loam	7
8 – Silty Clay Loam	7
9 – Clay Loam	8
10 – Sandy Clay	8
11 – Silty Clay	8
12 – Clay	9
13 – Organic Matter	5
14 – Water	1
15 – Bedrock/Impervious	10

Computing methods

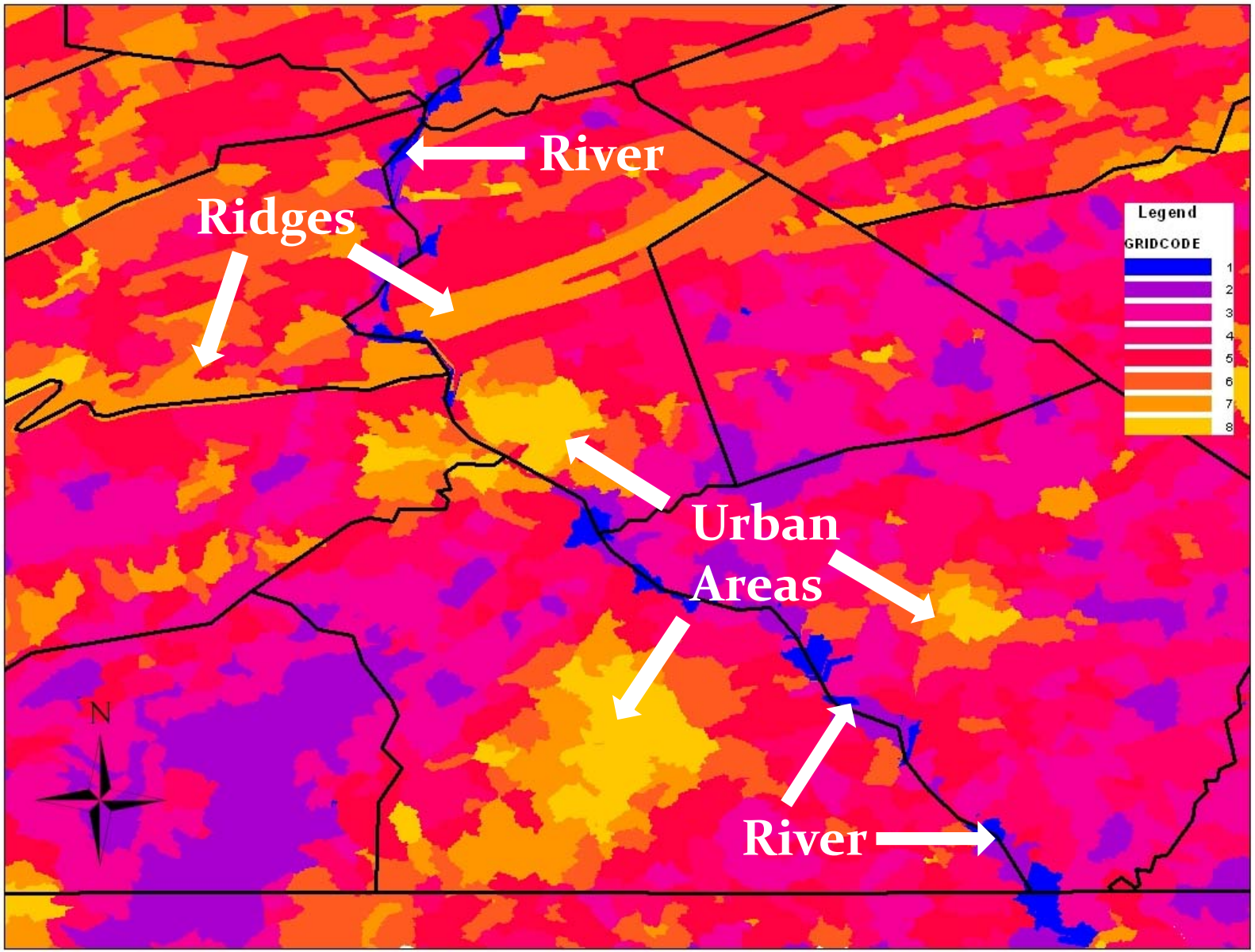
- When computing the FFPI, it is important to note that you can weight any individual layer depending on its importance.
- Based on precedence from previous runs of FFPI at other offices, and consulting hydrologists at the MARFC, we were guided to place more weight on Land Use/Land cover and slope.
- We also looked at which computing method was best. When converting from a Raster to a shapefile by basin we created a mean, median and mode and it was determined the mean gave the greatest representation of preceding knowledge.


