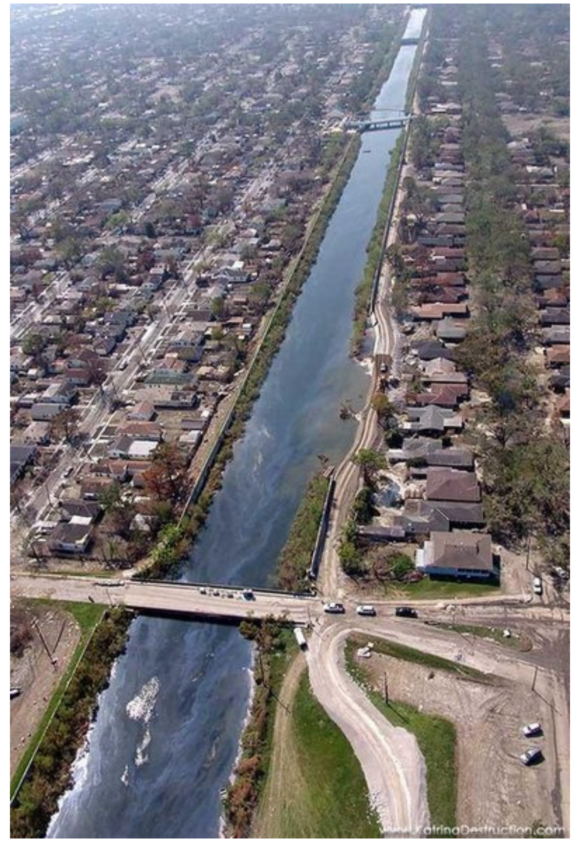
Mapping the capacity of watersheds to regulate floods



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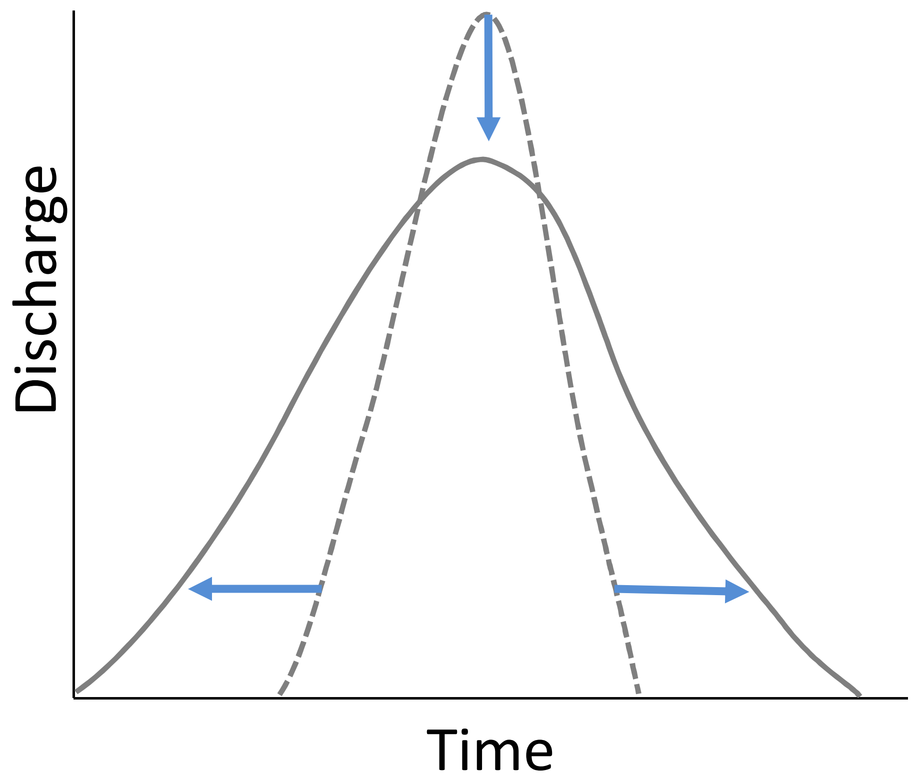
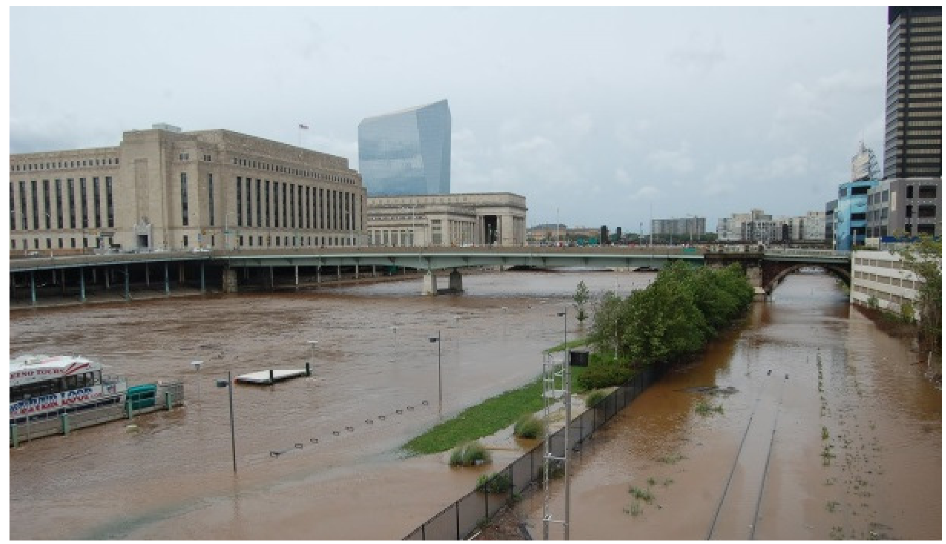
[2] U.S. Geological Survey, Virginia Cooperative Fish and Wildlife Research Unit, Virginia Tech

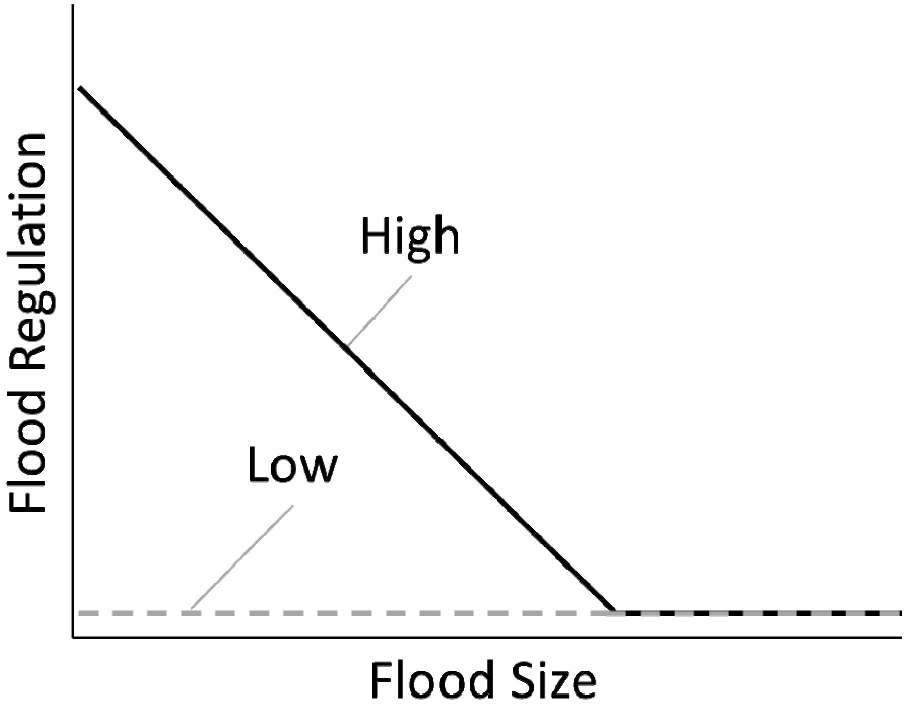
UCOWR-NIWR-CUAHSI Conference
June 18, 2014
Medford, MA

