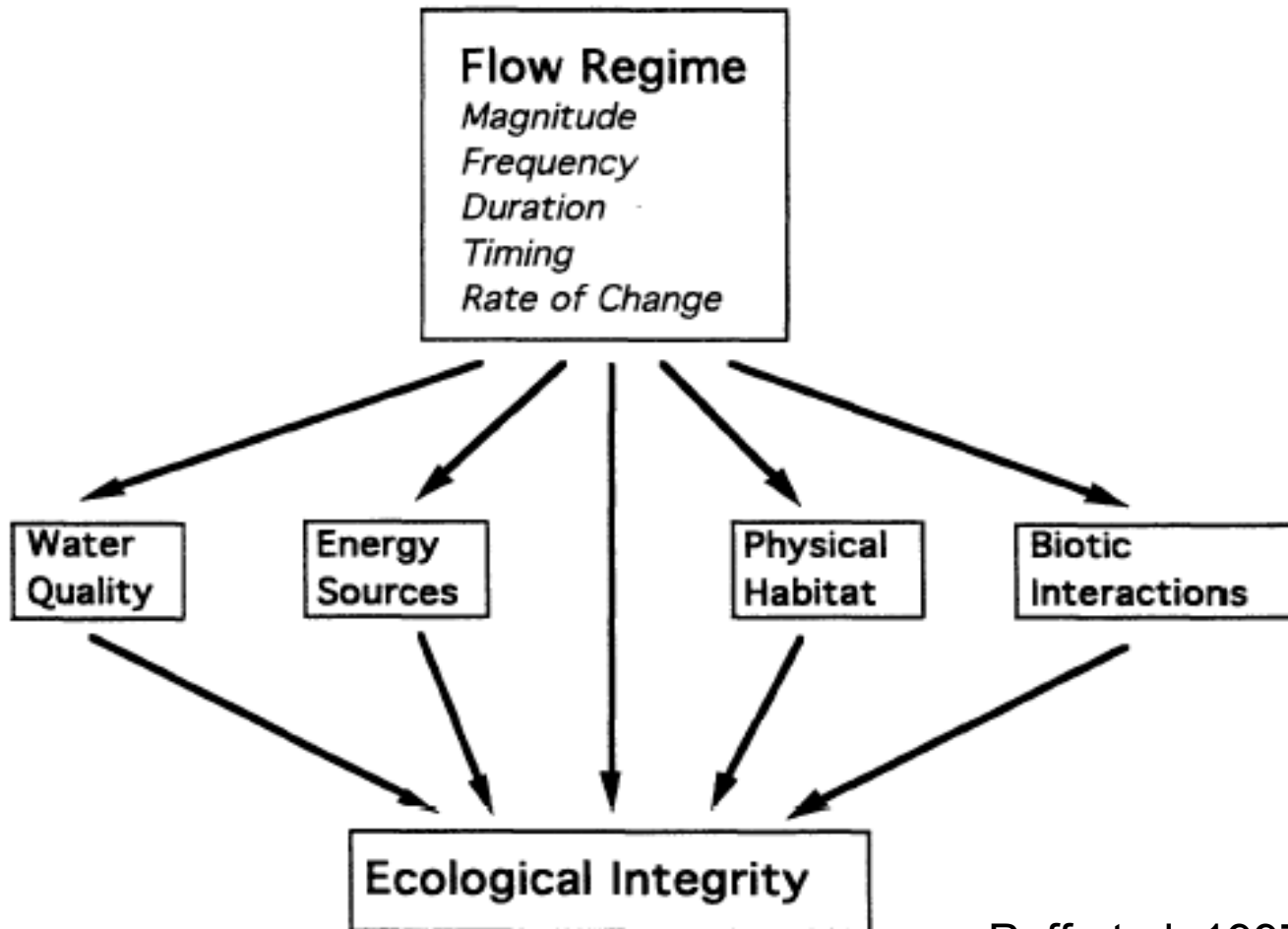


The background of the slide is a dark, atmospheric photograph of a mountain valley. In the foreground, there's a calm body of water, likely a lake, reflecting the surrounding environment. The middle ground shows steep, forested slopes leading up to the mountains. The background features jagged mountain peaks, some of which are partially shrouded in mist or low clouds. The overall color palette is muted, with various shades of blue, grey, and green, creating a somber and majestic feel.

Another face of the changing climate: comparing hydrologic response to fluctuating climate with land use effects

Michael J. Paul
Erik Leppo
Tetra Tech, Inc.