Flash Flood Potential Index for Pennsylvania
N
Legend
Pennsylvania
FPPI
1 - 2
2 - 3
3 - 4
4 - 5
5 - 6
6 - 7
7 - 8
8 - 9
9 - 10
0 15 30 60 90 120
Miles
Created by Joseph Ceru and Craig Evanego
Binghamton
Elmira
Erie
Scranton
Wilkes-Barre
New York City Metro Area
New Brunswick
Allentown
Warren
Trenton
Reading
Levittown
Willingboro
Harrisburg
Philadelphia Metro Area
Camden
Altoona
Lancaster
McKeesport
Vineland
Hagerstown
Baltimore Metro Area
Simpsonville
Montgomery Village
Severna Park
Bowie
Washington Metro Area
Centerville

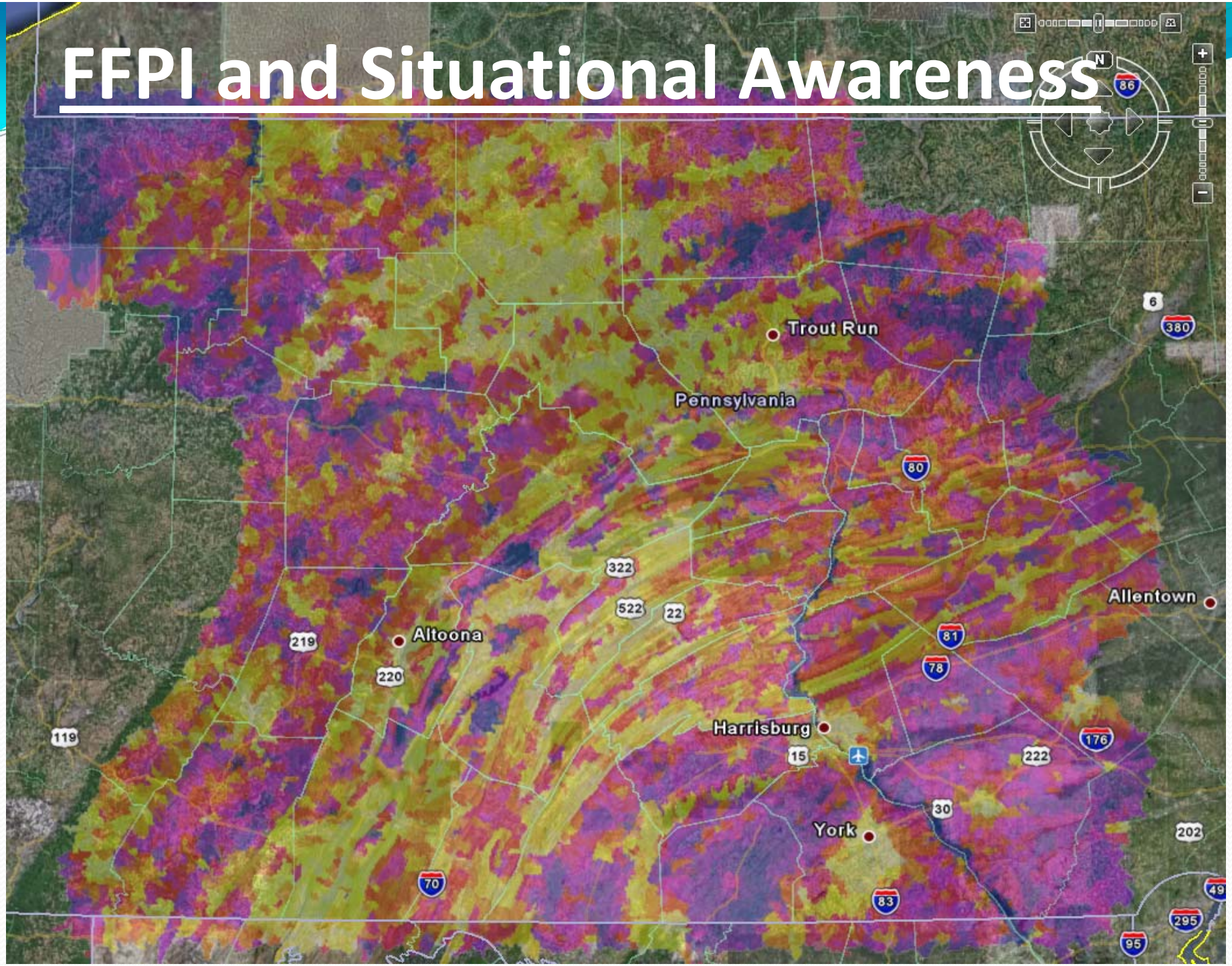
Flash Flood Potential Index by sub basins for Pennsylvania