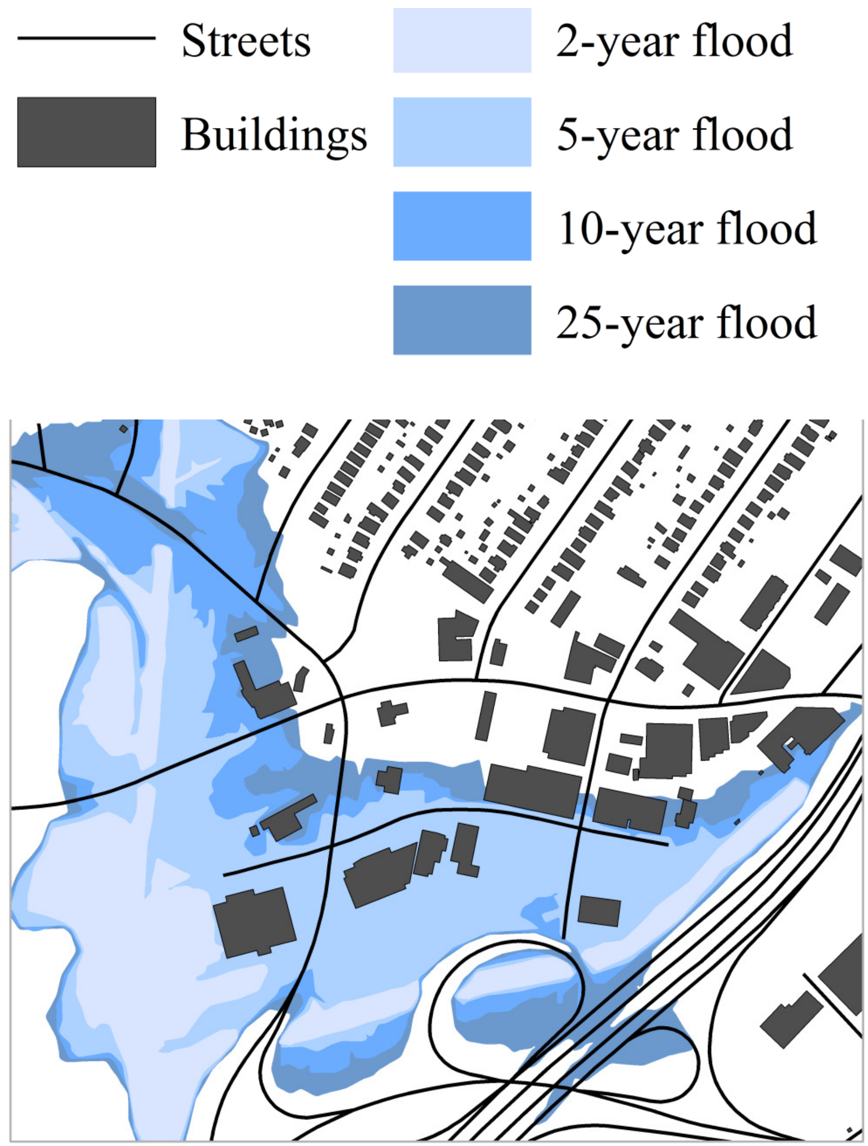
What do we mean by capacity?



Why do we care about regulating inland floods?