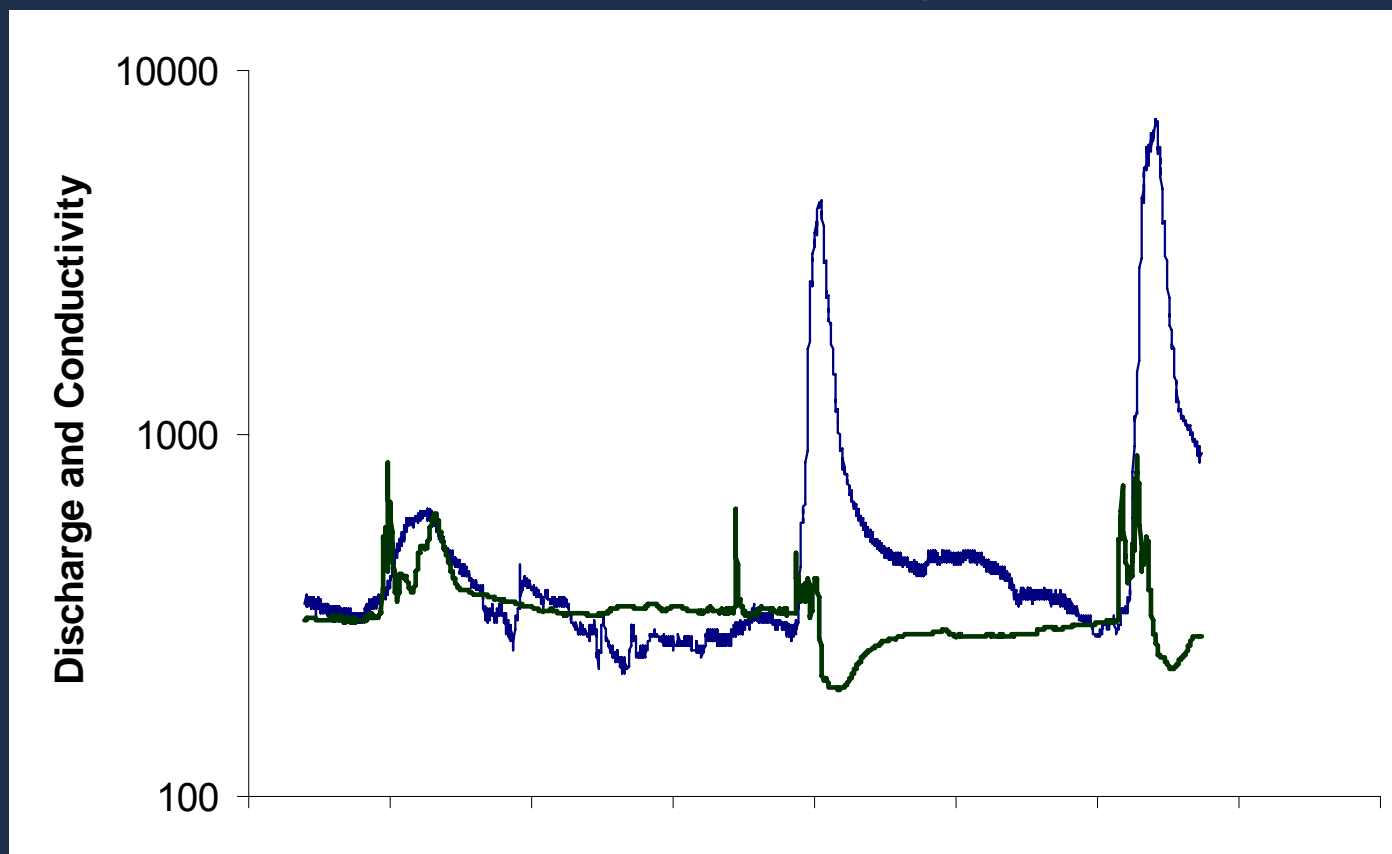
Why flow matters



Poff et al. 1997

Why flow matters

Water quality



USGS 01481500 BRANDYWINE CREEK AT WILMINGTON, DE

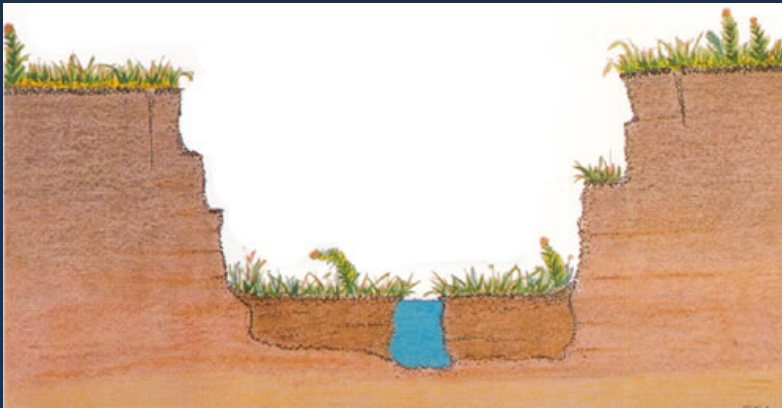
Why flow matters

Energy Supply



Why flow matters

Channel Form = $f(\text{sediment, discharge})$

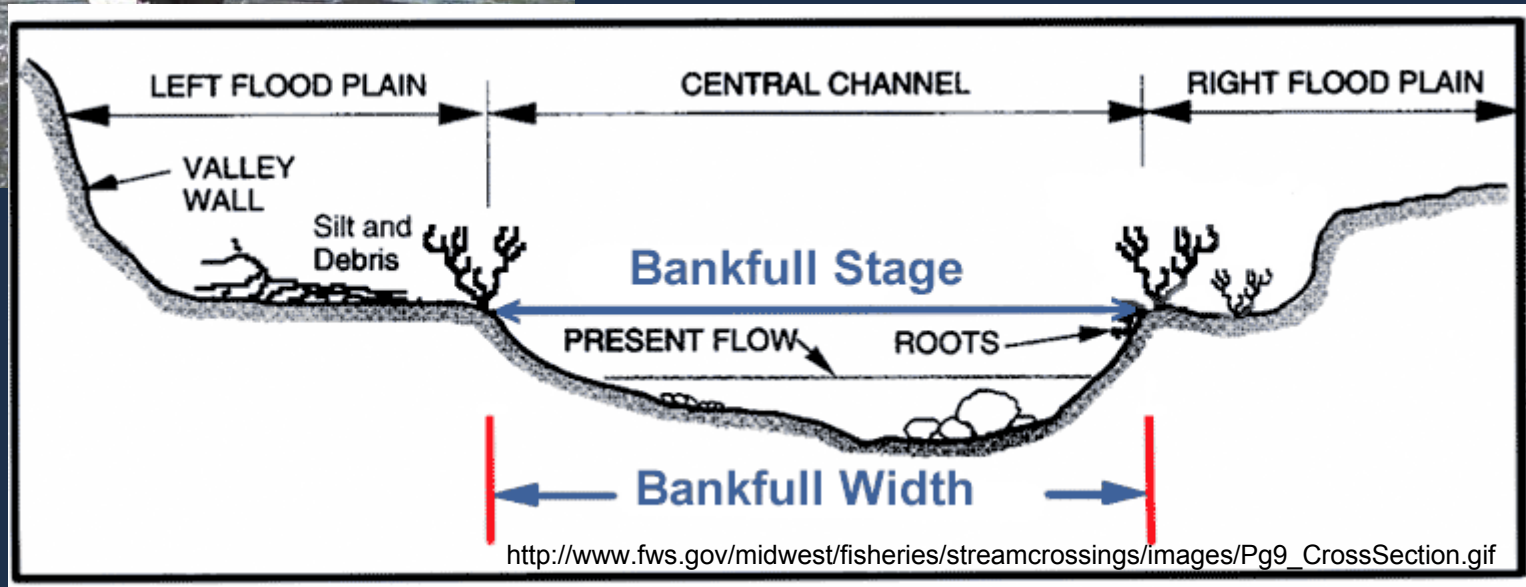


Habitat

Why flow matters



Habitat Volume



Why flow matters

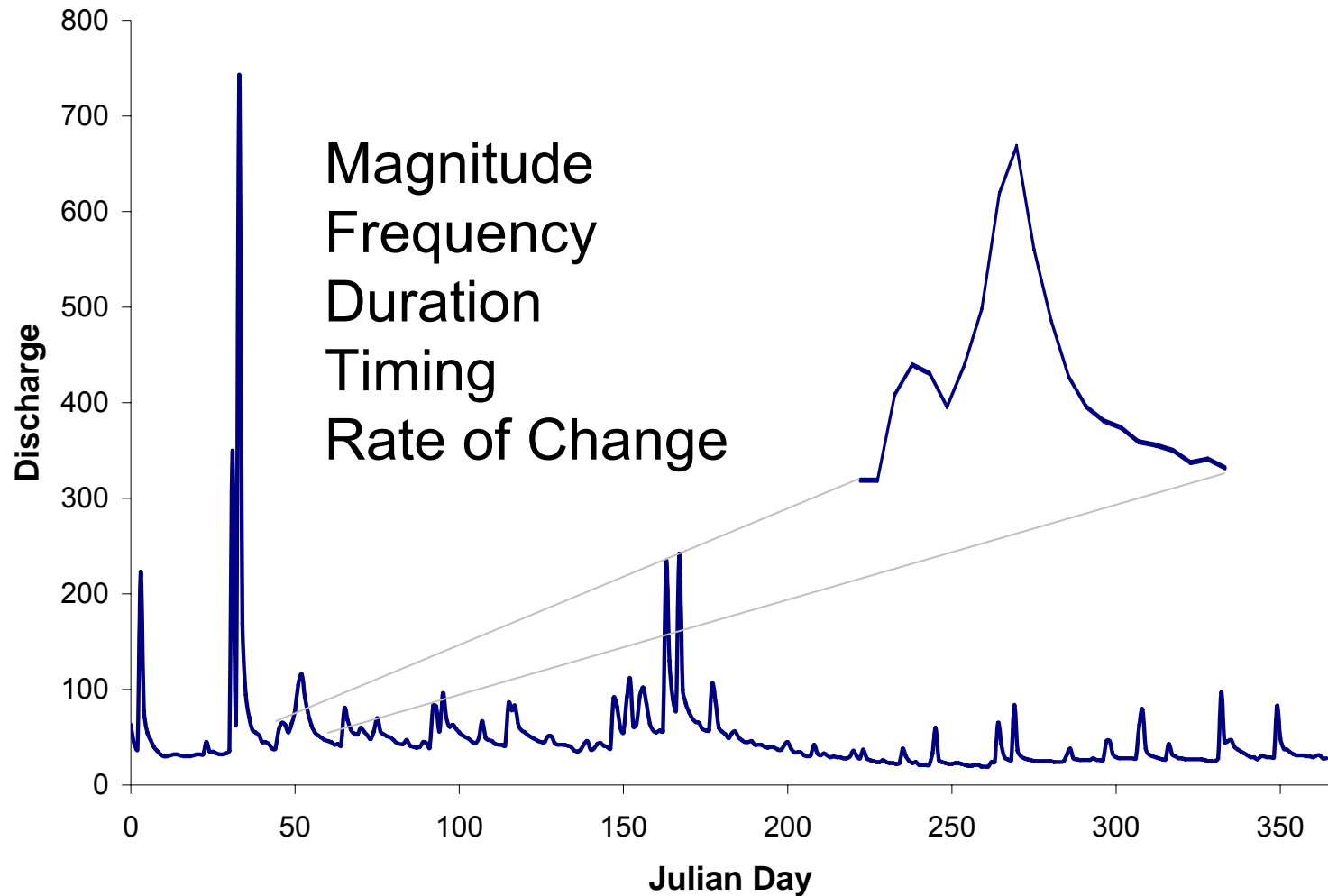


Biological Interactions



NABS (www.benthos.org)

Standard Metrics



Indicators of Hydrologic Alteration (IHA)

Conservation Biology 1996, v. 10(4)

A Method for Assessing Hydrologic Alteration within Ecosystems

BRIAN D. RICHTER,[‡]
AND DAVID P. BRAI

*The Nature Conservancy, I

†The Nature Conservancy,

‡The Nature Conservancy,

Table 1. Summary of hydrologic parameters used in the Indicators of Hydrologic Alteration and their characteristics.

<i>IHA statistics group</i>	<i>Regime characteristics</i>	<i>Hydrologic parameters</i>
Group 1: Magnitude of monthly water conditions	Magnitude Timing	Mean value for each calendar month
Group 2: Magnitude and duration of annual extreme water conditions	Magnitude Duration	Annual minima 1-day means Annual maxima 1-day means Annual minima 3-day means Annual maxima 3-day means Annual minima 7-day means Annual maxima 7-day means Annual minima 30-day means Annual maxima 30-day means Annual minima 90-day means Annual maxima 90-day means
Group 3: Timing of annual extreme water conditions	Timing	Julian date of each annual 1 day maximum Julian date of each annual 1 day minimum
Group 4: Frequency and duration of high and low pulses	Magnitude Frequency Duration	No. of high pulses each year No. of low pulses each year Mean duration of high pulses within each year Mean duration of low pulses within each year
Group 5: Rate and frequency of water condition changes	Frequency Rate of change	Means of all positive differences between consecutive daily means Means of all negative differences between consecutive daily values No. of rises No. of falls