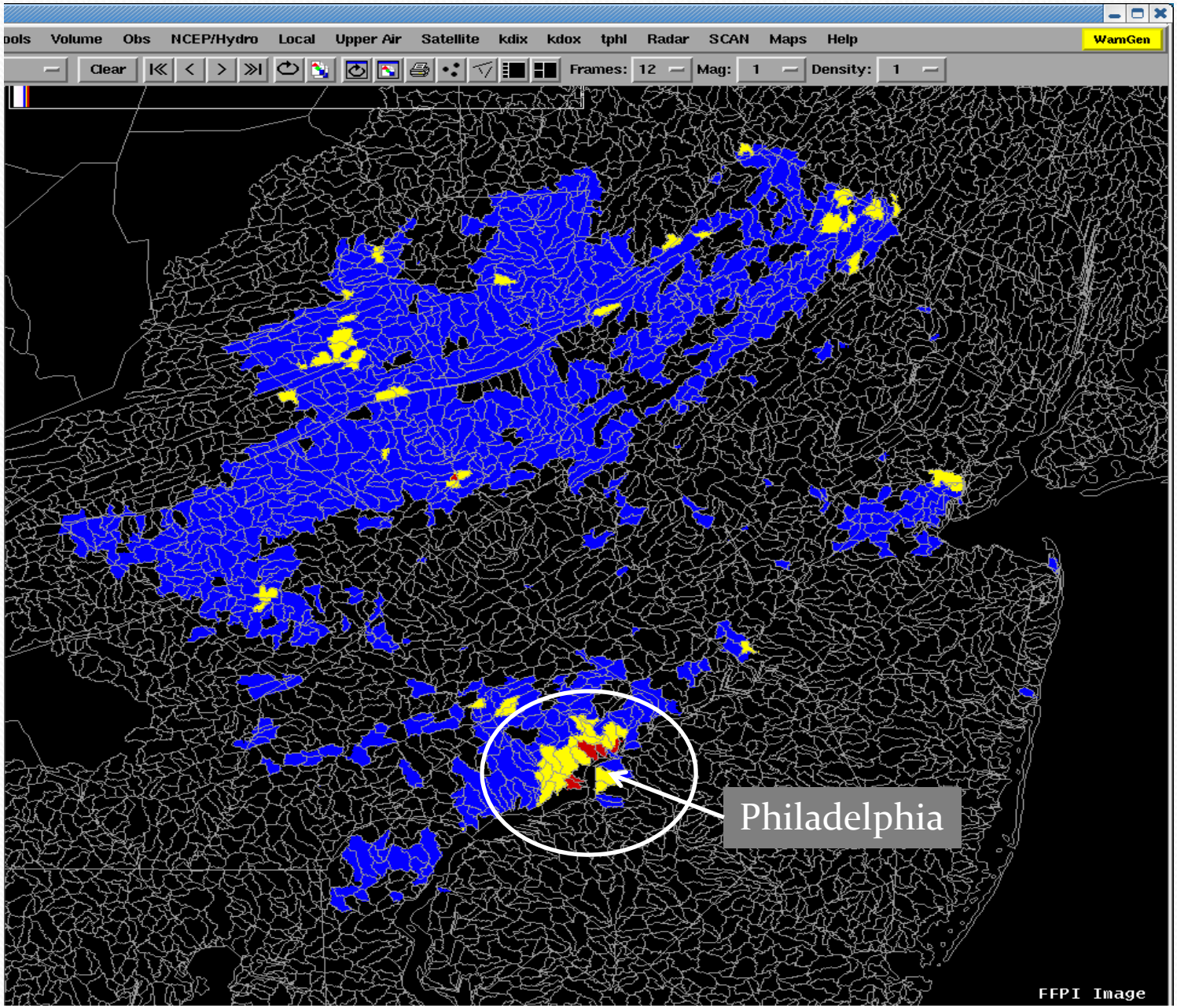
FFPI for Lower Susquehanna Valley



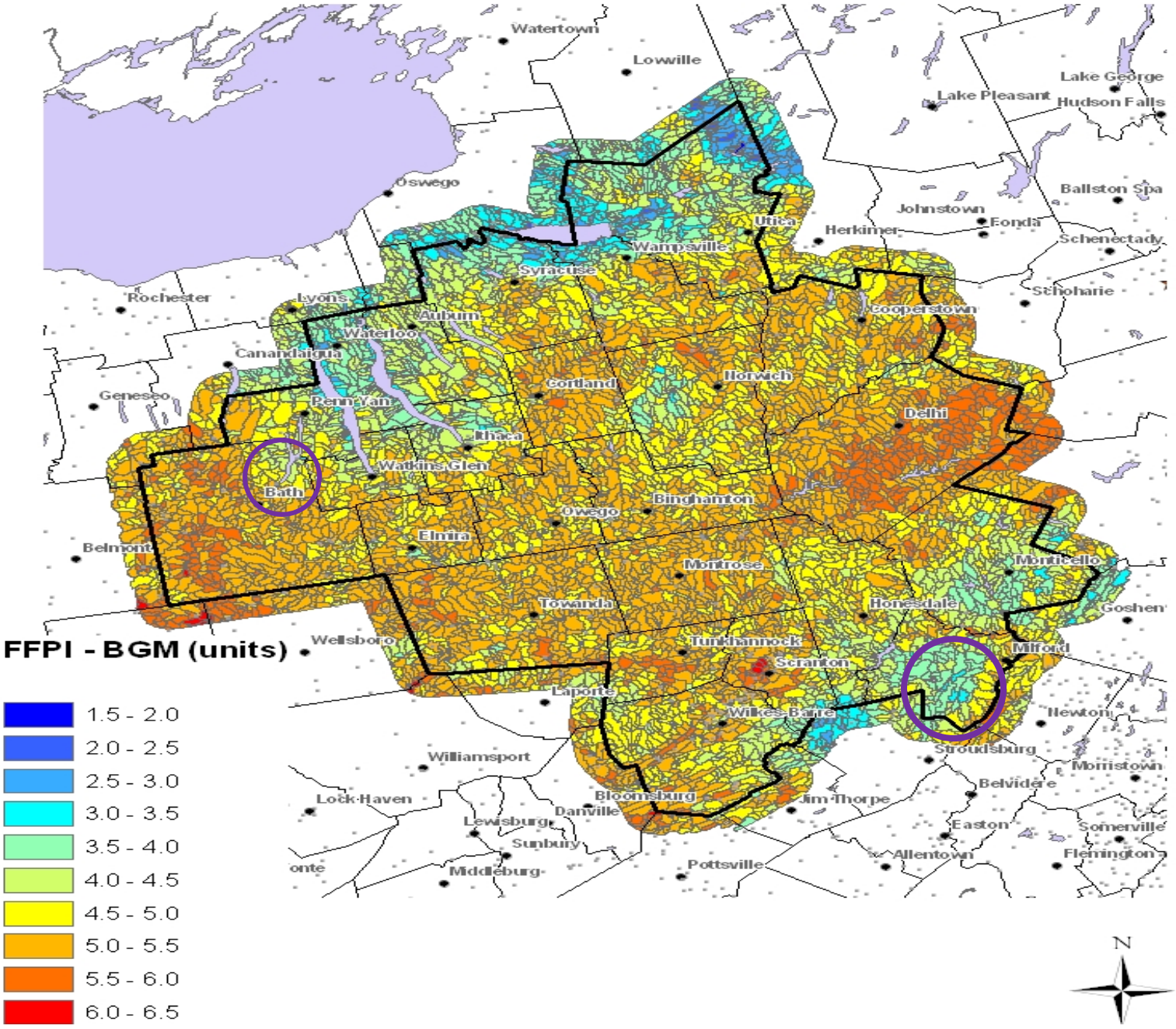
FFPI and Situational Awareness



Use in AWIPS


bols Volume Obs NCEP/Hydro Local Upper Air Satellite kdix kdox tphl Radar SCAN Maps Help
WarnGen
Clear
Frames: 12
Mag: 1
Density: 1
Philadelphia
FFPI Image

Flash Flood Potential Index (FFPI)



Benefits and verification

- Reduced false alarms
  - Two warnings - Pike County, PA and Oneida County, NY were not issued. Follow-up confirmed no flooding
- Better Situational Awareness
  - Emergency managers and County officials better aware of areas prone to flooding and why.
  - Forecasters more aware of areas more likely to be “flashier”.
- Increased Lead Time
  - Boosted forecaster confidence that additional rain would lead to flash flooding (Warn on Forecast) –Major flash flooding resulted in Delaware County, NY