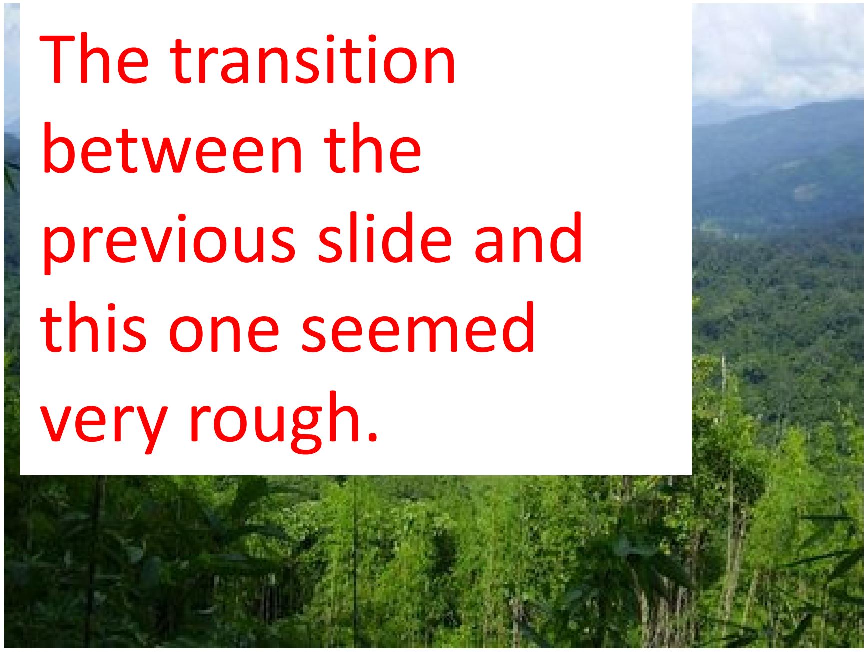






Landscapes can regulate floods < 10-year flood

Biophysical features that regulate floods

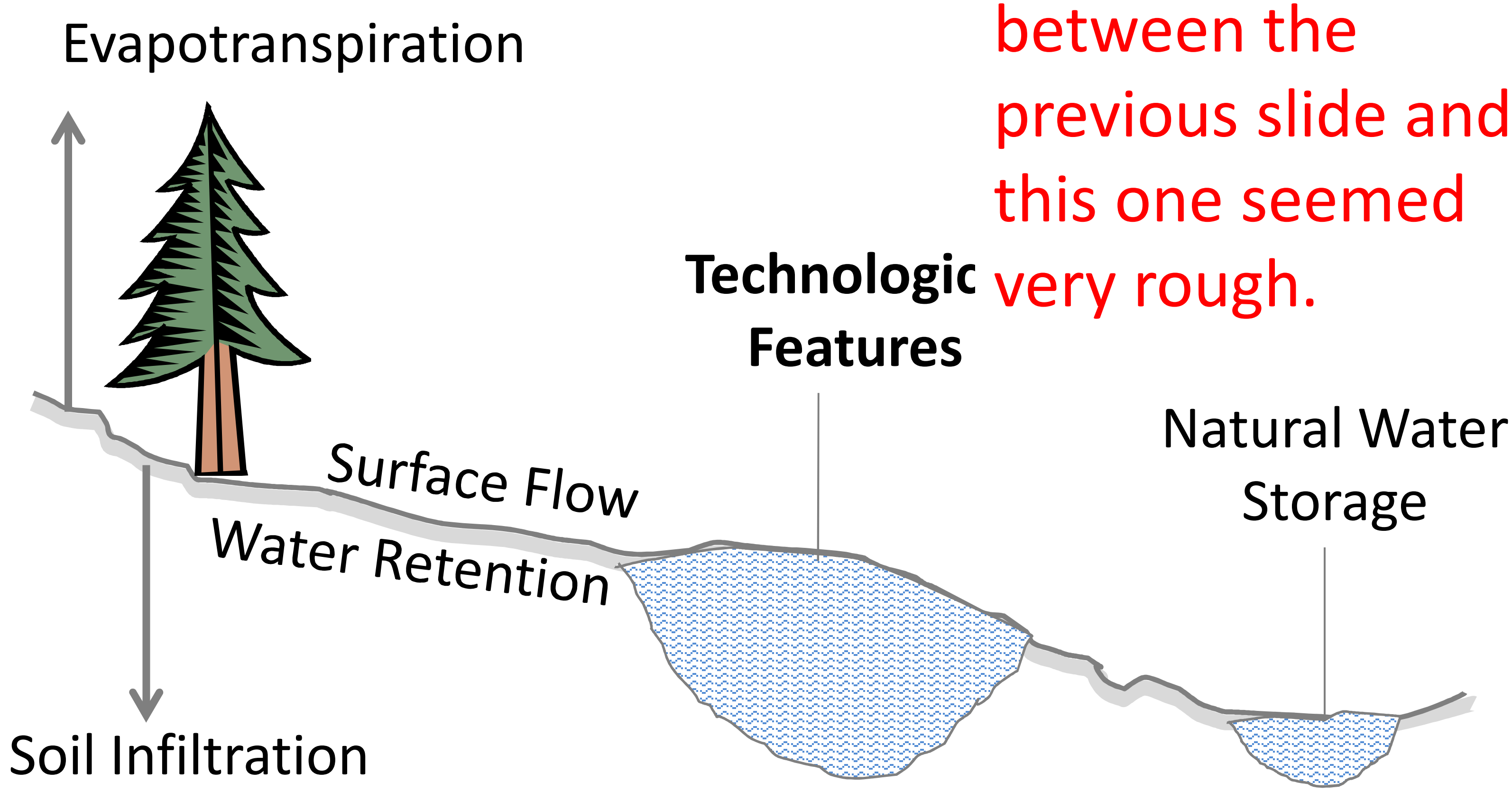


The transition between the previous slide and this one seemed very rough.

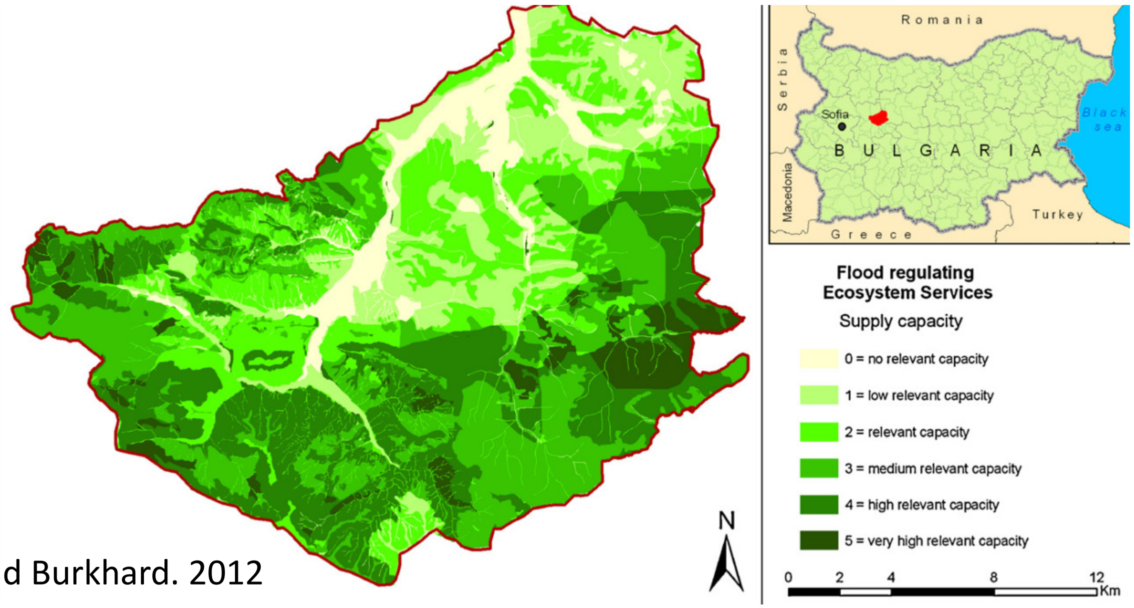
Technological features that regulate floods, and water

What landscape processes regulate floods?

The transition between the previous slide and this one seemed very rough.

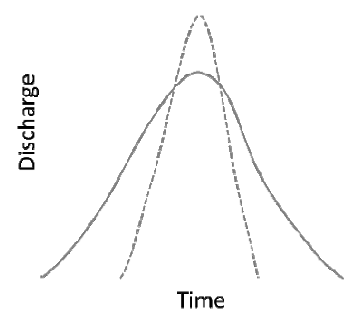


12+ papers on mapping flood regulation as an ES



Nedkov and Burkhard. 2012

- Technological features not included
- Role of landscape features not assessed with long-term hydrologic records



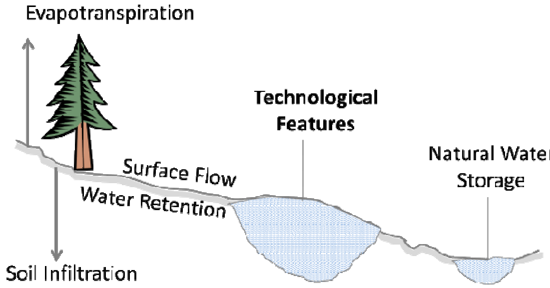
Study objectives

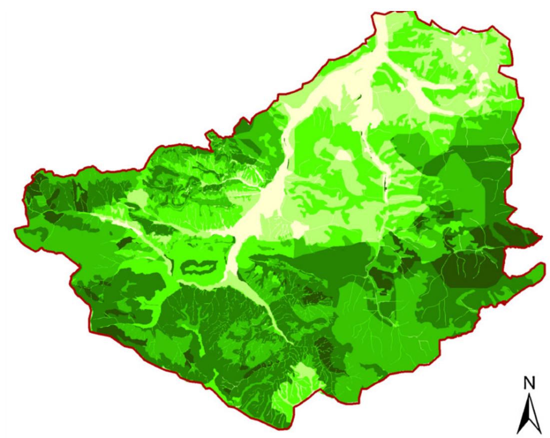
1) Identify landscape indicators that regulate floods