Flashiness

A NEW FLASHINESS INDEX: CHARACTERISTICS AND APPLICATIONS TO MIDWESTERN RIVERS AND STREAMS¹

David B. Baker, R. Peter Richards, Timothy T. Loftus, and Jack W. Kramer²

JAWRA 2004

- Sum of flow changes divided by total flow

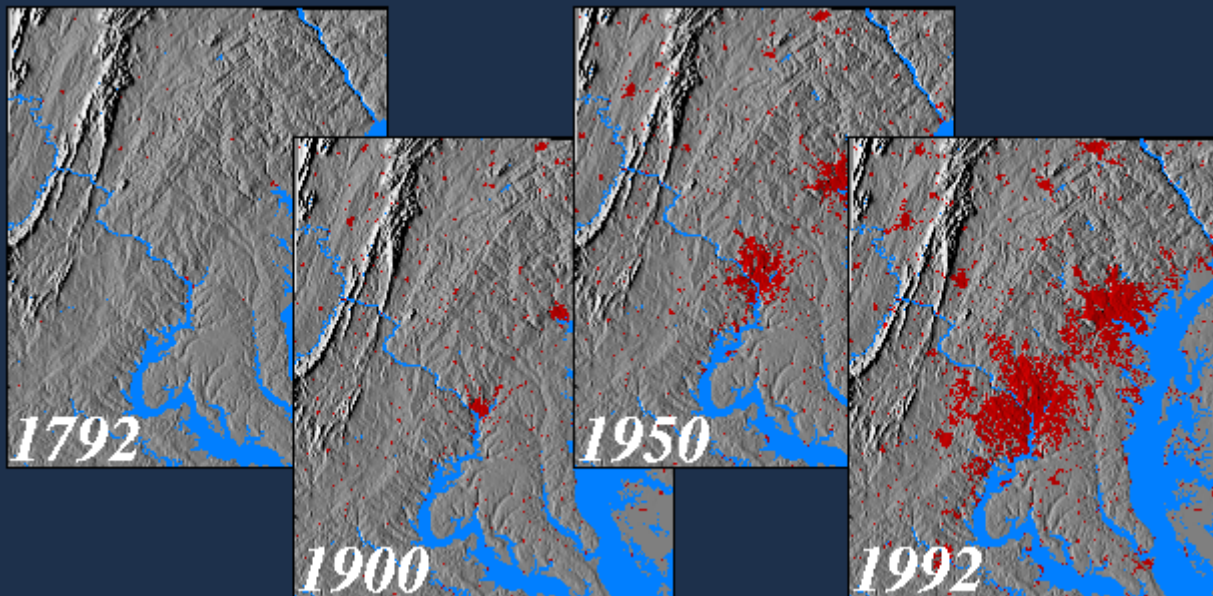
$$R - B \text{ Index} = \frac{\sum_{i=1}^n |q_i - q_{i-1}|}{\sum_{i=1}^n q_i}$$

Climate Prediction

- Mid-Atlantic
 - Similar precipitation
 - Fewer floods

On top of all this...

Urban Growth in Baltington



Urbanization Also Affects Flow

Less
Urban

More floods
Greater magnitude

~Affects on baseflow

336

PAUL ■ MEYER

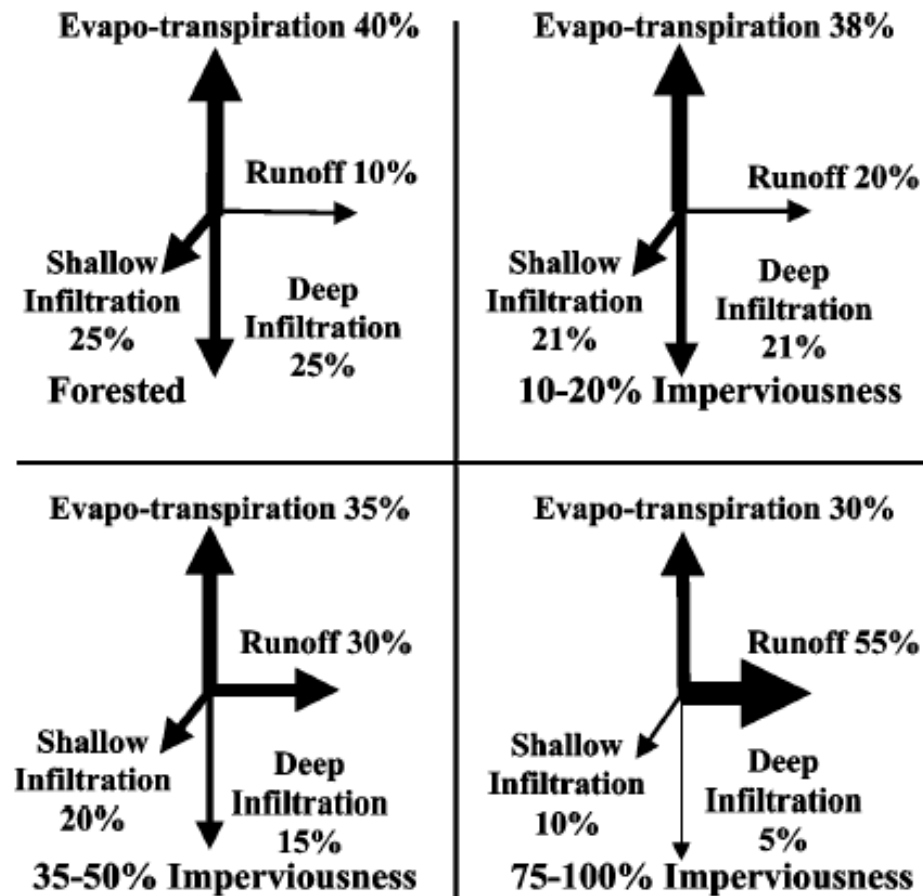


Figure 1 Changes in hydrologic flows with increasing impervious surface cover in urbanizing catchments (after Arnold & Gibbons 1996).

More
Urban

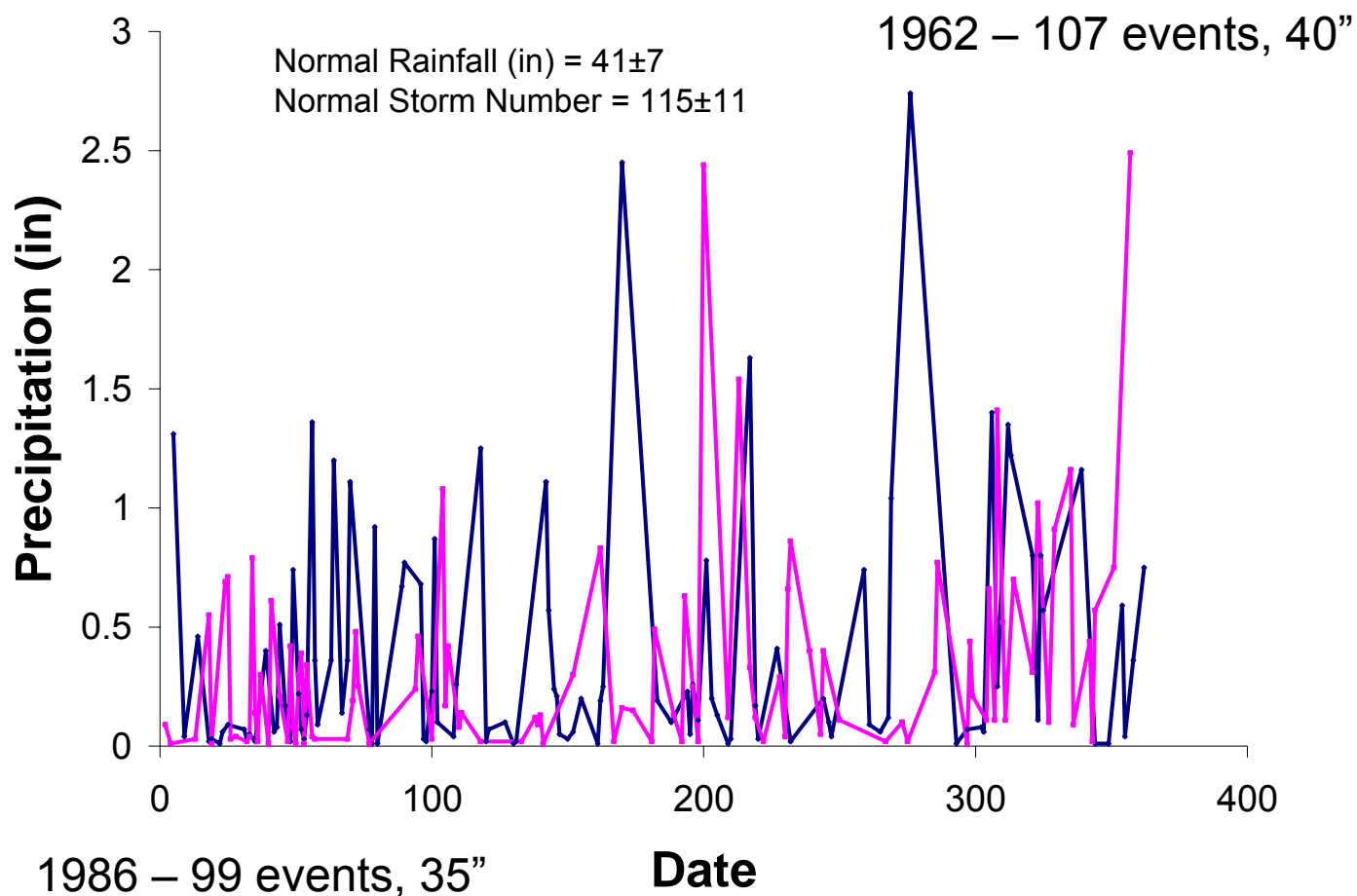
A Flow Case Study

- How would hydrologic response to climatic change in Mid-Atlantic compare with land use impacts?
- Focused on Baltington Metroplex.