Future Work with the FFPI

- Incorporate NRCS SSURGO soil data.
- Incorporate a frozen ground variable into the FFPI, Work with the MARFC to verify FFPI effectiveness using historical flood data.
- Create smaller scale with greater resolution FFPI data with LIDAR data.
- Automate for bi-weekly AVHRR “greenness” data into the FFPI.

Summary

- The Flash Flood Potential Index (FFPI) provides a quantitative look at flash flood potential on a sub-basin level across our Pennsylvania.
- Can be used to direct us to the specific drivers…be it slope, soil, vegetation density or land use…that most contributes to flash flooding in a particular sub-basin.
- Provides an explanation as to why a specific sub-basin may be more flood-prone than another.
- The FFPI is best used operationally when mapped to the AWIPS FFMP basins for comparison with other flash flood tools and techniques.

Additional References & Acknowledgements

- Smith, Greg, (2003): Flash Flood Potential: Determining the Hydrologic Response of FFMP Basins to Heavy Rain by Analyzing Their Physiographic Characteristics. A white paper available from the NWS Colorado Basin River Forecast Center at http://www.cbrfc. noaa.gov/papers/ffp_wpap.pdf, 11 pp
- Kruzdlo, Ray ; Ceru Joseph (2010) Flash Flood Potential Index for WFO Mount Holly/Philadelphia
- Classification and indexing methodologies for FFPI developed by Jim Brewster of NWS Binghamton, NY
- Matt Kelsch, Flash Flood Hydrology & QPE, 10 March 2010
- Dr. Richard Koehler
- Greg Heavener, ITO WFO Mount Holly
- Mike Kozar, graduate student Florida State University.