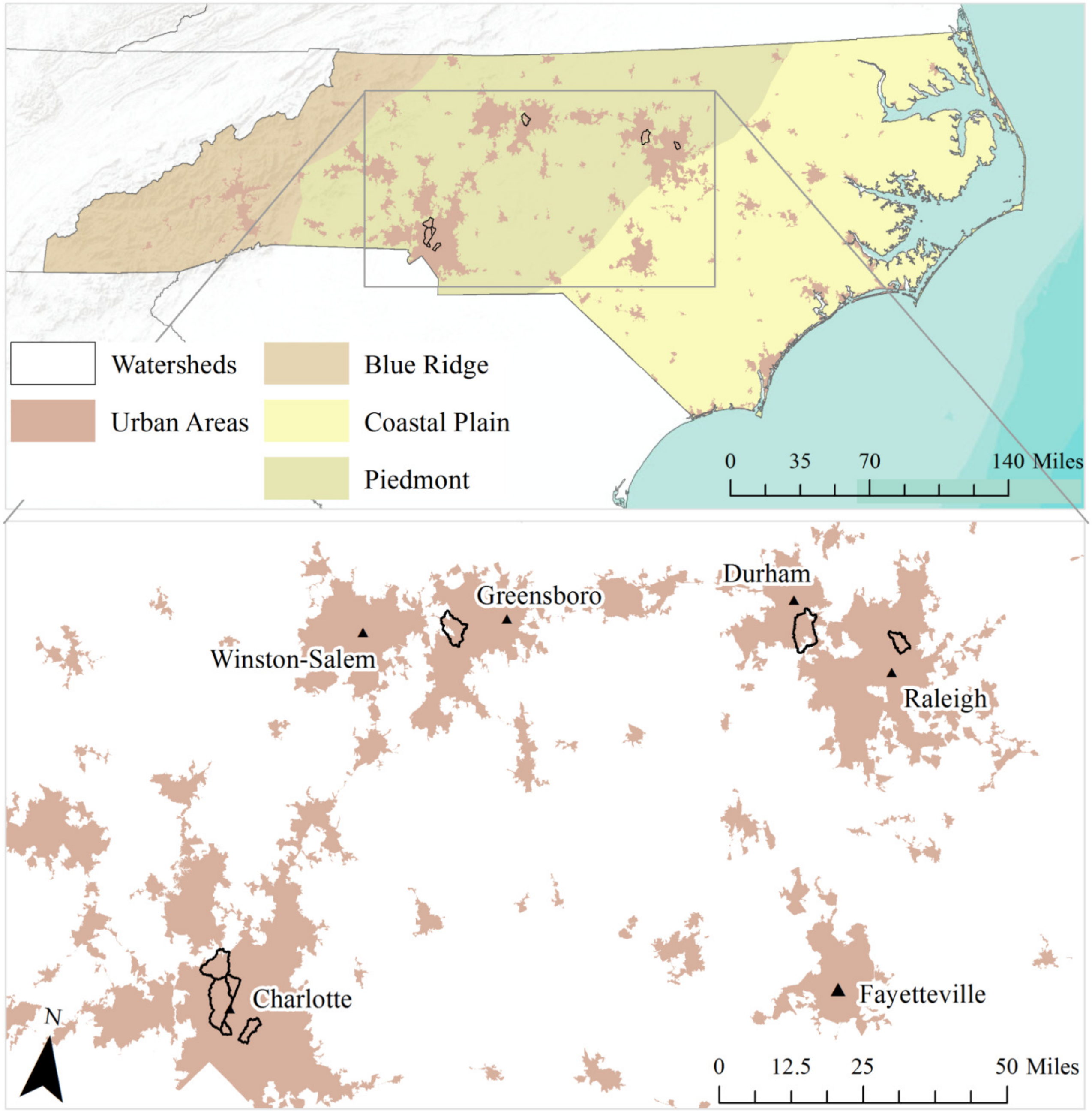
2) Assess the relative importance of each indicator in explaining flood metrics

3) Map technological and biophysical flood regulation capacities based on indicator-importance

4) Assess how observed flooding respond to biophysical and technological regulation capacity







8 watersheds

Piedmont of North Carolina

Drainage area ≤ 80 km^2

Urban (60-100%)

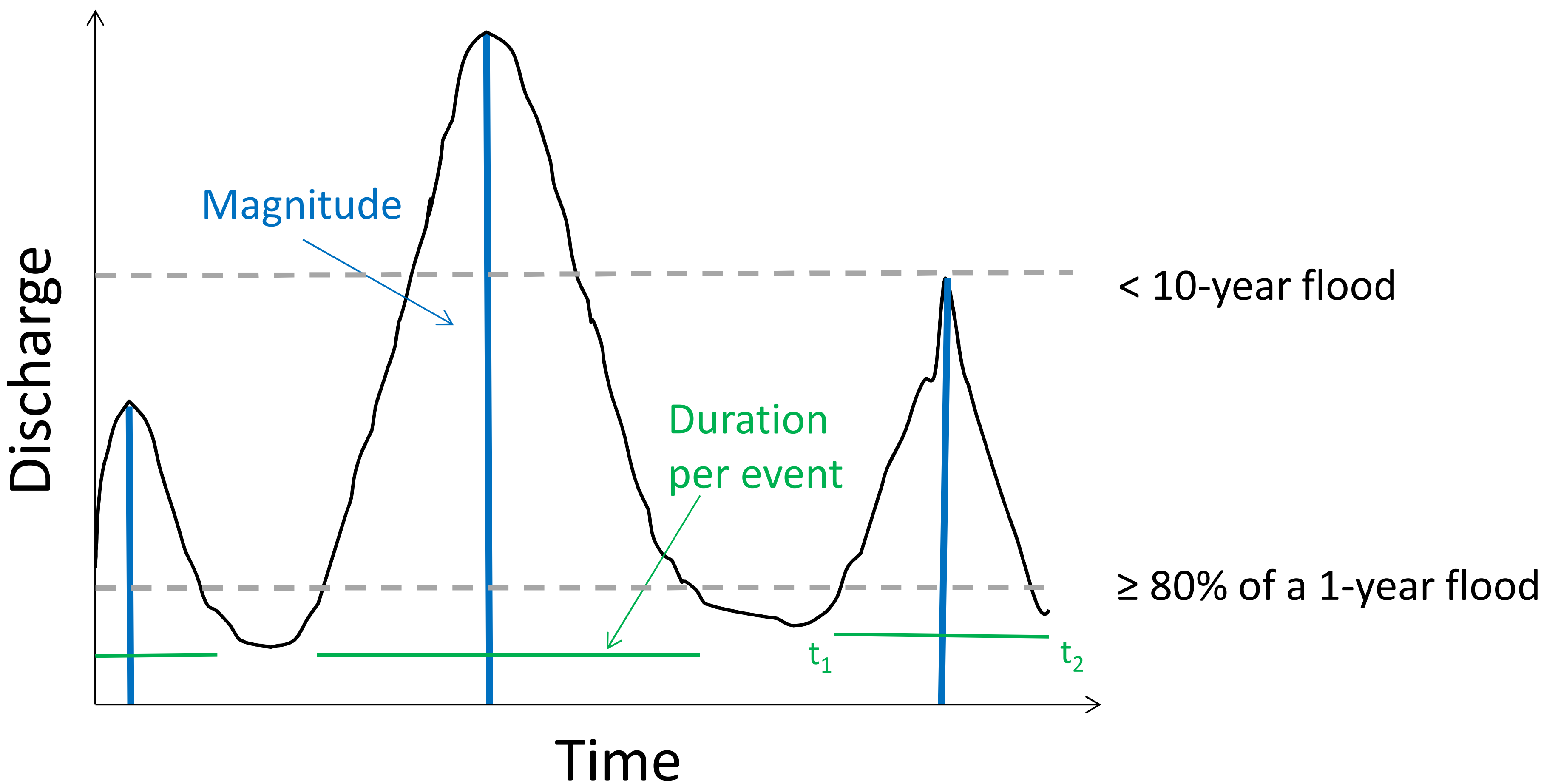
Forest (0-34%)