What we did

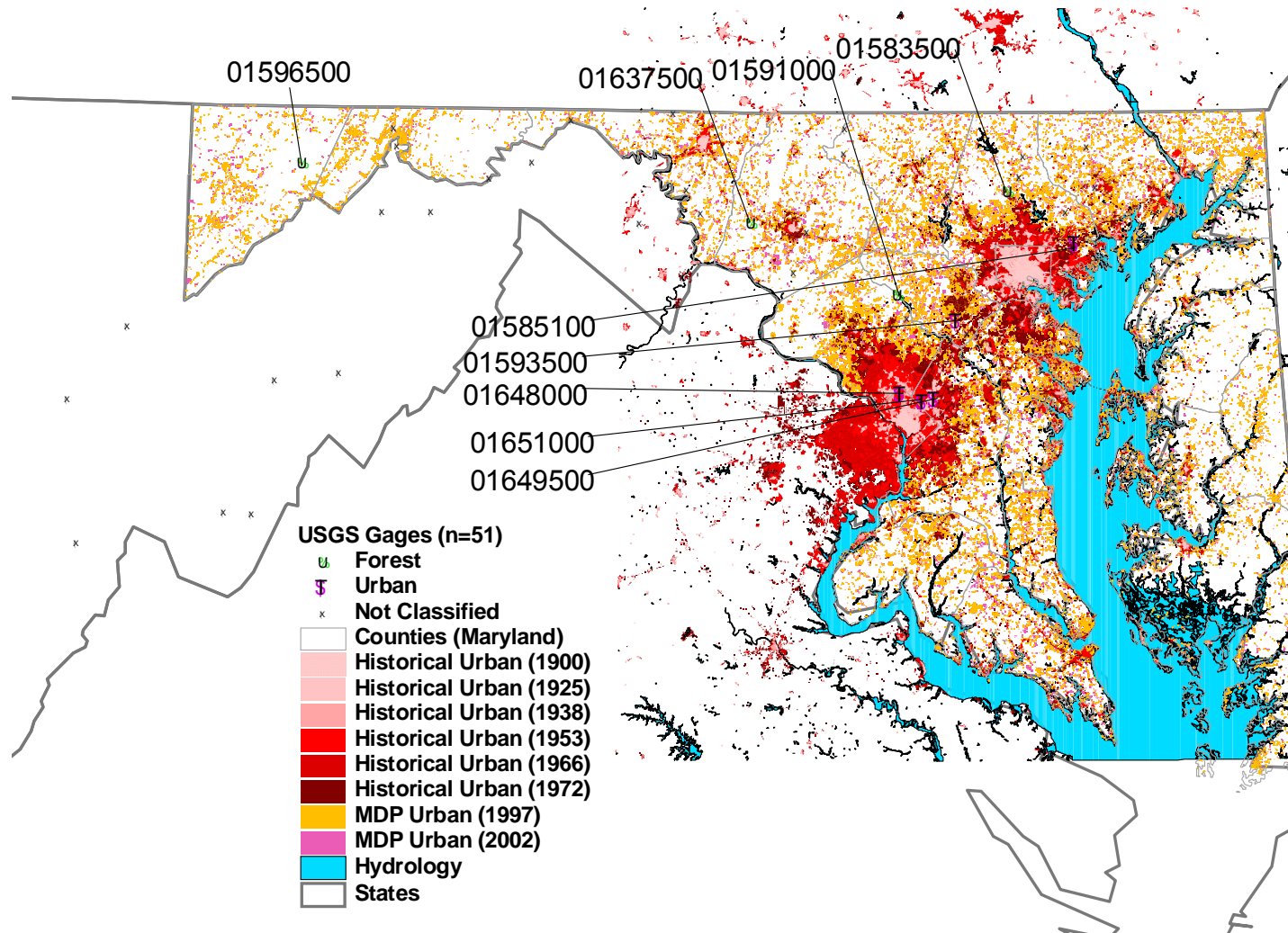
- Find “future climate”-like years from past.

“Future”	Normal
1963	1960
1964	1961
1967	1985
1968	1987
1969	1992
1976	1994
1986	1997
2002	2001



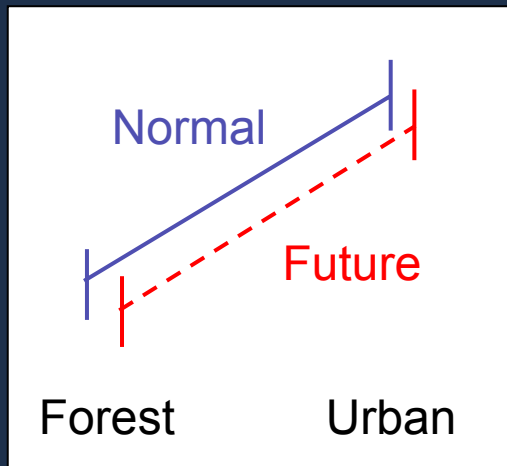
What we did

- Collect urban and forest flow data

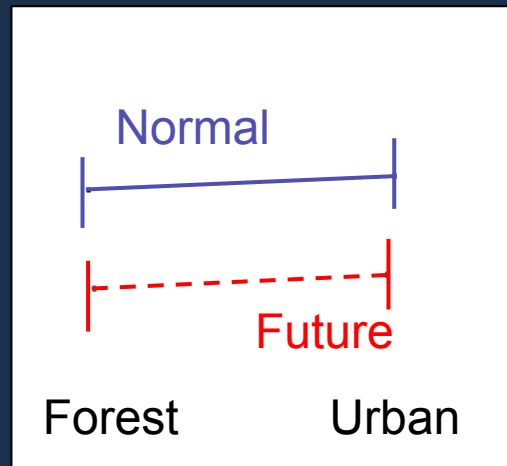


What we did

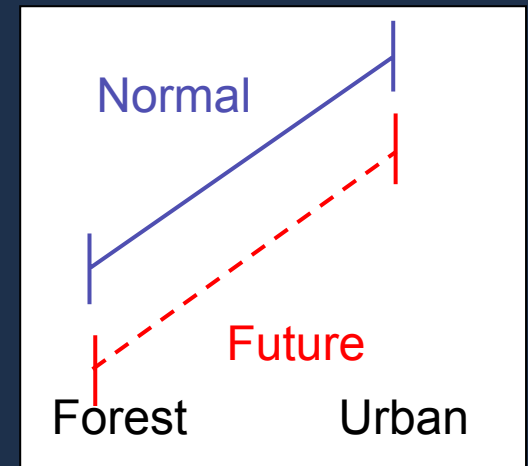
- Compared flow between land use and “climate” with 2-way ANOVA