Mean Rainfall 1060 mm yr^{-1}

Sandy/Loamy soils 12-77%

Hydrologic records

1991 – 2013 (23 years)



1 Spatially explicit landscape indicators that regulate floods

Singh et al. (2013) table: NLCD to ET rate
‘90, ‘92, ‘01, ‘06, ‘11

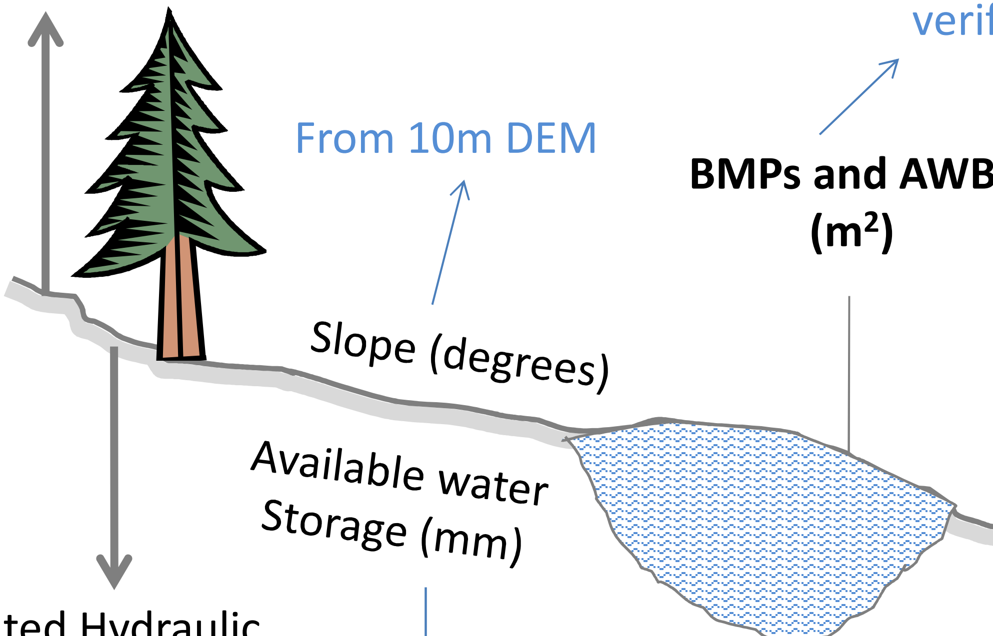
Evapotranspiration Rate (mm yr^{-1})

Compiled database;
verified, digitized, dated

From 10m DEM

BMPs and AWBs
(m^2)

Johnson and Fecko
(2008) equation:
from DA to width



Slope (degrees)

Streams (m^2)

Available water
Storage (mm)

Saturated Hydraulic
Conductivity (um s^{-1})

Need to make
clearer what I will
define as biophysical
and technological

SSURGO 10m Database

*ET, BMP, AWB change through time

2a Derive indicator importance factors based on flood metrics

Generalized Linear Mixed Model (GLMM) set up:

RESPONSE		EXPLANATORY
Magnitude	Biophysical Indicators	Evapotranspiration Rate (ET), Saturated Hydraulic Conductivity (Ksat), Available Water Storage (AWS), Slope, % Streams
Magnitude	Technological Indicators	Best Management Practices (% BMPs) and Artificial Waterbodies (% AWBs)
Duration	Biophysical Indicators	Evapotranspiration Rate (ET), Saturated Hydraulic Conductivity (Ksat), Available Water Storage (AWS), Slope, % Streams
Duration	Technological Indicators	Best Management Practices (% BMPs) and Artificial Waterbodies (% AWBs)

2b Derive indicator importance factors based on flood metrics

GLMM example -

Response Variable:

Magnitude

Random Effect:

Station ID

Fixed Effects:

Mean annual precipitation

Technological indicators (2)

Model	Variables	# parameters	AICc	AICc weight
1	Intercept only	1	381.16	0.02
2	Int, AWB	2	375.17	0.42
3	Int, BMP	2	375.19	0.41
4	Int, AWB, BMP	3	377.25	0.15

- Derive AIC
- Calculate AIC weight
- Sum weight for each indicator

Sum BMP weight is 0.56

Conducted this process for B indicators and magnitude, and duration – B and T

2c

Derive indicator importance factors based on flood metrics

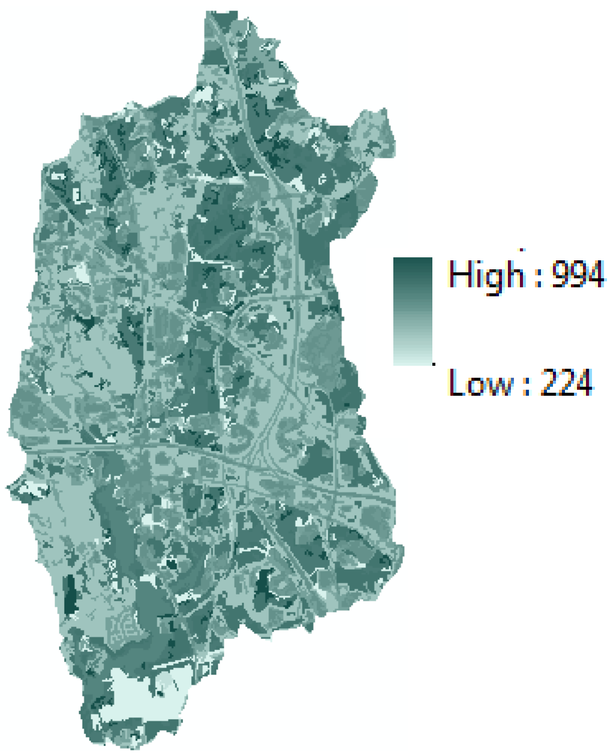
Components	Indicators	Magnitude		Duration	
		Unscaled	Scaled	Unscaled	Scaled
Biophysical	ET	0.37	0.62	0.95	**1.00**
	Ksat	0.32	0.54	0.36	0.38
	AWS	0.30	0.50	0.51	0.54
	Slope	0.42	0.70	0.31	0.33
	% Stream	0.59	**1.00**	0.57	0.60
Technological	% BMP	0.56	0.99	0.49	0.76
	% AWB	0.57	**1.00**	0.64	**1.00**