Land Use – Yes
Climate – No

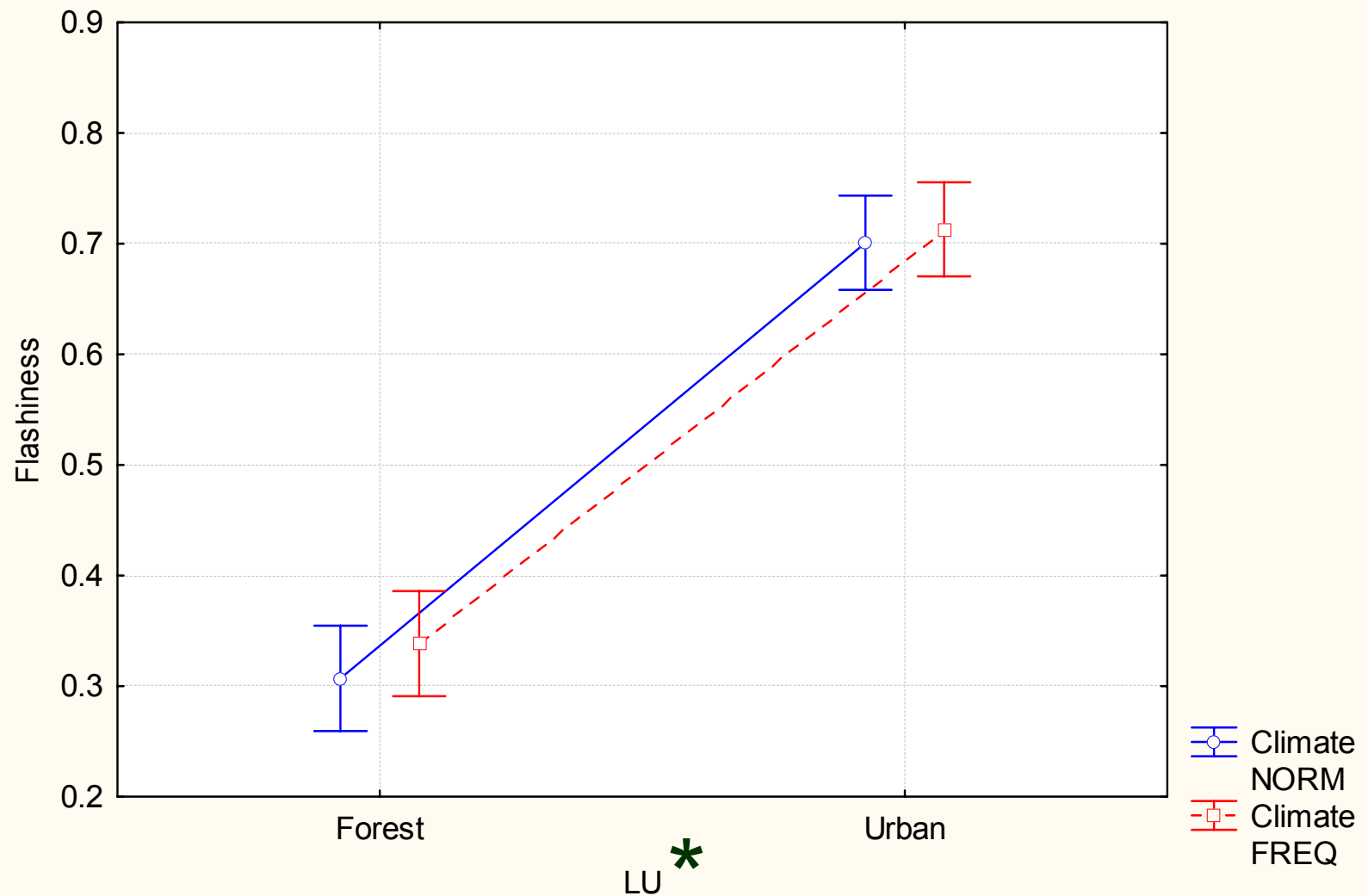


Land Use – No
Climate – Yes

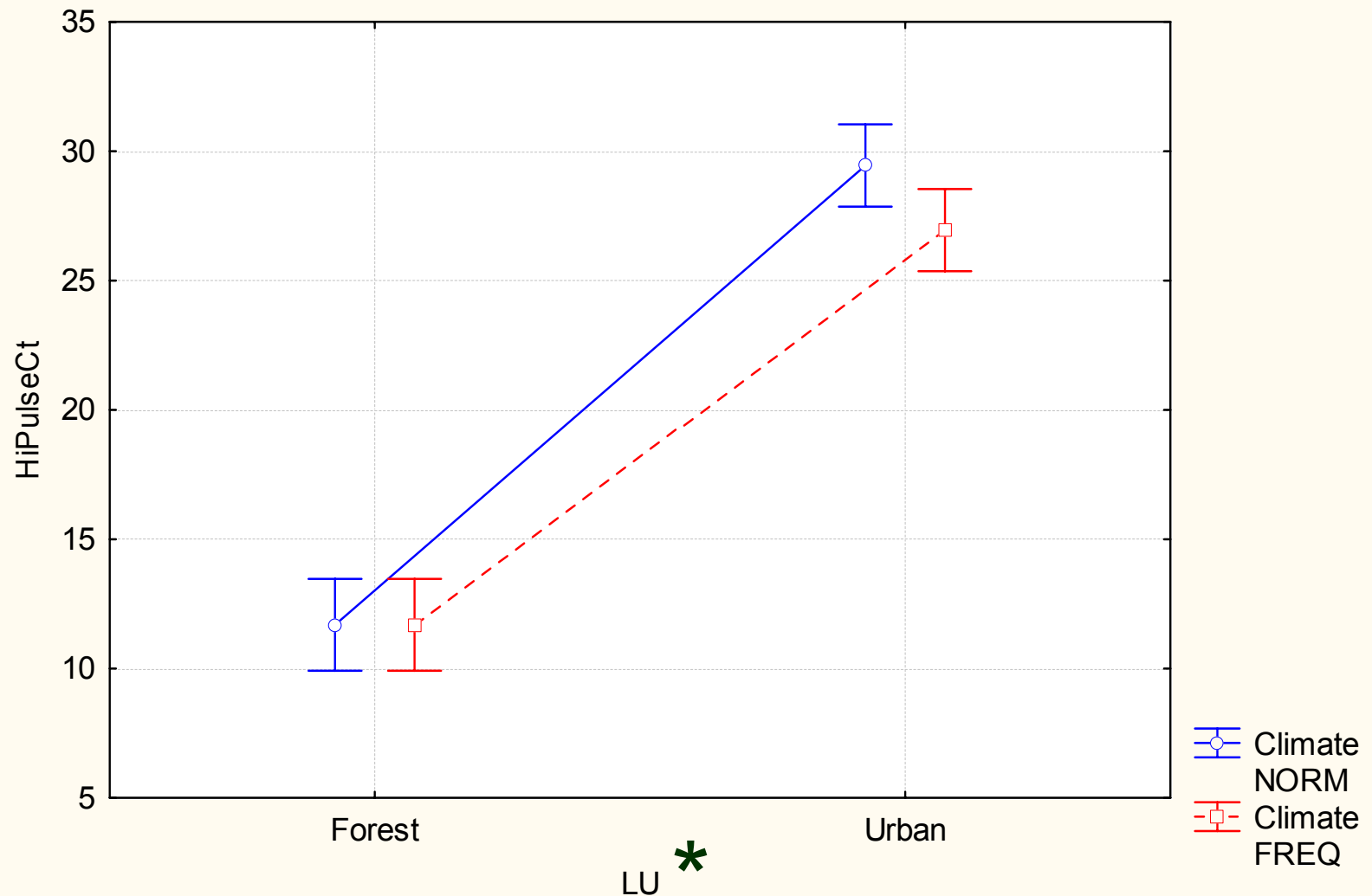


Land Use – Yes
Climate – Yes

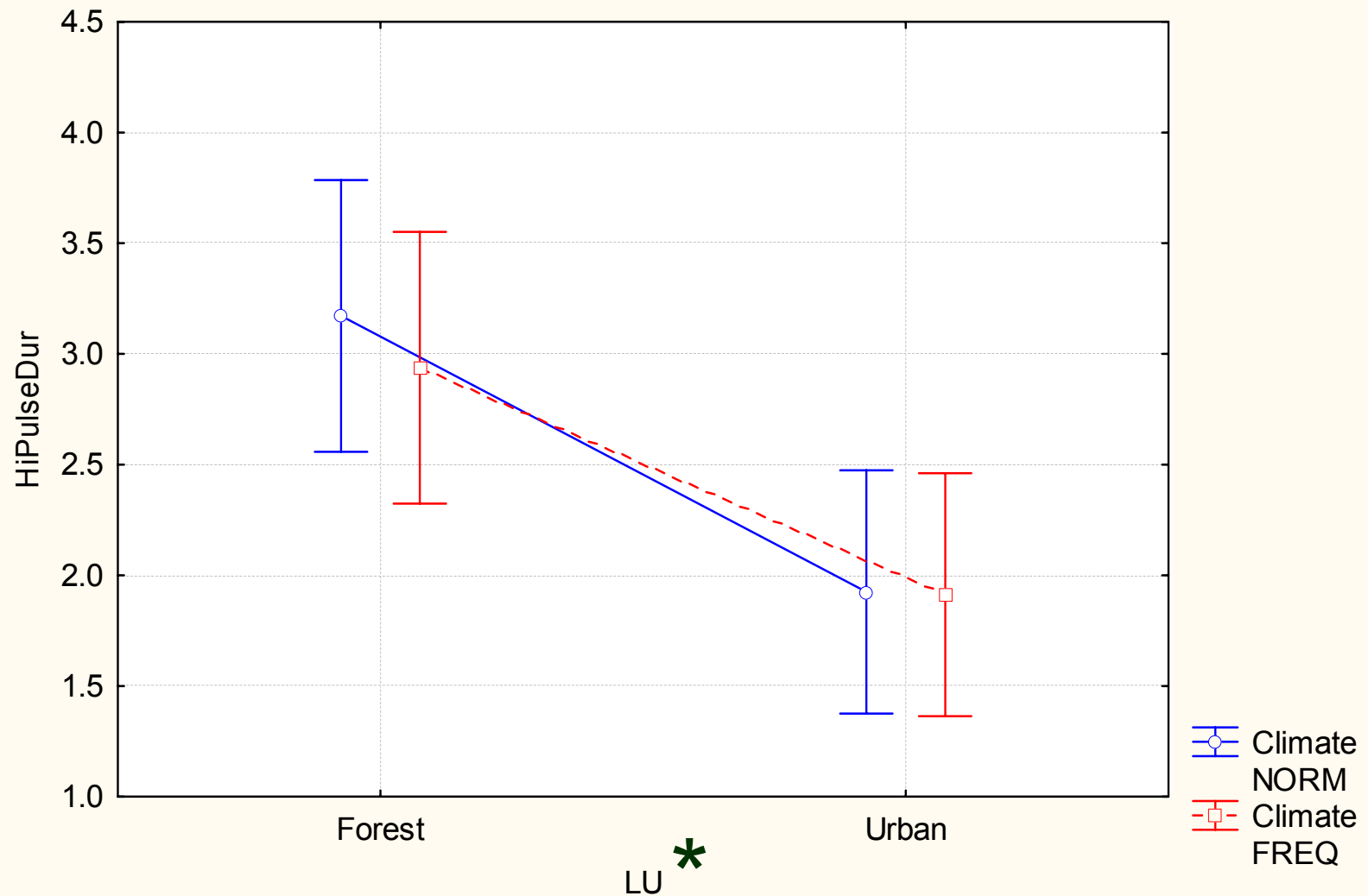
What we found



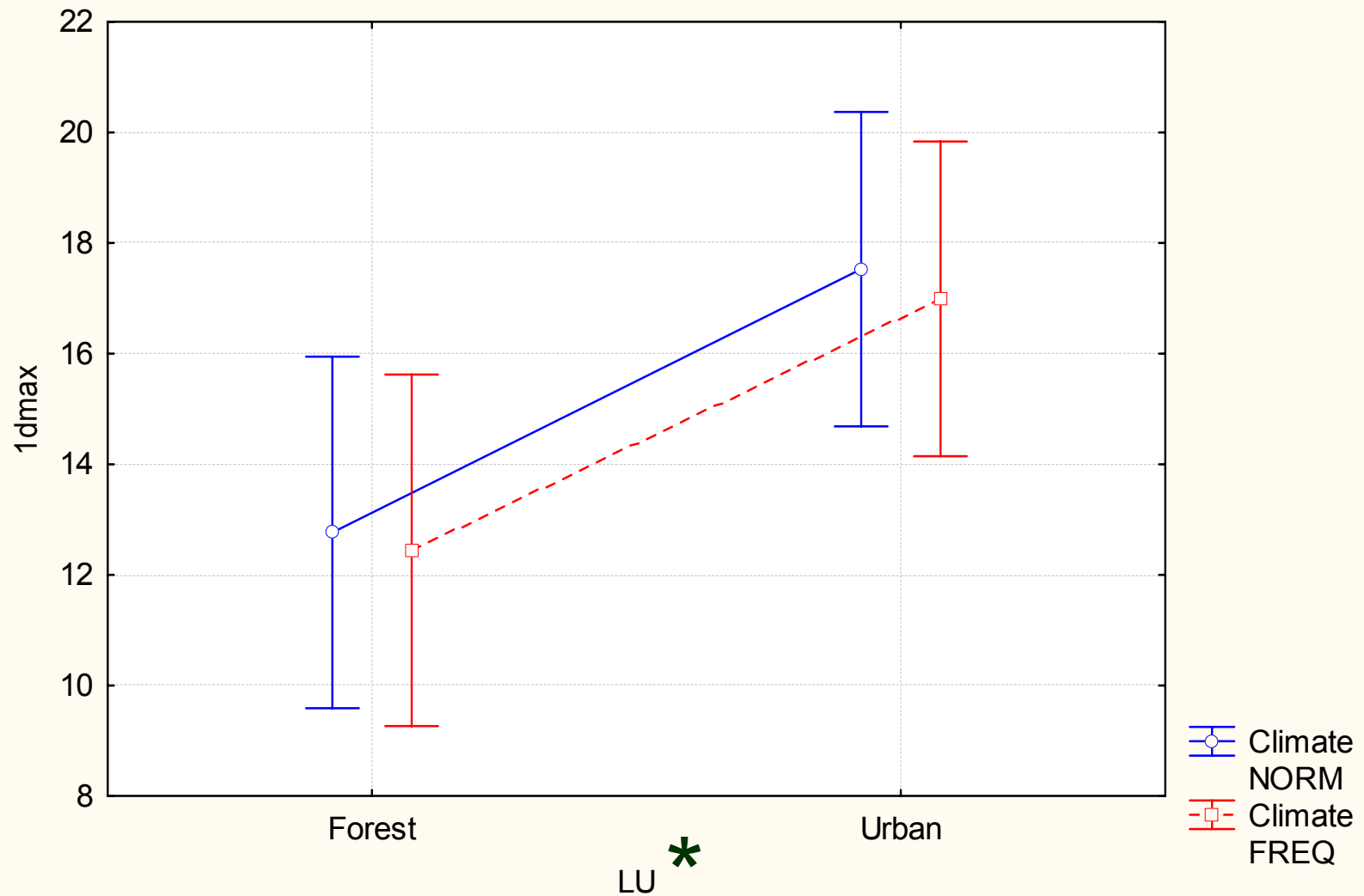
What we found



What we found



What we found



What we found

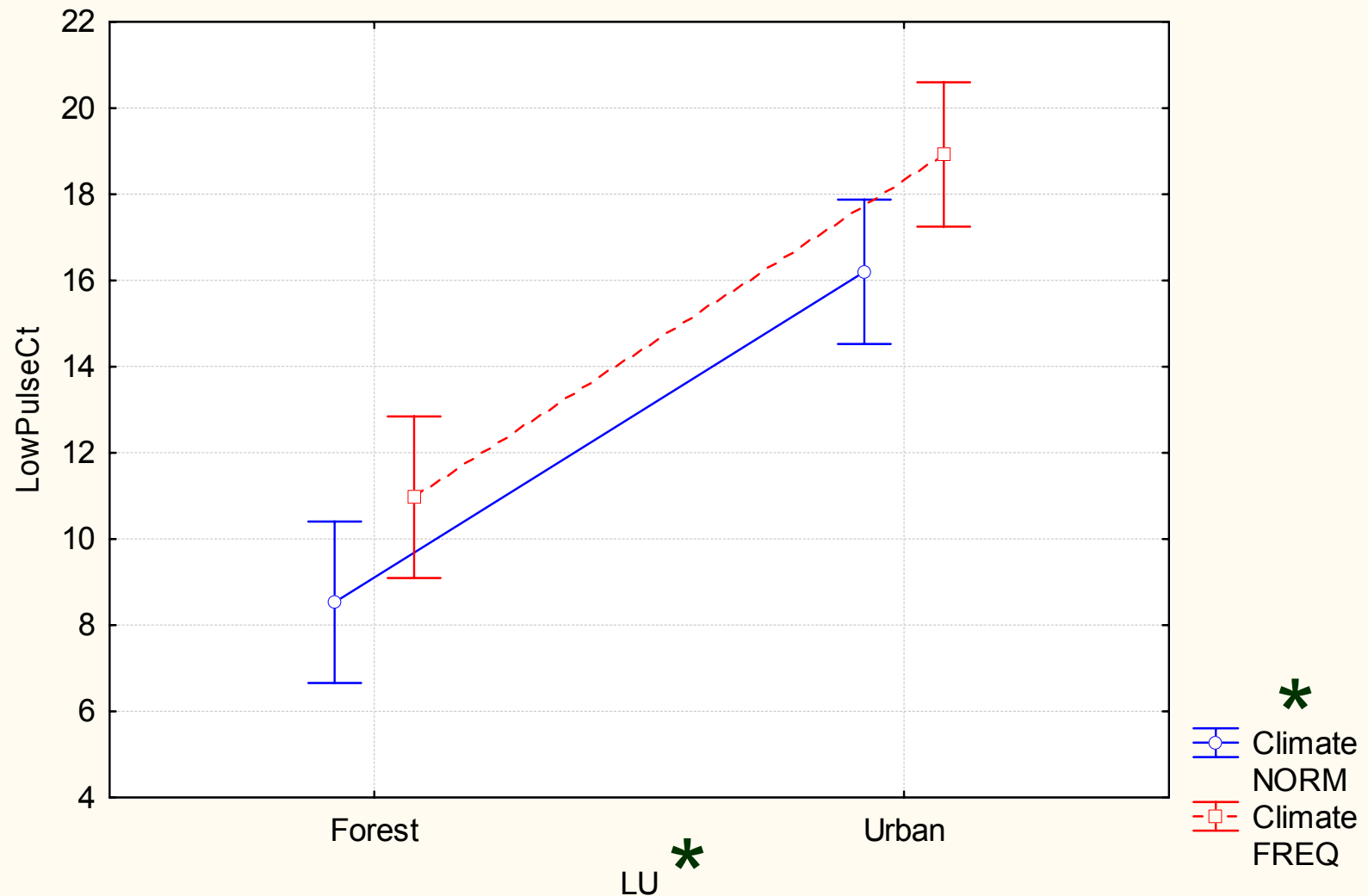