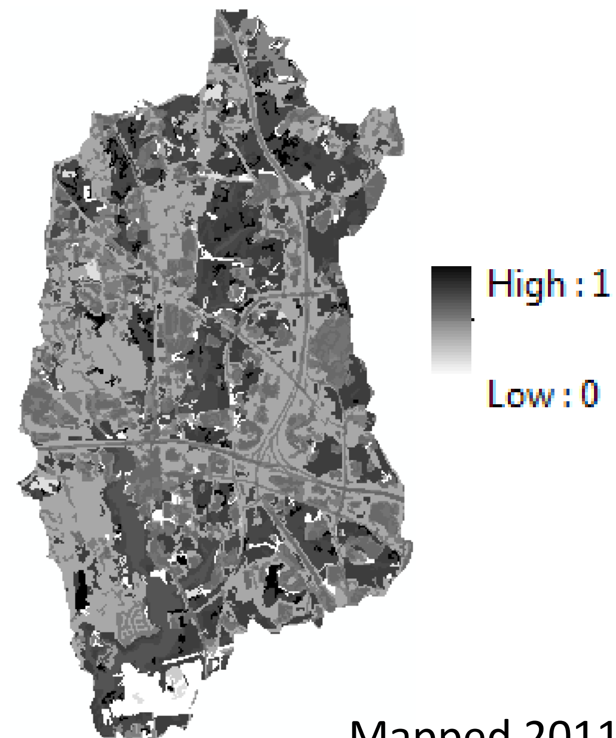
3a Map Flood Regulation Capacities

Standardize indicators in GIS from 0 to 1

$$\frac{(X - X_{min})}{(X_{max} - X_{min})}$$

Example: Evapotranspiration Rate





Mapped 2011-2013

3b

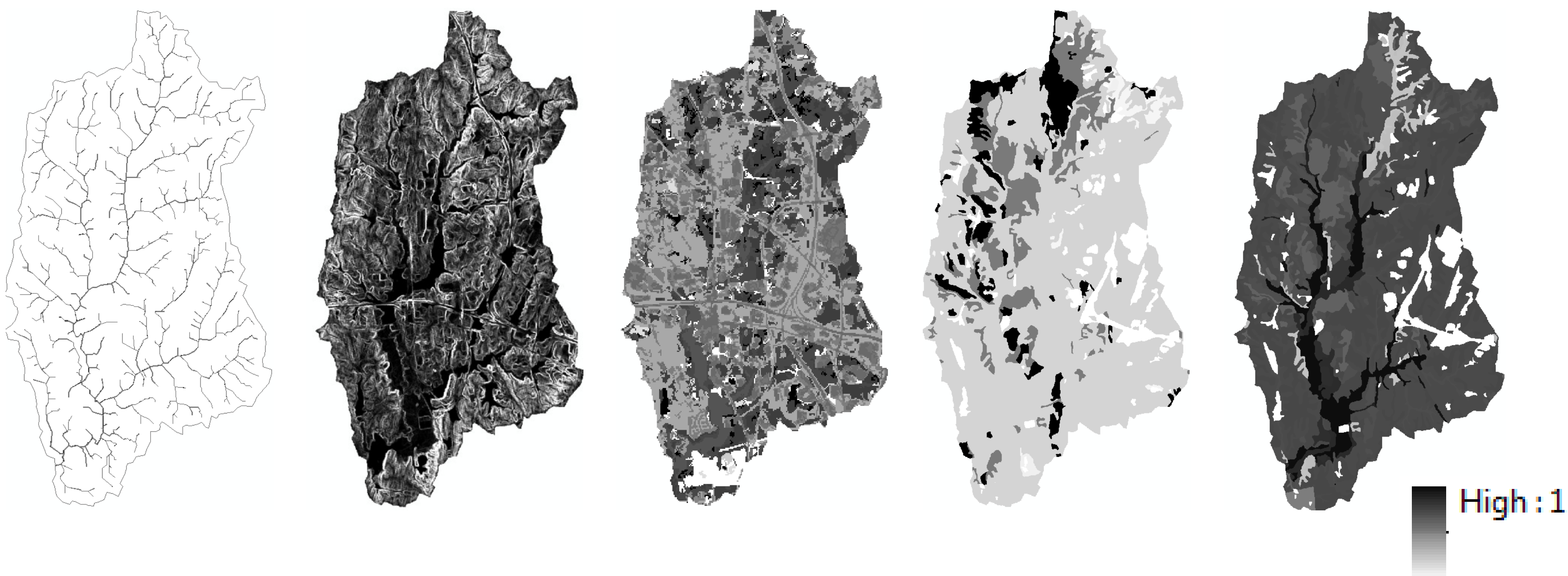
Map Flood Regulation Capacities

Indicator importance factors

Magnitude

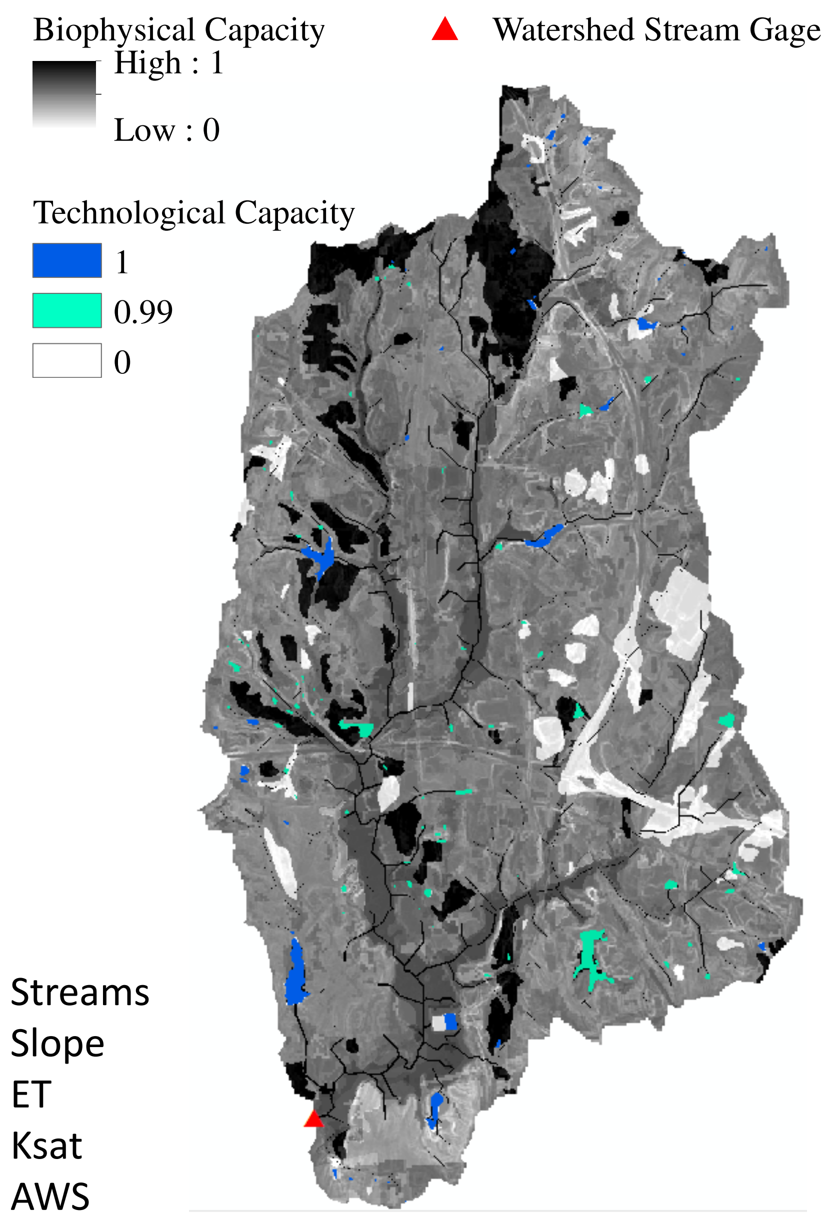
Biophysical Capacity = 1.0(Streams) + 0.7(Slope) + 0.62(ET) + 0.54(Ksat) + 0.5(AWS)

Stream | Slope | ET | Ksat | AWS

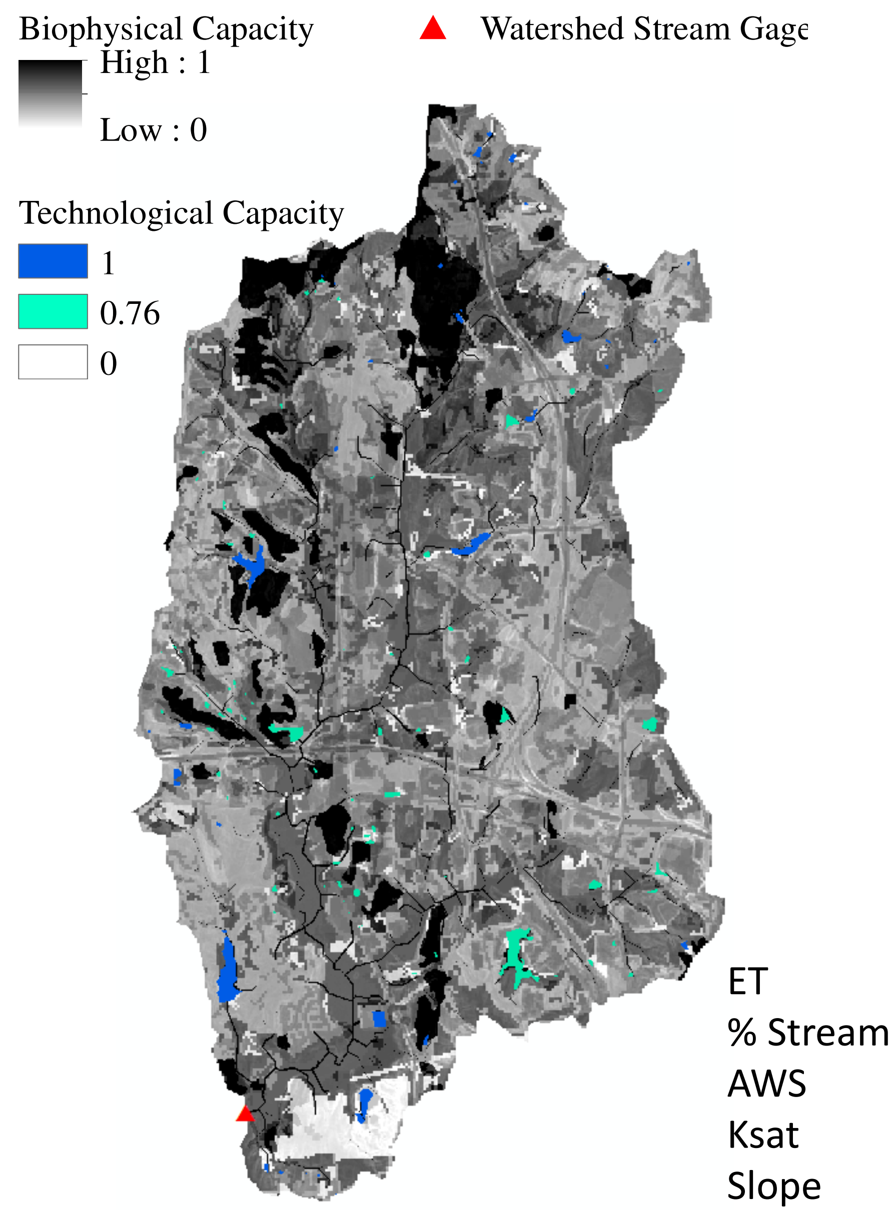


Re-standardized from 0 to 1

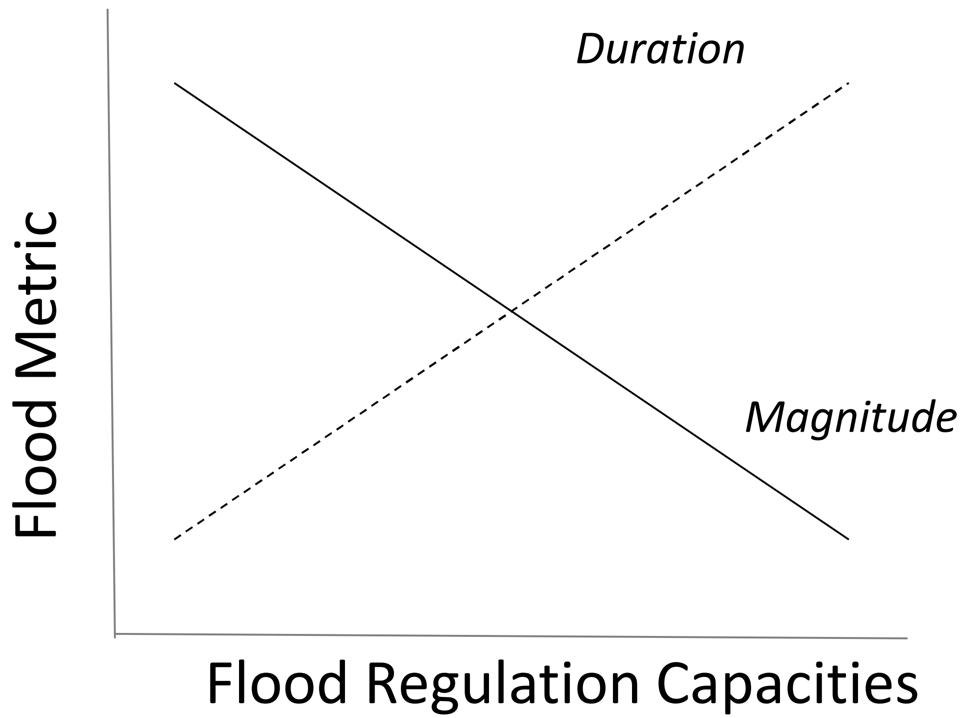
Magnitude-derived capacity

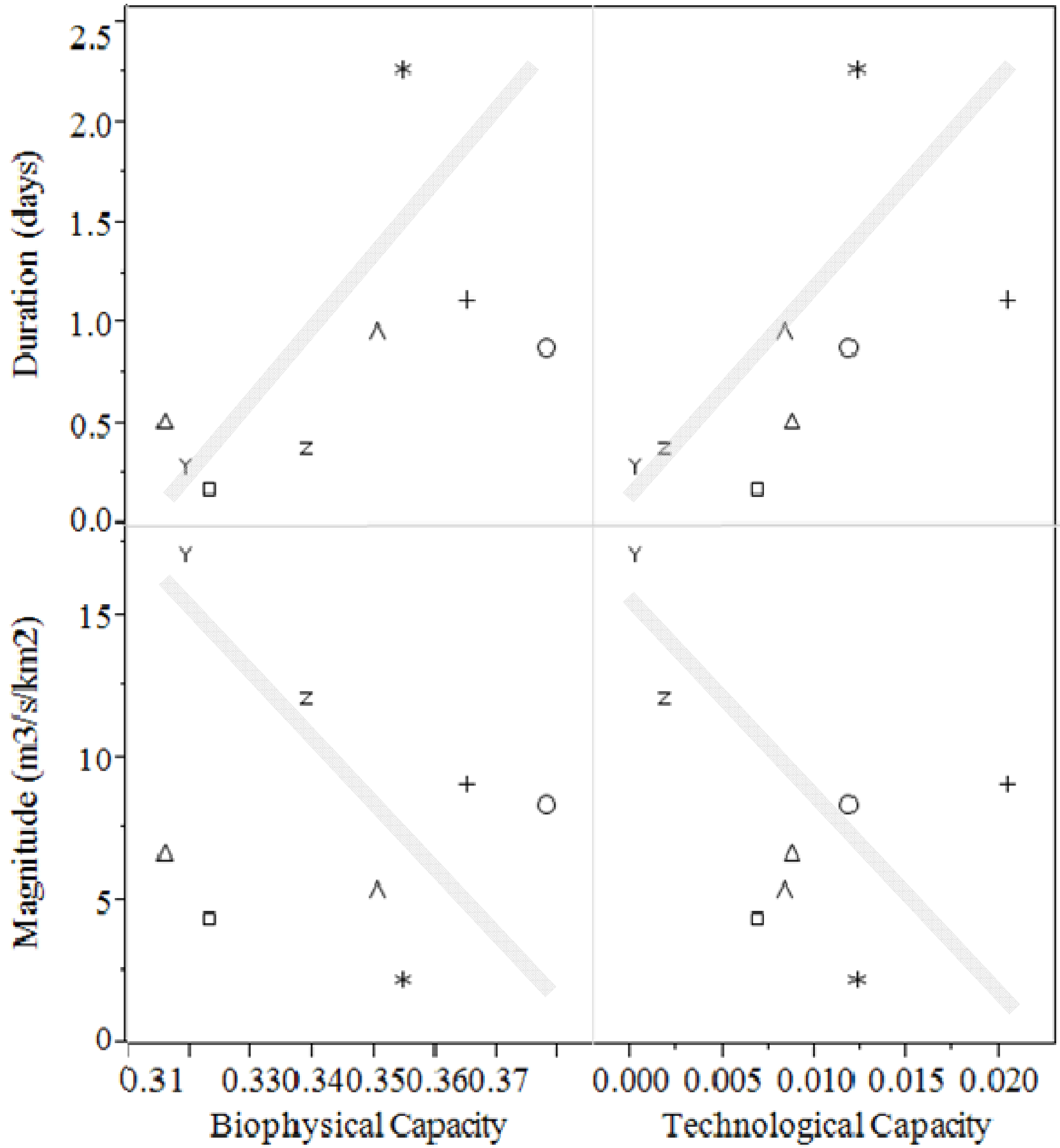


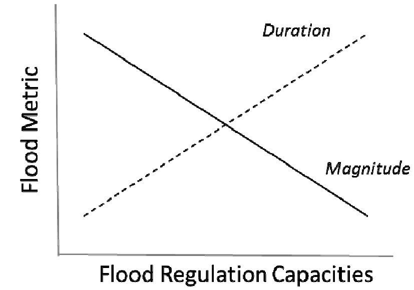
Duration-derived capacity



4 Assess how capacities respond to flood metrics



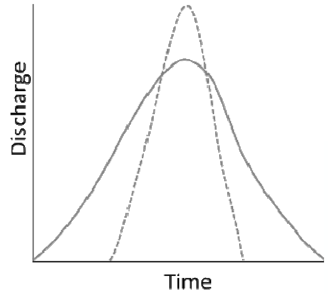




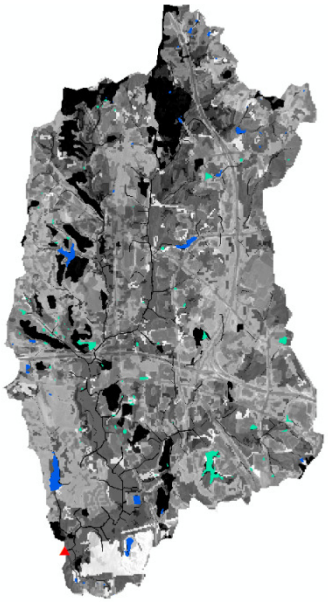
Floods are responding as expected based on what we know about the landscape

In this study, we

Included technological features



Derived indicator-importance factors based on flood metrics



Mapped technological and biophysical flood regulation capacity

Transferability and limitations

- Importance-values are location-specific
- Long-term hydrologic records
- Publicly available databases

Thank you

Acknowledgments

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