<u>High Flow Metrics</u>	<u>Land Use</u>	<u>Climate</u>
Flashiness	Y	N
High Pulse Count/Duration	Y	N
1 day max	Y	N
3 day max/7 day max	N	N
Rise rate/Fall rate	Y	N
Reversals	Y	N
High Flood Peak/Frequency/Duration	Y	N
Small Flood Peak/Duration	Y	N

Land Use Swamps Climate Effects

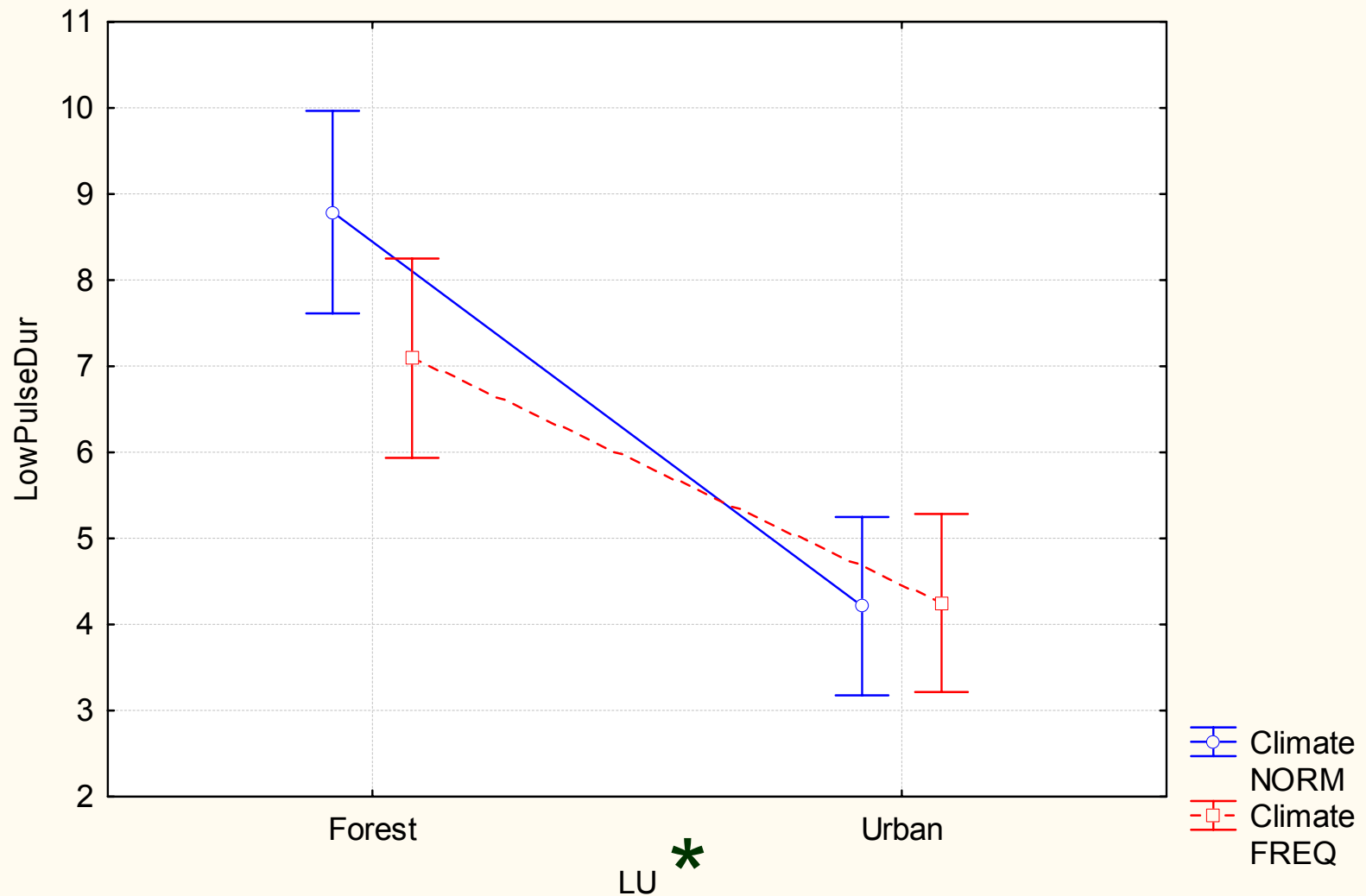
Climate: Magnitude NA; Frequency NA; Duration NA; Timing NA; Rate of Change NA

Land Use: Magnitude ↑; Frequency ↑; Duration ↓; Timing NA; Rate of Change ↑

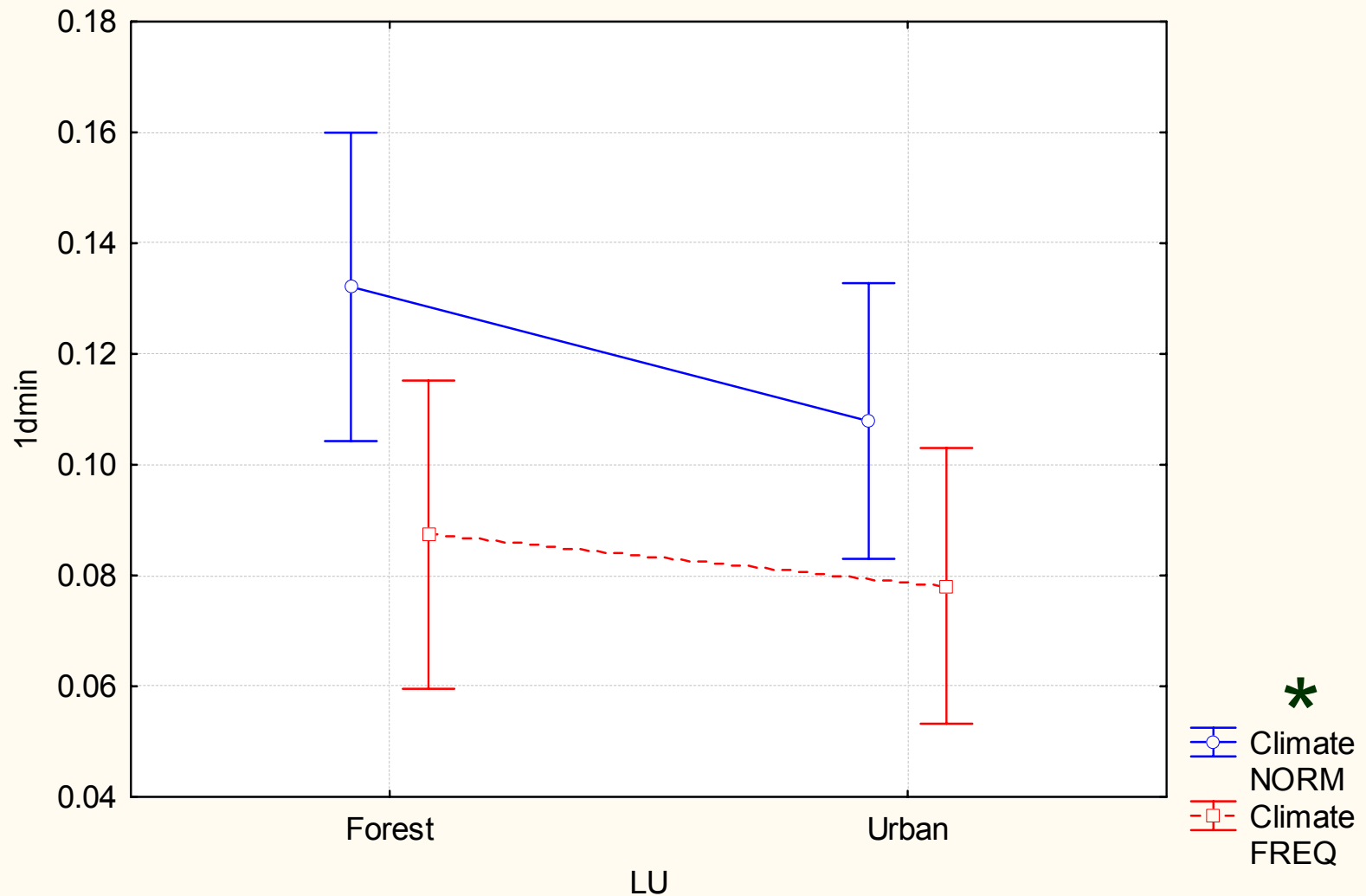
What we found



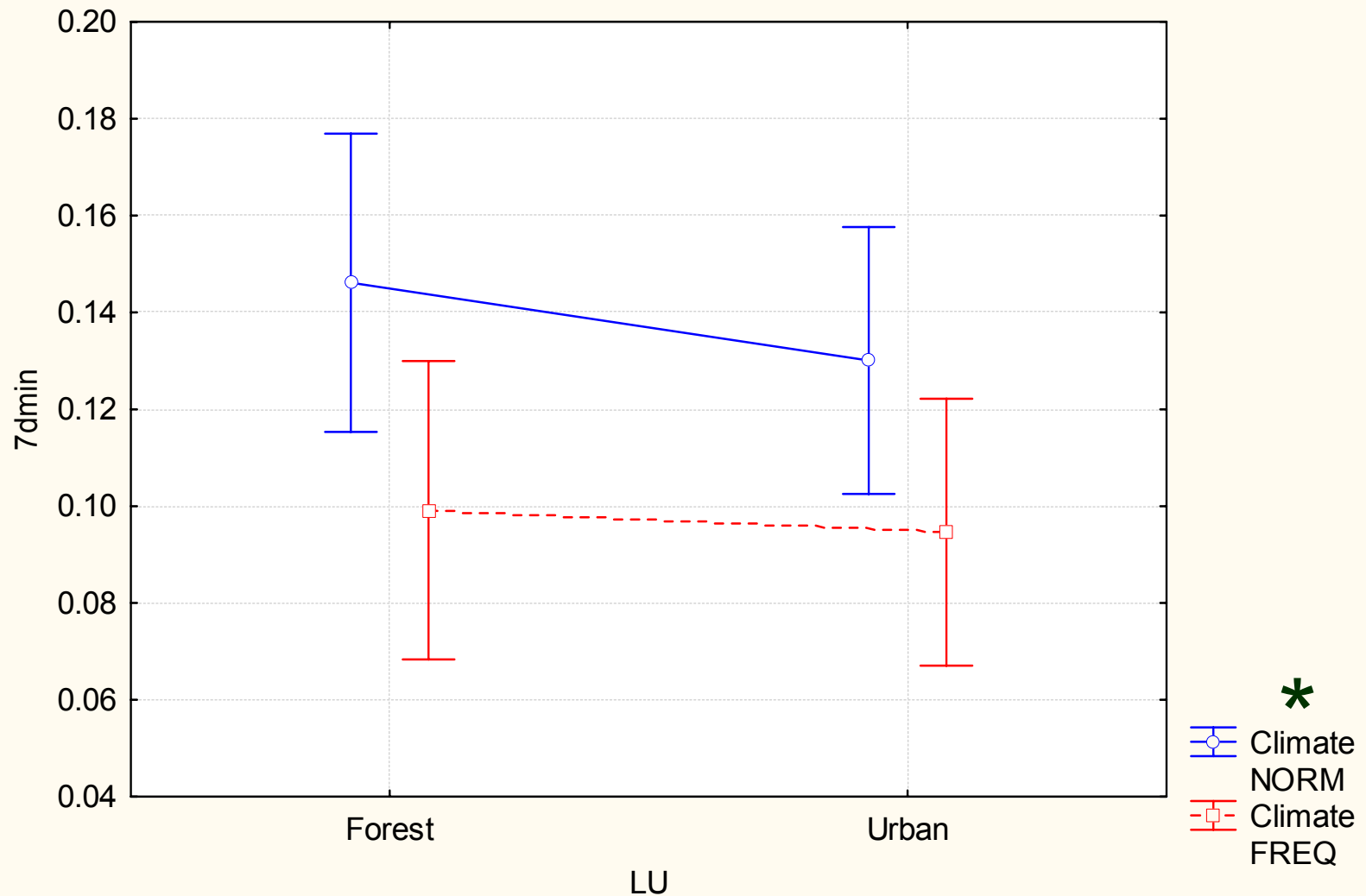
What we found



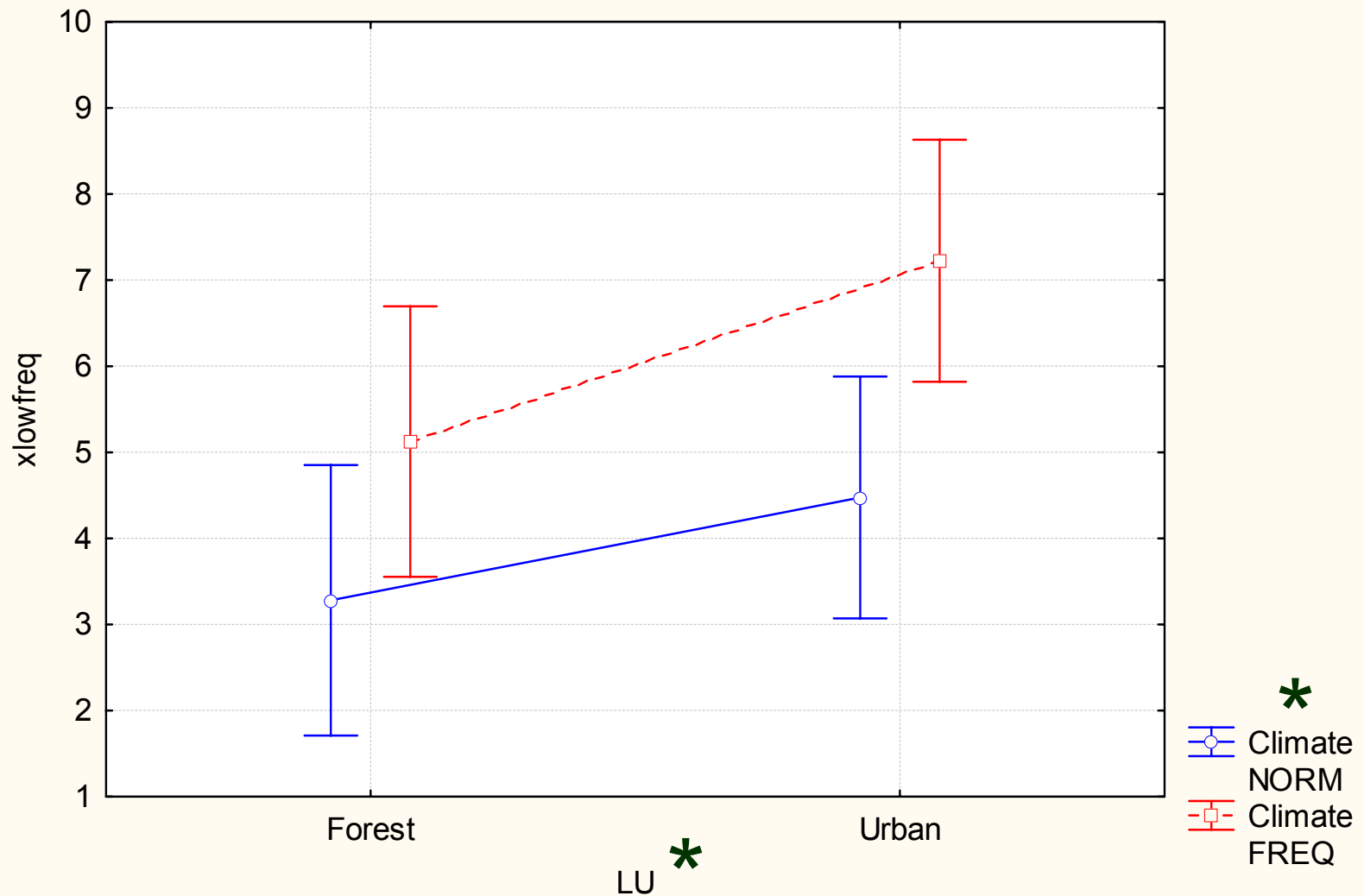
What we found



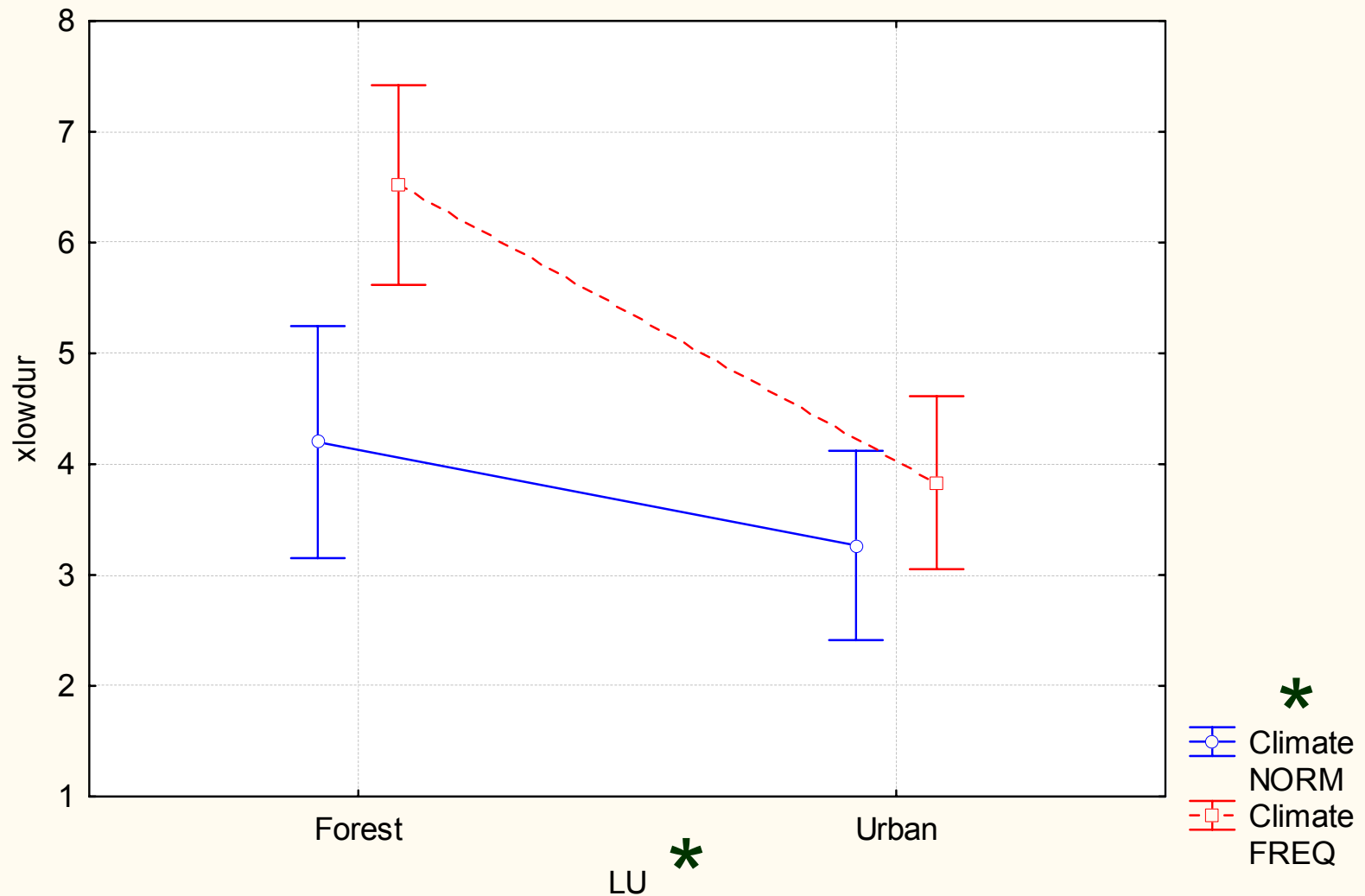
What we found



What we found



What we found



What we found

<u>Low Flow Metrics</u>	<u>Land Use</u>	<u>Climate</u>
Low Pulse Count	Y	Y
Low Pulse Duration	Y	N
1 day/3 day/7 day min	N	Y
Extreme Low Peak	N	N
Extreme Low Frequency/Duration	Y	Y

Climate Swamps Land Use Effects

Climate: Magnitude ↓; Frequency ↑; Duration ↑; Timing ↓; Rate of Change NA

Land Use: Magnitude NA; Frequency ↑; Duration ↓; Timing NA; Rate of Change NA

Summary

High Flow Events

Future Climate Effect Small Relative to
Land Use

**More Frequent, Shorter, Higher
Flows in Urban**



>



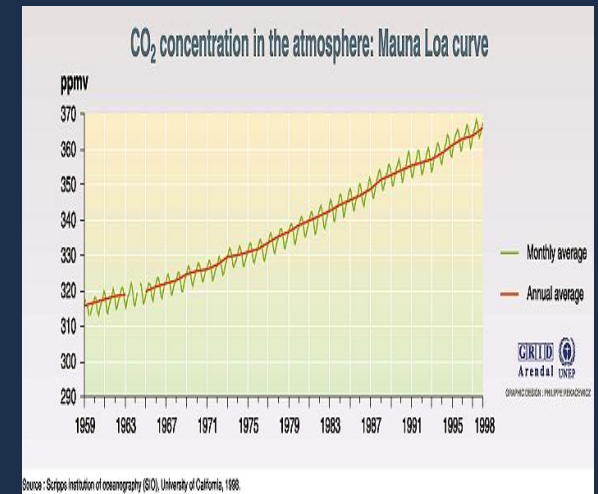
Low Flow Events

Future Climate Effect Large Relative to
Land Use

**More Frequent, Longer, Lower Flows
in “Future Climate”**



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Climate and Land Use

- Climate will affect stream flows
- Happening over an ongoing dramatic change in land use
- Effects of climate change will be felt to differing degrees relative to land use change